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ORIGINAL RESEARCH

Comparing Emergency Medical Services Processing Times for Stroke Patients Before and During COVID-19 Pandemic; A Cross-sectional Study

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Abstract: **Introduction:** Coronavirus disease 2019 (COVID-19) has directly affected global healthcare, especially the front-line of healthcare provision, including emergency medical services (EMS). The present study aimed to compare EMS processing times and the number of acute stroke patients serviced by EMS before and during COVID-19 pandemic. **Methods:** This is a retrospective observational review of Bangkok Surgico Medical Ambulance and Rescue Team (S.M.A.R.T.) EMS data from 2018 to 2021. The EMS processing times and the number of acute strokes were compared between pre-COVID-19 era (January 1st, 2018, and December 31st, 2019) and during COVID-19 pandemic (January 1st, 2020, and December 31st, 2021). **Results:** The number of stroke patients transported by EMS in one year, before and during COVID-19 pandemic was 128 and 150 cases, respectively (Change difference = 17.2%, 95% CI: 11.1–24.9). However, the average number of acute stroke patients per week was not significantly different ($p = 0.386$). The mean total EMS processing times before and during COVID-19 era were 25.59 ± 11.12 and 45.47 ± 14.61 minutes, respectively (mean difference of 19.88 (95% CI: 16.77–22.99) minutes; $p < 0.001$). The mean time from symptom onset to EMS arrival ($p < 0.001$), the mean call time ($p < 0.001$), the mean response time ($p < 0.001$), and the mean scene time ($p < 0.001$) were significantly higher during COVID-19 period. The mean transportation times for stroke patients was similar before and during COVID-19 pandemic (10.14 ± 6.28 and 9.41 ± 6.31 minutes, respectively; $p = 0.338$). **Conclusion:** During COVID-19 pandemic, the number of acute stroke patients serviced by EMS increased substantially, but there was no difference in the average number of patients per week. During the pandemic, EMS processing times markedly increased.

Keywords: Stroke; COVID-19; Emergency medical services

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1. Introduction

Acute stroke is a severe neurological emergency that causes illness, mortality, and long-term morbidity. It is also an important global public health issue (1). Acute stroke is a time-sensitive condition. Prompt evaluation and management are crucial to patient outcomes (2). As the first responders, emergency medical services (EMS) play an important role in this. EMS deliver patients to designated hospitals or stroke centers through a stroke fast track (3). Several previous studies have confirmed that EMS are important for rapid stroke center access, which increases treatment efficiency and positive outcomes in acute stroke patients (4, 5). COVID-19 not only affected stroke patients, but also led to an

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increase in the incidence of other emergency medical conditions, such as acute coronary syndrome, and delayed treatment in the context of EMS, reported in the previous systematic review and meta-analyses (6). Since late 2019, the world faced coronavirus disease 2019 (COVID-19). COVID-19 began in Hubei, China, and then spread dramatically around the world. Thailand was one of the first countries outside of China to report infection. The first Thai patient was confirmed on 13th January 2020 by Thailand's Ministry of Public Health (7). Subsequently, COVID-19 continued to spread throughout Thailand, affecting every sector. The pandemic directly affected the healthcare system, especially EMS, as they are the first responders to emergency patients, including those with COVID-19 (8). EMS established improvements to their operations in response to COVID-19, including protocol development and the use of personal protective equipment (PPE) to prevent infection of EMS staff (9). The pandemic also affected EMS processing times. In the USA, the number of patients requesting EMS for conditions other than COVID-19 markedly decreased compared to that in the same period in the previous year, and the total number of EMS requests decreased by 26.1% (10). Yet, despite this, EMS response times substantially increased during COVID-19 (11). An observational study on the impact of COVID-19 on acute stroke patients serviced by EMS in Busan, South Korea, reported a decrease in the rate of acute stroke patients requesting EMS by 8.2% and a doubling of EMS processing times compared to that in the non-pandemic period (12). In Massachusetts, USA, the number of EMS callouts for acute stroke patients decreased by 12.3% during COVID-19 pandemic (13). In Catalonia, Spain, the number of EMS callouts for acute stroke patients decreased by 22.0% during COVID-19 (14). However, data on changes in EMS callouts for acute stroke during COVID-19 has not yet been collated in Thailand.

The present study aimed to compare EMS processing times and the number of acute stroke patients serviced by EMS before and during COVID-19 pandemic.

2. Methods

2.1. Study design and setting

This is a retrospective observational review of Bangkok Surgico Medical Ambulance and Rescue Team (S.M.A.R.T.) EMS data from 2018 to 2021. Data on acute stroke patients serviced by EMS in Bangkok were collected from EMS patient care reports and were used to compare EMS processing times and the number of acute stroke patients serviced by the EMS before and during COVID-19 pandemic. The area studied was that covered by the Surgico Medical Ambulance and Rescue Team, Faculty of Medicine, Vajira Hospital, Navamindradhiraj University, Bangkok. Data were obtained from the S.M.A.R.T. of the Faculty of Medicine at Vajira Hospital, which is the primary EMS unit in area one of Bangkok's nine areas. This team is dispatched by the Erawan Center in Bangkok, which has six public and private hospitals in its network and is responsible for an area of 50 km2, with a population of 500,000 (15). The first COVID-19 patient in the study area was confirmed on 13th January 2020 by Thailand's Ministry of Public Health. During the study period, there were 437,303 confirmed COVID-19 cases in the study area (16). During COVID-19 pandemic, the S.M.A.R.T. introduced additional protocols for the screening of patients under investigation (PUI) by paramedics or emergency nurse practitioners (ENPs) via the emergency medical hotline, 1554, or from the Bangkok dispatch center. This required the emergency medical dispatcher (EMD) to gather a patient symptom report and assess the risk of COVID-19 infection. EMS staff transporting patients were required to wear PPE and to avoid aerosol-generating procedures such as advanced airway management and mechanical cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest (OHCA) patients. In the study area, at least three members of the S.M.A.R.T. staff attended each emergency. This could include emergency physicians (EPs), paramedics, emergency nurse practitioners (ENPs), and emergency medical technicians (EMTs).

2.2. Participants

Patient data were collected with the assistance of the S.M.A.R.T. of the Faculty of Medicine at Vajira Hospital, Navamindradhiraj University. The data were obtained from EMS patient care reports using the response code (RC) for acute stroke, which was "18 code red 1 - red 9." The period between January 1st, 2018, and December 31st, 2019, was defined as pre-COVID-19 era, while the period between January 1st, 2020, and December 31st, 2021, was defined as during COVID-19 pandemic. Patients with a final diagnosis of acute stroke, RC code 18 with level red severity (18 red 1 - red 9), aged > 18 years and assisted by the S.M.A.R.T. of the Faculty of Medicine, Vajira Hospital, Navamindradhiraj University were included in our study. Patients who refused treatment or transportation to hospital, those with incomplete data, and those treated with end-of-life or palliative care were excluded.

2.3. Data gathering

Patient data were collected from EMS patient care reports. These reports are recorded on a form that consists of EMS operation unit data, patient data, and all treatments given by the EMS team. The reports are recorded by the EMD and the EMS staff responsible for the patient. The primary purpose of the reports is the evaluation of EMS service requirements when assigning healthcare funding for EMS units. The forms filled out from 2018 to 2021 were retrospectively col-

Table 1: Comparing the baseline characteristics of acute stroke patients as well as their EMS processing times before and during the coronavirus disease 2019 (COVID-19) pandemic

Characteristics	COVID-19 era		P value
	Before (N = 128)	During (N = 150)	
Number of patients per week			
Mean ± SD	1.96 ± 1.15	2.17 ± 1.22	0.386
Gender			
Male	77 (60.2)	85 (56.7)	0.556
Female	51 (39.8)	65 (43.3)	
Age (year)			
Mean ± SD	66.88 ± 14.33	66.11 ± 13.20	0.642
Underlying disease			
Yes	71 (55.5)	102 (68.0)	0.032
Vital signs (Prehospital)			
Systolic blood pressure	157.22 ± 39.05	163.62 ± 35.15	0.152
Diastolic blood pressure	92.68 ± 23.89	93.12 ± 23.15	0.876
Heart rate	88.34 ± 21.87	93.14 ± 19.99	0.057
Oxygen saturation	96.58 ± 3.03	97.05 ± 2.10	0.142
Glasgow coma score	11.55 ± 3.40	12.51 ± 2.89	0.011
EMS processing times (minutes)			
Symptom to EMS	13.52 ± 11.58	56.27 ± 76.6	< 0.001
Call time	1.48 ± 0.77	3.62 ± 1.89	< 0.001
Response time	2.75 ± 2.45	16.54 ± 8.86	< 0.001
Scene time	12.23 ± 5.54	19.68 ± 7.81	< 0.001
Transportation time	10.14 ± 6.28	9.41 ± 6.31	0.338
Total	25.59 ± 11.12	45.47 ± 14.61	< 0.001

Data are presented as number (%) and mean ± standard deviation (SD). EMS: emergency medical services.

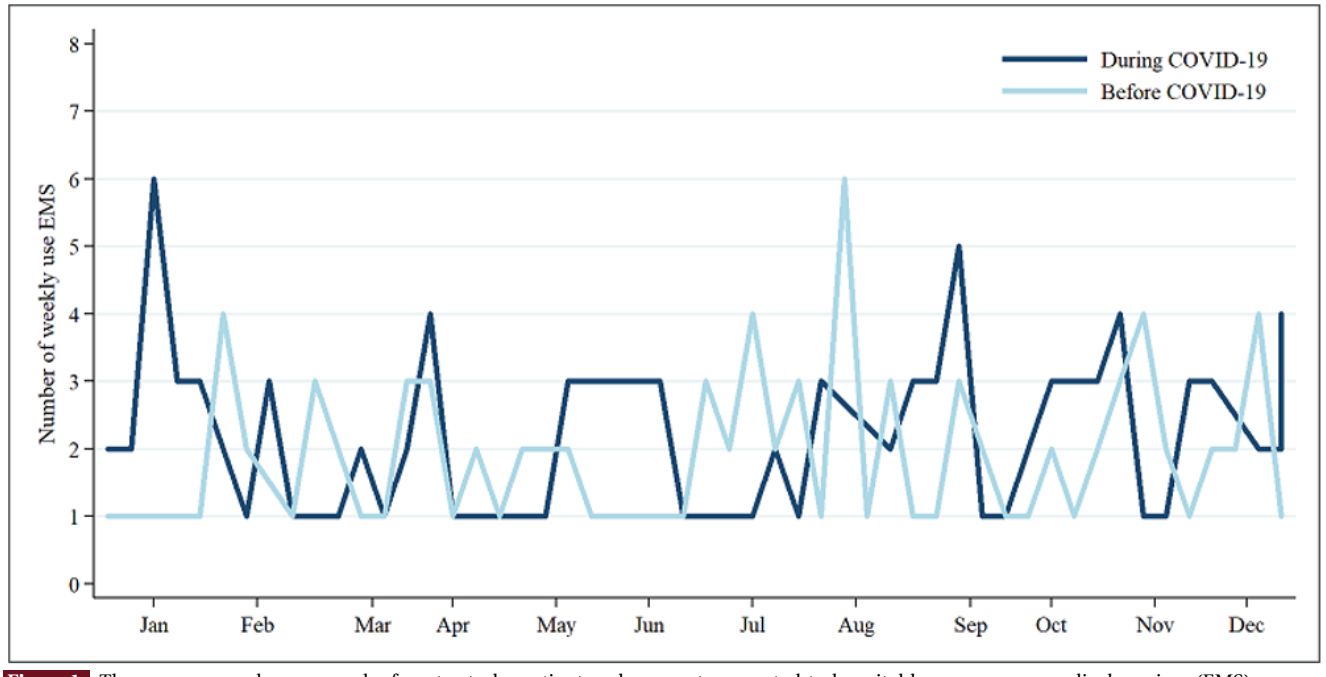

Figure 1: The average number per week of acute stroke patients, who were transported to hospital by emergency medical services (EMS) before and during COVID-19 period.

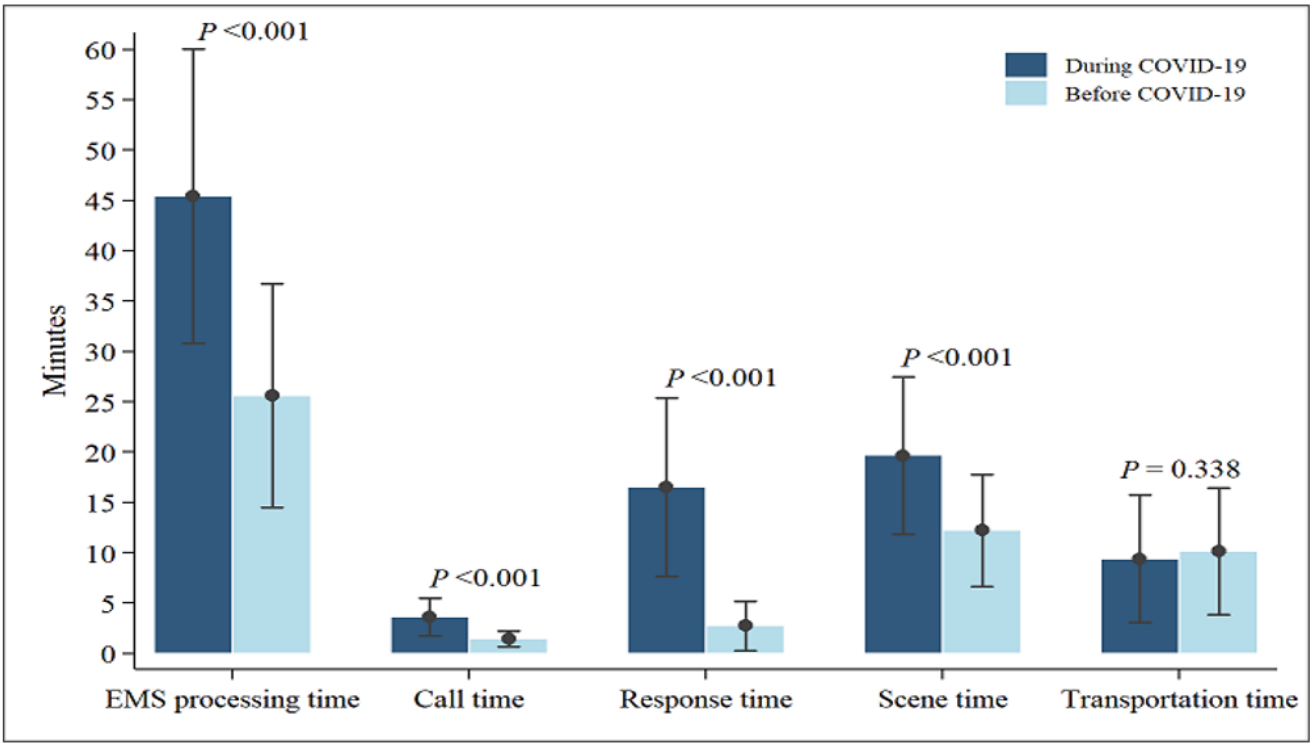

Figure 2: The average number per week of acute stroke patients, who were transported to hospital by emergency medical services (EMS) before and during COVID-19 period.

lected, with the period from January 1st, 2018, to December 31st, 2019, defined as pre-COVID-19; and the period from January 1st, 2020, to December 31st, 2021, defined as during COVID-19. The data from EMS patient care reports for all acute stroke patients meeting our criteria were recorded and saved in Microsoft Excel. This included patient demographic and clinical characteristics, including gender, age, underlying diseases, prehospital systolic blood pressure, prehospital diastolic blood pressure, prehospital heart rate, prehospital oxygen saturation, prehospital Glasgow coma score, and time from symptom onset to EMS arrival (in min); and EMS processing time, including call time (in minutes), response time (in min), scene time (in min), transportation time (in minutes), and total processing time (in min).

2.4. Definitions

- The period between January 1st, 2018, and December 31st, 2019, was defined as pre-COVID-19, while the period between January 1st, 2020, and December 31st, 2021, was defined as during COVID-19.
- EMS processing time was the total time from the beginning of the call to emergency services to the arrival of the patient (by ambulance) at the designated hospital.
- Call time was the time from the beginning of the emergency call to the order for ambulance dispatch.
- Response time was the time from the end of the emergency call to ambulance arrival at the scene.
- Scene time was the time from ambulance arrival at the scene to ambulance departure from the scene.
- Transportation time was the time from ambulance departure from the scene to ambulance arrival at the designated hospital.
- The response code (RC) “RC 18 red 1 - RC 18 red 9” was the code for acute ischemic or hemorrhagic stroke with a high severity level.

2.5. Sample size determination

For the primary objectives, mean values of each category were compared between before and during the pandemic (17). For the sample size calculation, we referred to statistical data from a previous study (18). The mean EMS processing times for acute stroke patients before and during COVID-19 were 31.3 and 35.4 min, respectively, and the interquartile ranges (IQRs) were 23–37 and 25–41. The standard deviations (SDs) were 10.37 and 11.85, respectively (12). The ratio of the sample size compared to the studied groups was defined as 1. We set the significance level as $p > 0.05$ and the power as 80%. The calculated minimum sample size was determined to be 116 per group.

In the present study, the sample comprised acute stroke

patients serviced by the EMS of the S.M.A.R.T., Faculty of Medicine Vajira Hospital, Navamindradhiraj University, who matched our eligibility criteria over the 4 years. The number of patients during the pre-COVID-19 period was 128, and the number during COVID-19 was 150. Thus, our total sample size was 278, which was sufficient for analysis.

2.6. Statistical analysis

To examine the distribution of variables, we converted the raw data to descriptive statistics. Continuous variables were presented as the mean ± SD or the median and IQR. Categorical variables were presented as frequencies and proportions. We compared the two groups using independent t-tests or Mann–Whitney U tests for numeric variables and chi-square or Fisher's exact tests for categorical variables. The differences between means before and during COVID-19 were reported with 95% confidence intervals (CIs).

To compare the number of acute stroke patients serviced by EMS before and during COVID-19, data were described as frequency distributions and difference percentages between the two periods, with 95% CI. An interrupted time-series analysis with a linear first-order autoregressive model was used to compare the number of patients before and during COVID-19 (change in the number of events per week to evaluate the change in the number of weekly EMS stroke cases). Statistical analyses were performed using SPSS Statistics for Windows, version 28.0. (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered statistically significant.

2.7. Ethical statement

This study was conducted in accordance with the tenets of the Declaration of Helsinki 1975 and its revisions in 2000. It was approved by the Institutional Review Board of the Faculty of Medicine Vajira Hospital, Navamindradhiraj University (COA no. 099/2565). The informed consent requirement was waived due to the retrospective nature and anonymity of all patient data.

3. Results

3.1. Baseline characteristics of studied patients

Table 1 compares the baseline characteristics of stroke patients before and during COVID-19 pandemic. The number of stroke patients transported by EMS in one year, before and during COVID-19 pandemic was 128 and 150 cases, respectively (Change difference = 17.2%, 95% CI: 11.1–24.9). However, the average number of acute stroke patients per week was not significantly different (1.96 ± 1.15 cases before and 2.17 ± 1.22 during COVID-19; p = 0.386; Figure 1). The mean age of patients before and during the pandemic were 66.11 ± 13.20 and 66.88 ± 14.33 years, respectively (p = 0.642). The proportions of male patients before and during COVID-19 were 56.7% and 60.2%, respectively (p = 0.556). The mean systolic blood pressure (p = 0.152), diastolic blood pressure (p = 0.876), heart rate (p = 0.057), and oxygen saturation (p = 0.142) of stroke patients in prehospital setting was same before and during COVID-19 era. The mean Glasgow coma scale of patients was significantly higher during COVID-19 pandemic (12.51 ± 2.89 vs. 11.55 ± 3.40; p = 0.011). In addition, the prevalence of underlying diseases during COVID-19 era was higher than before the pandemic (68.0% vs. 55.5%; p = 0.032).

3.2. EMS processing times

Figure 2 and table 1 compare the total EMS processing times for acute stroke patients before and during COVID-19 pandemic. The mean total EMS processing times before and during COVID-19 pandemic were 25.59 ± 11.12 and 45.47 ± 14.61 minutes, respectively (mean difference of 19.88 (95% CI: 16.77–22.99) minutes; p < 0.001). The mean duration from symptom onset to EMS arrival (p < 0.001), the mean call time (p < 0.001), the mean response time (p < 0.001), and the mean scene time (p < 0.001) were significantly higher during COVID-19 period (table 1 and figure 2). The mean transportation times for stroke patients was similar before and during COVID-19 pandemic (10.14 ± 6.28 and 9.41 ± 6.31 minutes, respectively; p = 0.338).

4. Discussion

The number of acute stroke patients serviced by EMS increased by 17.2% during COVID-19 pandemic. The mean EMS processing times, call times, response times, and scene times were all significantly higher during COVID-19 pandemic compared to before, but there was no significant change in the transportation times.

The present study supported the findings of previous systematic reviews and meta-analyses that have reported an increase in the incidence and risk of acute stroke in COVID-19 patients. Several factors may increase the risk of acute stroke in COVID-19 patients. These include abnormal coagulation, inflammation, platelet activation, and abnormal endothelial alterations (19, 20). Velasco et al. found a 53.0% increase in EMS callouts for acute stroke during COVID-19 pandemic, most of which were in urban areas (21). It is likely that most EMS callouts for all conditions, at all times, are in urban areas as they are more densely populated. However, this finding conflicted with those of several observational studies in other countries, including South Korea (12), the USA (13), and Spain (14), all of which found a decrease in incidence of acute stroke during COVID-19. Reasons postulated by the authors of these studies for this reduced incidence of stroke EMS callouts are broad explanations for a general reduction in the number of patients accessing EMS

during COVID-19 era, including the declaration of a state of emergency, social restrictions (11), stay-at-home measures, social distancing measures, and self-isolation (10). In the present study, we found that the number of acute stroke patients serviced by EMS in Bangkok, Thailand, increased by 17.2% during COVID-19. This is likely to have been because people were more inclined to call out EMS in medical emergencies rather than traveling to hospitals themselves or being taken by relatives, because the emergency departments of Bangkok hospitals had to temporarily close during COVID-19 pandemic to prevent co-mingling of COVID-19 patients and medically vulnerable non-COVID-19 patients. Also, because of the frequent presentation of COVID-19 patients in emergency departments, there was a need to ensure thorough disinfection of these departments and to quarantine high-risk staff. Therefore, EMS were often the sole means of access to hospital emergency departments. In addition, the declaration of a state of emergency by the Thai government was accompanied by the implementation of a 22.00–04.00 curfew, effective between March 26th and June 30th, 2020. This provided an additional reason for people choosing EMS rather than delivering patients to hospitals themselves, at least during the curfew hours. The increase in acute stroke patients seen by EMS during COVID-19 pandemic was also observed in a study by Ikenberg et al., who reported an 86% increase in EMS stroke RC during the lockdown (22).

EMS processing times, call times, response times, and scene times markedly increased during COVID-19 pandemic. This result was compatible with those of previous studies that had found increased EMS processing times during the pandemic (12, 14, 23, 24). The greatest increases in EMS processing times in this study occurred during a period in which Bangkok EMS experienced a huge increase in callouts, both for COVID-19 patients and other medical emergencies, with a greater frequency of calls to the emergency hotline 1669 than ever before, leading to many callers reaching a busy signal. Moreover, the new COVID-19 protocols required the EMD at the Bangkok dispatch center to gather PUI medical histories and assess the COVID-19 risk to attending EMS staff. This increased call times and response times, despite the planning and implementation of strategies to stabilize operations during the pandemic. The primary strategy used to decrease call times was a computer-assisted triage system that separated and directed calls about COVID-19 patients from those concerned with other medical emergencies. Nonetheless, call and response times were still significantly increased during the pandemic in the present study. Because of the risk of infection, the S.M.A.R.T. staff attending callouts were required to wear PPE to every emergency attended, leading to increased response times. The period during which staff were required to wear PPE was directly correlated with the increased response times (24). An additional protocol implemented during the pandemic was an en route call to the person who requested the service by the leader of the attending S.M.A.R.T. This was to evaluate the patient's symptom severity and COVID-19 risk, with questions about recent travel to high-risk areas for COVID-19 infection and COVID-19 symptoms such as an abnormal sense of taste or smell. This may have had additional effects on response times.

During the pandemic, the attending EMS staff faced difficulties in the evaluation and management of emergency patients, with contact precautions and PPE use interfering with communication and treatment. In the region studied, the EMS team leaders are responsible for decisions about hospital delivery of acute stroke patients. However, before delivery, they must coordinate the reporting of patient symptoms and stroke fast track activation with EMD at the Bangkok dispatch center who, in turn, is required to pass on this information to the emergency department equipped for stroke patient management closest to the scene. During the pandemic, Bangkok hospital emergency departments were overcrowded with both COVID-19 and other emergency patients. As a result, some emergency departments were unable to admit new acute stroke patients, resulting in further increases in scene times. Previous research indicated that this was also an issue in Okayama during COVID-19 pandemic, with delays in the delivery of emergency patients to hospitals due to overcrowded emergency departments with insufficient resources to deal with the increased number of patients (25). No difference was found between the mean EMS transportation times before and during the pandemic. We posit that this is because, in the study location, most patients would not have been far from the designated hospital, and traffic conditions were not noticeably altered by the pandemic, with heavy congestion in the capital city, even during COVID-19 pandemic.

4.1. Strengths and limitations of this study

A strength of the present study was its comparison of processing times and the number of acute stroke patients serviced by EMS before and during COVID-19. Our results offer considerable potential benefits to EMS in developing countries. The information on the effects of a medical crisis on EMS treatment of time-sensitive diseases such as acute stroke can be utilized to improve the efficacy of EMS and streamline their crisis response practices. There were several limitations in the present study. Firstly, and most importantly, the only data obtained on acute stroke patients was prehospital information from the ambulance operation report. We did not have access to any information regarding their treatment in the emergency department or the administration of anticoagulants or other medications. Secondly, due to the retrospective nature of our study, the data of some

acute stroke patients were incomplete, and these patients had to be excluded. Thirdly, data were derived from only one medical facility (S.M.A.R.T., Faculty of Medicine, Vajira Hospital, Navamindradhiraj University). Hence, while our outcomes can be considered representative of effects on EMS in equivalent or similar settings substantially affected by the COVID-19 pandemic, they cannot be applied more broadly to other contexts. Fourthly, the period between January 1st, 2018, and December 31st, 2019, was defined as pre-COVID-19, while the period between January 1st, 2020, and December 31st, 2021, was defined as the COVID-19 pandemic period. This provided a study period of four years. However, strictly speaking, the COVID-19 pandemic remained ongoing at the time this paper was written (June 2022). Lastly, the present study was observational. Consequently, the effects of COVID-19 on EMS processing times and the number of acute stroke patients serviced by EMS could not be comprehensively evaluated, and valid and reliable causality could not be inferred with certainty from the relationships between variables. Future qualitative, prospective, and population-based studies are needed for the accurate attribution of causality.

5. Conclusion

During the 2 years of the COVID-19 pandemic, the number of acute stroke patients serviced by EMS substantially increased. However, there were no significant changes in the average number of acute stroke patients treated by EMS per week. During the pandemic period, all EMS processing times significantly increased.

6. Declarations

6.1. Acknowledgments

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6.2. Authors' contributions

Conceptualization: Thongpitak Huabbangyang, Sutida Koikhunthod, Jakkapan Wanna, Nutthapong Sudajun and Parichat Khaisri; Methodology: Thongpitak Huabbangyang, Rossakorn Klaiaungthong and Krit Prasittichok; Software: Thongpitak Huabbangyang and Anucha Kamsom; Validation: Thongpitak Huabbangyang, Rossakorn Klaiaungthong and Krit Prasittichok; Formal analysis: Thongpitak Huabbangyang and Anucha Kamsom; Investigation: Thongpitak Huabbangyang, Sutida Koikhunthod, Jakkapan Wanna, Nutthapong Sudajun and Parichat Khaisri; Resources: Thongpitak Huabbangyang, Suthida Koikhuntod, Jakkapan Wanna, Nutthapong Sudajun, Parichat Khaisri and Rossakorn Klaiaungthong; Data Curation: Thongpitak Huabbangyang and Anucha Kamsom; Writing – Original Draft: Thongpitak Huabbangyang, Rossakorn Klaiaungthong and Krit Prasittichok; Writing - Review & Editing: Thongpitak Huabbangyang; Visualization: Thongpitak Huabbangyang and Rossakorn Klaiaungthong; Supervision: Krit Prasittichok; Project administration: Thongpitak Huabbangyang; Funding acquisition: Rossakorn Klaiaungthong

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6.4. Conflict of interest

The authors have no conflicting interests to declare

6.5. Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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