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Characteristics of Emergency Neurological Patients Who Were Transported by Helicopter Emergency Medical Services in Tochigi, Japan

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In Japan, reports on the association of individual characteristics, and geographical distance and time with clinical outcomes for neurological emergencies involving helicopter emergency medical services (HEMS) are scarce. Using Tochigi HEMS data (2010-2018), we assessed the characteristics of 1,170 emergency neurological patients (e.g., stroke, neurotrauma, and seizure) at the base hospital, which covered 58% of all HEMS patients in the prefecture. After initial treatment in the emergency room, emergency physicians confirmed the clinical outcomes of each patient compared to those at the incident sites (recovery/non-recovery). We calculated the geographic distance from the base hospital to each incident site, and estimated and adjusted odds ratios (aOR) and 95% confidence intervals (CI) for non-recovery against distance. The mean distance between the incident site and base hospital was 22.0 ± 11.7 km, and 77.4% of patients recovered following initial treatment. Two peak age groups were observed among emergency neurological diseases, including seizures in patients who were aged < 5 years and stroke and neurotrauma in patients who were aged 70-80 years. The percentages of stroke, traumatic head and brain injury, and seizure were 35.8%, 29.2%, and 22.8%, respectively. The incidence of stroke (aOR = 11.8, 95% CI 6.86-20.3) and neurotrauma (aOR = 4.86, 95% CI 2.78-8.51) independently predicted a poor prognosis. However, no significant association was observed with the distance from the base hospital. Therefore, in the Tochigi prefecture, geographical disparities may not affect the short-term prognosis of patients with neurological emergencies who were transported by HEMS.

Keywords: geographic distribution; helicopter emergency medical services; Japan; neurological emergency; stroke
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Introduction

Worldwide helicopter emergency medical services (HEMS) using helicopter ambulances have rapidly expanded in the latter part of the twentieth century (Michaels et al. 2019; Risgaard et al. 2020). In addition to traditional ground emergency medical services with automotive ambulances, HEMS plays an essential role in emergency medicine, particularly in neurological emergencies (e.g., stroke, neurotrauma, and seizure) (Mayer 2006; Wijdicks 2017). For instance, it was reported that HEMS shortened the time to initial treatment with specialized neurocritical care because helicopter ambulances cruise at a speed of ~200 km/h (Galvagno et al. 2012; Mommsen et al. 2012; Michaels et al. 2019), and provided an opportunity to administer immediate interventions (e.g., tissue plasmino-

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gen activator) that result in favorable outcomes (Patel et al. 2002; Suarez et al. 2004; Bershad et al. 2008). It is also reported that the geographic distance from the patient with a neurological emergency to designated neurocritical emergency center may impact clinical outcomes (Ueno et al. 2019).

In Japan, local governments have utilized well trained emergency physicians and nurses onboard HEMS as a public emergency service since 2001 (Ueno et al. 2019) to initiate medical care as soon as possible. Previous studies reported the benefits of HEMS in treating trauma patients (Matsumoto et al. 2006; Abe et al. 2014; Tsuchiya et al. 2016). However, one study reported controversial outcomes for cerebral infarction (Ueno et al. 2019). Little is known about the association of overall and specific emergency neurological conditions and HEMS in Japan. In addition, little is known about the potential geographical disparities in relation to the clinical outcomes of patients with neurological emergencies who used HEMS. The characteristics and outcomes of neurological emergencies vary across different settings (Feigin et al. 2013; Rzonca et al. 2019; Ueno et al. 2019; Zakariassen et al. 2019). Therefore, identifying these disparities, in particular clinical outcomes associated with geographical distance and time, will help in understanding the needs of neurological emergencies in Japan, where stroke remains a high priority and health burden (Takashima et al. 2017).

We hypothesized that the geographical distance affected clinical outcomes of patients with neurological emergencies because of the varying times to initial treatment. Therefore, we intended to assess the individual characteristics, geographical distance, time, and associated clinical outcomes of patients with neurological emergencies who used HEMS in Japan, using Tochigi HEMS data.

Materials and Methods

Study design and setting

This is a retrospective, observational study that analyzed a dataset of patients with neurological emergencies who used Tochigi HEMS from 2010-2018. The details of the Tochigi Prefecture have been previously described (Noguchi et al. 2020). Briefly, Tochigi Prefecture has a population of 2 million people (1.5% of the total population of Japan) with a total area of 6,408 km^2 and is located 100 km north of Tokyo. The major industries are manufacturing and agriculture/forestry, and stroke mortality is common (age-standardized mortalities for stroke in 2019 were 110.1/100,000 population in the Tochigi Prefecture compared to 86.1/100,000 population in Japan) (Vital statistics of Japan 2019).

As previously described (Ueno et al. 2019), Tochigi HEMS (one helicopter ambulance available since 2010) follows the general rule of HEMS in Japan, where according to the two-step HEMS regulation, both the helicopter and automotive ambulances are dispatched at the same time. Once a HEMS is called, the following protocol is adopted: (1) the helicopter ambulance takes off within 3 min and reaches any location in the prefecture within ~20 min; (2) an automotive ambulance simultaneously transports the patient from the incident site to the landing point; (3) the helicopter ambulance lands at the landing point nearest to the patient from among ~600 designated landing points; (4) onboard emergency physicians and nurses start primary treatment immediately upon arrival; (5) for further diagnosis and treatment, the emergency physicians choose either the helicopter or the automotive ambulance to transport the patient to the best suitable designated hospital.

Although anyone can call for an automotive ambulance free of charge by dialing 1-1-9, local fire departments can explicitly decide to call for HEMS after the initial triage that satisfies any of the following four criteria: (1) a life-threatening condition is imminent or suspected; (2) the patient is critically ill, but the transportation is expected to take a long time; (3) a shortened transportation time is essential due to a complicated emergency condition requiring specialized treatment (e.g., multiple injuries); (4) an emergency physician is needed at the incident site for diagnosis and treatment. The helicopter ambulance is on standby at the base hospital (Dokkyo Medical University Hospital; Fig. 1). To administrate the Tochigi HEMS, the base hospital provides an education program for emergency staff to acquire the latest and adequate medical knowledge and skills for emergency medicine. It also provides opportunities to obtain coordination abilities (e.g., a national license for a special radio operator for second-class on-the-ground services) with other hospitals and fire departments in the Tochigi HEMS area. In addition, the local regulation requires that to be appointed as official HEMS staff, the emergency physicians should experience 50 sets of on-the-job HEMS training.

The database included basic information (e.g., sex, age, and date) and clinical information [e.g., initial triage, pre-hospital diagnosis, and pre-hospital Glasgow Coma Scale (GCS)]. The geographical information included the landing points used and the time to initial contact with the patient from the time of the call for service. Although details of the initial treatments were not available, the database uniquely included short-term clinical outcomes by the end of initial treatment in the emergency room of the base hospital. To maintain the accuracy and quality of the data, the HEMS staff routinely and punctually register the information regarding each HEMS activity and patient in the database on the same day as the activity. The database is maintained in a designated desktop computer, and only one authorized person is allowed to change and update the data. In addition, the Tochigi HEMS staff (emergency physicians, nurses, and fire department paramedics) routinely gather to hold a meeting to discuss and update the registered information. We obtained de-identified data using an opt out approach, under the research agreement between the authors and the Tochigi HEMS. The requirement for informed consent was waived because of the anonymous

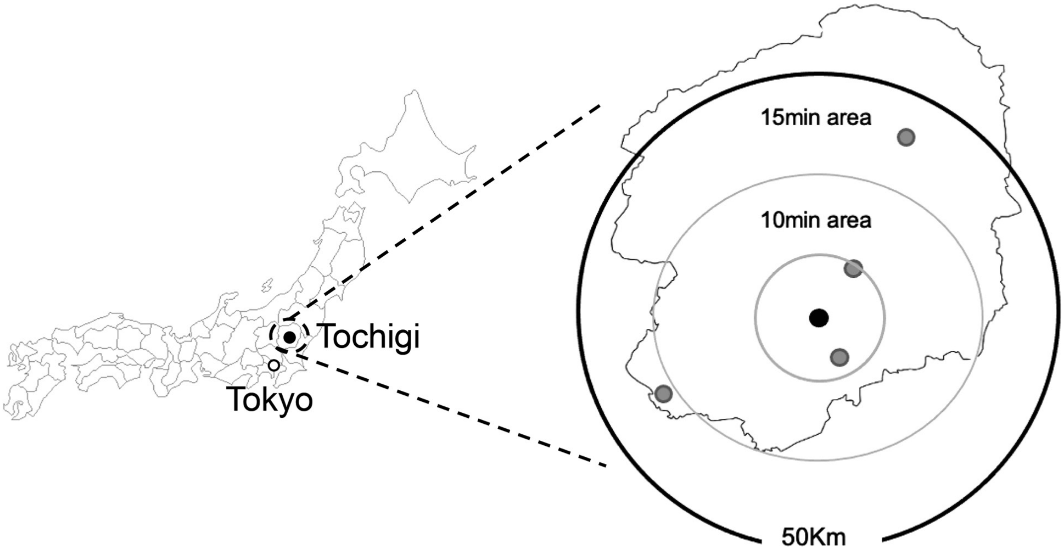

Fig. 1. Tochigi helicopter emergency medical services.
The dark circle indicates the base hospital (Dokkyo Medical University Hospital), and the gray circles indicate the other four tertiary emergency centers.

nature of the data. The study was carried out in accordance with the guidelines outlined in the Helsinki Declaration of 1964, and the research ethics committee of the Dokkyo Medical University Hospital (Protocol Number R37-21J) approved this study.

Inclusion and exclusion criteria of the study subjects

From the 3,056 HEMS patients transported to the base hospital (58.1% of the total 5,256 Tochigi HEMS patients), 1,561 non-neurological emergency patients (51.1%) were excluded, as were patients with incomplete data for geographical information (n = 19, 1.3%), contact time (n = 54, 3.6%), pre-hospital GCS (n = 198, 13.2%), and outcomes (n = 54, 3.6%), yielding 1,170 emergency neurological patients for the analysis.

Definition

The patients were classified into three neurological emergency groups according to the fourth edition of *Emergency Neurological Life Support* by the Neurocritical Care Society: stroke (cerebral infarction, intracranial hemorrhage, and subarachnoid hemorrhage); neurotrauma (traumatic injuries of the brain, spinal cord, and spine); and others (e.g., seizures) (Venkatasubramanian et al. 2020) (Table 1). Pre-hospital triage (mild, moderate, severe, and death), based on the Tochigi prefecture's emergency medical service Code of Conduct (https://www.pref.tochigi.lg.jp/c02/system/honchou/honchou/documents/r1handbook.pdf), and GCS (mild, 14-15; moderate, 9-13; and severe, 3-8) determined by emergency physicians were used to classify the severity of each case.

We calculated the geographical distance (km) from the base hospital to every designated landing point in the prefecture using geometrically calculated latitude and longitude with a trigonometric function. We also classified four seasons (spring, summer, fall, and winter) that affect dispatching the helicopter ambulance. Tochigi HEMS are available from 8:30 a.m. to 30 min before sunset. Seasons, in particular winter and colder conditions, predicted a poor neurological outcome in previous studies (Turin et al. 2009; Chu et al. 2018).

Outcome

For clinical outcomes, we assessed clinical changes from the initial status at the incident site to the end of treatment in the emergency room. For instance, seizures can be stopped promptly in the incident site by antiepileptic agents, and strokes can be improved by thrombolytic therapy in the emergency room (Patel et al. 2002; Suarez et al. 2004; Bershad et al. 2008; Muramatsu et al. 2019).

In prehospital settings, Tochigi HEMS staff administer oxygen and intravenous infusions to maintain hemodynamics, when appropriate, for patients with neurological emergencies. Tracheal intubation is considered, with sedatives or muscle relaxants (depending on the situation), if the level of GCS is below 8. When consciousness is disturbed, the serum glucose level is measured; then, intravenous glucose is administered for hypoglycemia. Antiemetic agents (metoclopramide) are administered to prevent vomiting during transport by helicopter ambulance. Additionally, for patients with stroke, a 15 to 30-degree head-up position is maintained to prevent hypoxemia, airway obstruction/aspiration, or increased intracranial pressure. Blood samples are collected on the incident site when considering thrombolytic therapy in the emergency room, enabling a blood test after the arrival in the emergency room. For neurotrauma, spinal motion restriction is ensured. For seizures, antiepileptic agents (e.g., benzodiazepine) are administered at the incident site.

This short-term outcome, confirmed by emergency physicians, was classified into four categories (recovery, no change, worse, and death). We grouped the patients into the recovered (recovery) and non-recovered groups (no change, worse, or death).

Statistical analysis

First, we described the characteristics and related outcomes of neurological emergencies involving Tochigi HEMS. Next, we estimated the odds ratios (ORs) and 95% confidence intervals (CIs) for non-recovery against geographical distance using logistic regression. In Model 1, we adjusted for age, sex, year, season, and diagnosis. We also estimated the OR and 95% CI for non-recovery against time to first contact. In Model 2, we simultaneously included the geographical distance and time to first contact, with further adjustment for GCS, and stratified the analysis according to the emergency neurological conditions.

In the sensitivity analyses, because of the similarity for geographical distance and time in the setting of HEMS, we estimated the ORs against distance and time, separately. We applied restricted cubic spline methods (Zaitsu et al. 2020), adjusted for age, sex, year, seasons, diagnosis, and GCS.

Statistical significance (alpha) was set at 0.05, and all *P*-values were two-sided. Data were analyzed using IBM SPSS Statistics software (version 25 for Windows; IBM; Armonk, NY, USA) and STATA/MP13.1 (StataCorp LLC; College Station, TX, USA).

Results

The mean distance of the incident site from the base hospital was 22.0 ± 11.7 km (~30 min from the takeoff at the base hospital to the first contact with emergency physicians), and 77.4% recovered by the end of initial treatment. Male patients were dominant (men-to-women ratio: 1.76), and the percentages of stroke, neurotrauma, and seizure were 35.8%, 29.2%, and 22.8%, respectively (Table 1). Two peak age groups were observed in those < 5 years and those between 70 and 80 years in both men and women, where the first peak was attributed to seizures and the second peak was attributed to stroke and neurotrauma (Fig. 2). The number of patients increased over time during the first half of the study period and then gradually decreased (Table 1). Most patients had moderate to severe conditions, and no seasonal differences were observed (Table 1).

Compared with the recovered patients, non-recovered patients were older, had a higher percentage of stroke, and had higher severity levels and GCSs at pre-hospital triage (Table 1). However, no significant differences were observed in geographical distance, time, seasons, or transportation types (Table 1 and Fig. 3). The recovery rates were as follows: stroke (58.4%, 245/419); neurotrauma (80.7%, 276/342); and seizure (99.3%, 265/267).

In the regression analysis, the geographical distance and time did not predict clinical outcomes (Model 1; Table 2). In Model 2, the incidence of stroke (OR = 11.8, 95% CI 6.86-20.3), neurotrauma (OR = 4.86, 95% CI 2.78-8.51), and the severity of GCS independently predicted a poor outcome; however, the geographical distance, time, and seasons were not associated with outcomes (Model 2; Table 2). In the stratified analyses for different emergency neurological conditions (Table 3), the geographical distance and time did not predict clinical outcomes in each neurological emergency group (i.e., stroke, neurotrauma, and other diseases).

In the sensitivity analyses, we did not observe a statistical significance for the geographical distance and time (Fig. 4).

Discussion

We documented the characteristics of patients with neurological emergencies who were transported by HEMS in Tochigi, Japan, where one helicopter ambulance covers the entire prefecture within ~20 min. Among numerous emergency neurological patients, we identified that stroke and neurotrauma were common in the older population, while seizures were common in the younger population. Geographical disparities did not impact short-term clinical outcomes in pre-hospital and emergency room settings, although stroke and neurotrauma mainly predicted a poor outcome with HEMS, implying that the individual severity of emergency neurological conditions (but not the geographical distance and time) is an important factor for outcome.

The geographical disadvantage of emergency neurological patients (i.e., distance from emergency centers) generally impacts the time to initial treatment with specialized neurocritical care, which is a crucial determinant for better clinical outcomes (Nirula et al. 2010; Mommsen et al. 2012; Michaels et al. 2019). In contrast, we did not observe geographical and environmental disparities in the clinical outcomes in HEMS under the universal health coverage and advanced emergency medical services in Japan (Zaitsu et al. 2019). In contrast to the HEMS setting in a previous study in Japan, in which the average distance from the base hospital was ~40 km (Ueno et al. 2019), the helicopter ambulance only covered a limited area in our study.

The two peaks observed based on age may be attributed to age-specific disease characteristics. For instance, seizures often occur in children, particularly at less than one year of age (Camfield and Camfield 2015; Fiest et al. 2017). In Japan, 49.1% of HEMS patients with seizures were reported to be < 13 years of age, and prompt administration of anticonvulsants (e.g., diazepam and midazolam) improved most seizures (Muramatsu et al. 2019). Our good recovery rate of seizures (> 99%) may be attributed to the success of HEMS in neurological emergencies for children in Japan and may help to minimize brain injury (Muramatsu et al. 2019). For the latter peak age, stroke continues to be a prioritized health burden in the general population of Japan (Takashima et al. 2017), and we also confirmed this pattern in HEMS-related neurological emergencies.

Table 1. Characteristics of emergency neurological patients transported to base hospital by Tochigi helicopter emergency medical services (2010-2018).

Characteristics		n (%) or mean ± SD			*P*-value[b]
		Total n = 1,170	Recovery n = 906	Non-recovery[a] n = 264	
Age, years		52 ± 28.1	47 ± 28.9	68 ± 17.5	< 0.001
Age category, years					
0-14		216 (18.5)	212 (23.4)	4 (1.5)	< 0.001
15-59		329 (28.1)	266 (29.4)	63 (23.9)	
≥ 60		625 (53.4)	428 (47.2)	197 (74.6)	
Men		746 (63.8)	577 (63.7)	169 (64.0)	0.92
Year					
2010		16 (1.4)	13 (1.4)	3 (1.1)	0.78
2011		10 (0.9)	9 (1)	1 (0.4)	
2012		148 (12.6)	110 (12.1)	38 (14.4)	
2013		140 (12)	106 (11.7)	34 (12.9)	
2014		197 (16.8)	152 (16.8)	45 (17)	
2015		193 (16.5)	150 (16.6)	43 (16.3)	
2016		184 (15.7)	140 (15.5)	44 (16.7)	
2017		161 (13.8)	125 (13.8)	36 (13.6)	
2018		121 (10.3)	101 (11.1)	20 (7.6)	
Season					
Spring (March-May)		316 (27)	242 (26.7)	74 (28.0)	0.86
Summer (June-August)		315 (26.9)	248 (27.4)	67 (25.4)	
Autumn (September-November)		260 (22.2)	198 (21.9)	62 (23.5)	
Winter (December-February)		279 (23.8)	218 (24.1)	61 (23.1)	
Distance, km		22.0 ± 11.7	21.8 ± 11.6	22.9 ± 12.1	0.17
Time to first contact, min		30.9 ± 12.1	31.0 ± 12.7	30.8 ± 9.9	0.83
Neurological emergency conditions					
Stroke	Cerebral infarction	165 (14.1)	117 (12.9)	48 (18.2)	< 0.001
	Intracranial hemorrhage	189 (16.2)	93 (10.3)	96 (36.4)	
	Subarachnoid hemorrhage	65 (5.6)	35 (3.9)	30 (11.4)	
Neurotrauma	Traumatic brain injury	243 (20.8)	186 (20.5)	57 (21.6)	
	Spinal cord injury	99 (8.5)	90 (9.9)	9 (3.4)	
Other	Transient ischemic attack	12 (1.0)	12 (1.3)	0 (0)	
	Seizures	267 (22.8)	265 (29.2)	2 (0.8)	
	Consciousness disorder	36 (3.1)	35 (3.9)	1 (0.4)	
	Post cardiac arrest syndrome	13 (1.1)	4 (0.4)	9 (3.4)	
	Toxic/poisoning	44 (3.8)	39 (4.3)	5 (1.9)	
	Encephalopathy/encephalitis	12 (1)	7 (0.8)	5 (1.9)	
	Metabolic etiology	13 (1.1)	12 (1.3)	1 (0.4)	
	Others	12 (1.0)	11 (1.2)	1 (0.4)	
Pre-hospital triage					
Mild		194 (16.6)	192 (21.2)	2 (0.8)	< 0.001
Moderate		255 (21.8)	244 (26.9)	11 (4.2)	
Severe		720 (61.5)	470 (51.9)	250 (94.7)	
Death		1 (0.1)	0 (0)	1 (0.4)	
Glasgow Coma Scale					
Mild, 14-15		471 (40.3)	435 (48)	36 (13.6)	< 0.001
Moderate, 9-13		297 (25.4)	252 (27.8)	45 (17)	
Severe, 3-8		402 (34.4)	219 (24.2)	183 (69.3)	
Activity type					
Air lifted		1,109 (94.8)	855 (94.4)	254 (96.2)	0.24
Ground escorted		61 (5.2)	51 (5.6)	10 (3.8)	

[a]Emergency physicians confirmed short-term clinical outcomes by the end of initial treatment at the base hospital's emergency room. Non-recovered patients showed no change (n = 99, 8.5%), worsened (n = 8, 0.7%), or died (n = 157, 13.4%).
[b]Chi-squared or t-test.
SD, standard deviation.

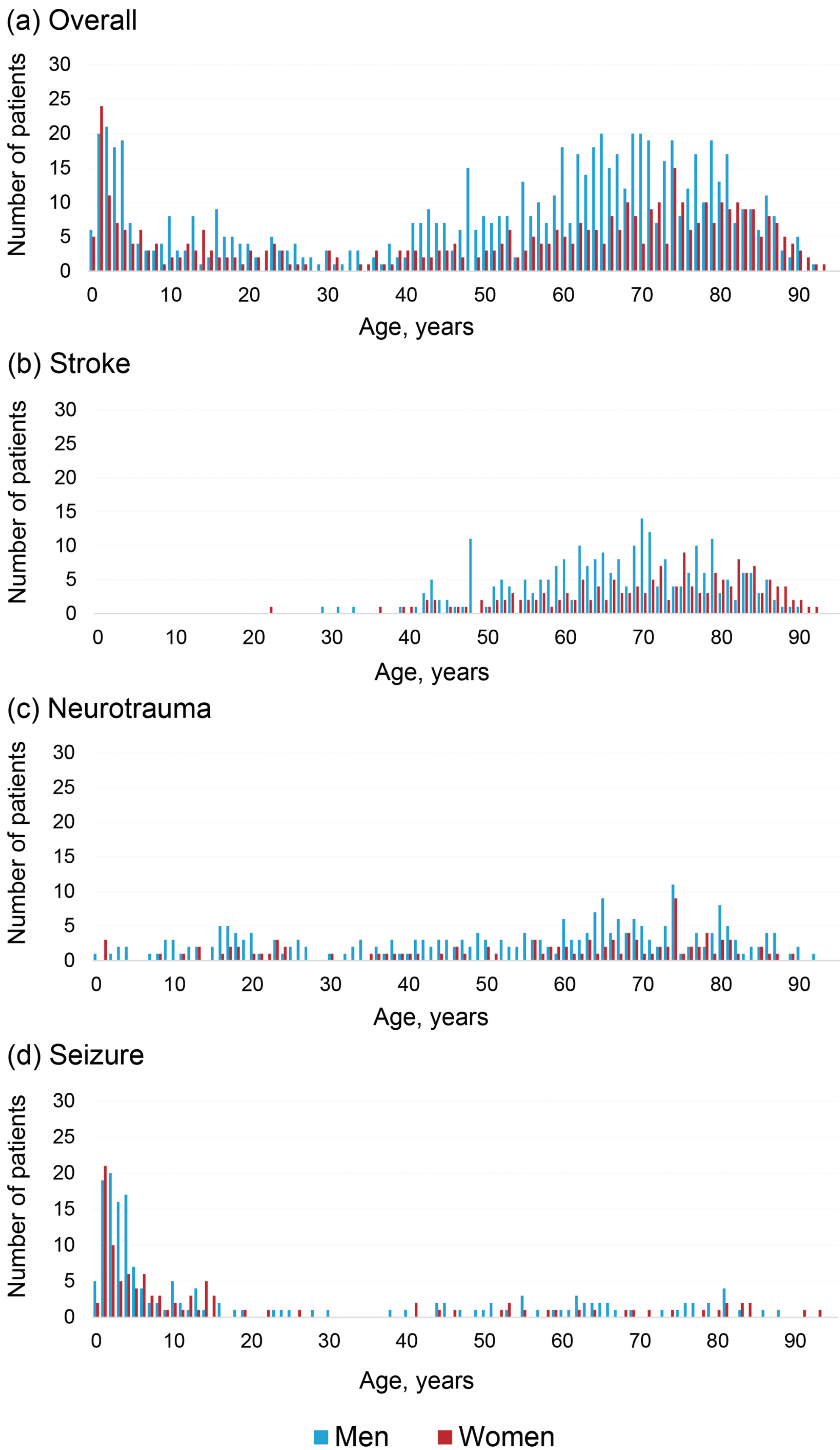

Fig. 2. Distribution of neurological emergency patients in helicopter emergency medical services.
The number of patients were as follows: (a) overall, 746 men and 424 women; (b) stroke, 255 men and 164 women; (c) neurotrauma, 241 men and 101 women; (d) seizure, 162 men and 105 women.

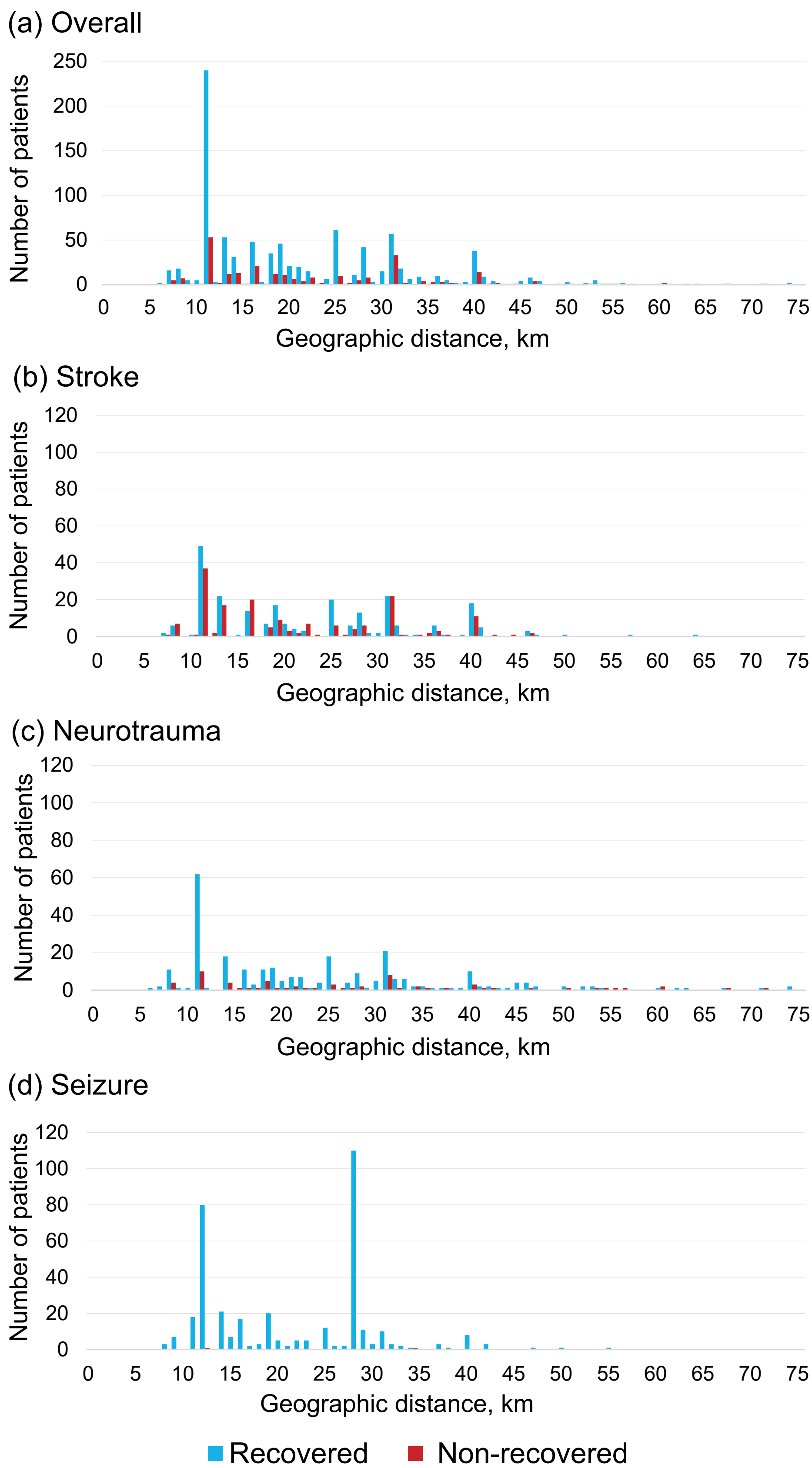

Fig. 3. Short-term clinical outcomes across different geographical distances.
The number of patients were as follows: (a) overall, 906 recovered and 264 non-recovered; (b) stroke, 244 recovered and 174 non-recovered; (c) neurotrauma, 276 recovered and 66 non-recovered; (d) seizure, 267 recovered and 2 non-recovered.

Table 2. Association of odds ratios of non-recovered patients and their clinical and geographical characteristics.

Characteristics	Univariate[a]		Model 1[b] For distance		Model 1[b] For time		Model 2[c]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Distance, km	1.01	0.99-1.02	1.00	0.99-1.02			1.00	0.99-1.02
Time to first contact, min	1.00	0.99-1.01			0.99	0.98-1.00	1.00	0.98-1.01
Age, years	1.04	1.03-1.04	1.03	1.02-1.04	1.03	1.02-1.04	1.02	1.01-1.03
Men	1.41	0.76-1.35	1.14	0.83-1.57	1.14	0.83-1.57	1.56	1.08-2.24
Year	0.96	0.90-1.03	0.97	0.90-1.05	0.97	0.89-1.04	0.97	0.89-1.06
Season								
Spring (March-May)	1.13	0.78-1.64	1.07	0.71-1.62	1.09	0.72-1.64	0.97	0.60-1.57
Summer (June-August)	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Autumn (September-November)	1.16	0.78-1.72	1.24	0.80-1.90	1.25	0.81-1.93	1.42	0.86-2.34
Winter (December-February)	1.04	0.70-1.53	1.06	0.69-1.62	1.09	0.71-1.68	0.99	0.60-1.64
Diagnosis								
Others	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Neurotrauma	3.84	2.35-6.28	2.65	1.60-4.41	2.81	1.69-4.67	4.86	2.78-8.51
Stroke	11.4	7.22-18.0	6.27	3.89-10.1	6.33	3.92-10.2	11.8	6.86-20.3
Glasgow Coma Scale								
Mild, 14-15	1.00	Reference					1.00	Reference
Moderate, 9-13	2.16	1.36-3.44					2.49	1.51-4.11
Severe, 3-8	10.1	6.82-15.0					16.4	10.5-25.6

[a]Data were estimated from 1,170 emergency neurological patients transported to the base hospital by Tochigi helicopter emergency medical services. ORs and 95% CIs for non-recovery were estimated using logistic regression analysis.
[b]Adjusted for age, sex, year, season, and diagnosis as potential confounding factors.
[c]Geographical distance, time to first contact, and Glasgow Coma Scale were simultaneously included.
CI, confidence interval; OR, odds ratio.

Table 3. Stratified analyses by emergency neurological conditions.

Characteristics	Model 1[a]		Model 2[b]	
	OR	95% CI	OR	95% CI
Stroke, n = 419				
Distance, km	0.98	0.97-1.00	0.98	0.96-1.00
Time to first contact, min	0.99	0.97-1.01	1.00	0.98-1.03
Neurotrauma, n = 342				
Distance, km	1.02	1.00-1.04	1.02	0.99-1.04
Time to first contact, min	0.99	0.96-1.01	0.99	0.97-1.02
Other diseases, n = 409				
Distance, km	1.02	0.98-1.06	1.02	0.98-1.07
Time to first contact, min	0.98	0.96-1.04	0.99	0.94-1.03

[a]ORs and 95% CIs of distance and time to first contact for non-recovery were estimated by logistic regression, separately. We adjusted for age, sex, year, and season.
[b]Distance, time to first contact, and Glasgow Coma Scale were simultaneously included.
CI, confidence interval; OR, odds ratio.

Traumatic brain injuries related to fall out may also contribute to neurological emergencies in older populations (Taylor et al. 2017).

This study has several limitations. First, our results represented only patients in the base hospital, thereby limiting external generalizability for other settings (including

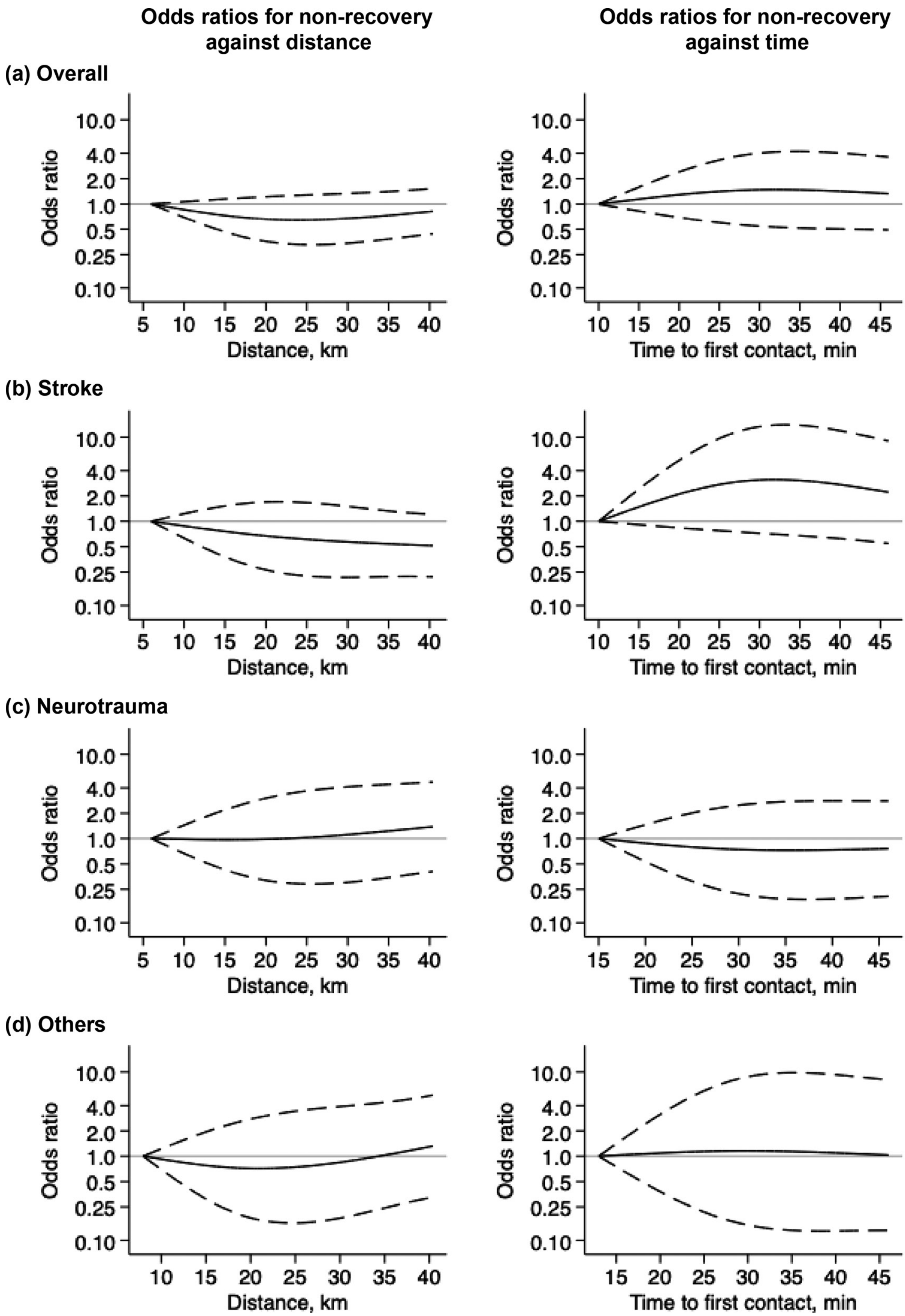

Fig. 4. Cubic spline curves for outcomes in overall and specific neurological emergencies against continuous geographical distance and time to first contact.
The odds ratios (solid line) and 95% confidence intervals (dashed line) were estimated by logistic regression, adjusted for age, sex, year, seasons, diagnosis, and Glasgow Coma Scale (GCS).

other hospitals in Tochigi, other prefectures with a larger area, and other countries). Second, our dataset had no long-term outcomes. Additionally, the types of treatments were not available although we adjusted the GCS (Gravesteijn et al. 2020). Lastly, we could not assess traditional ground emergency medical services or socioeconomic status (Ueno et al. 2019; Zaitsu et al. 2019). Because the overall benefits of HEMS against traditional ground emergency medical services have been controversial in neurological emergencies (Funder et al. 2017; Chen et al. 2018; Ueno et al. 2019), we are planning to gather this data in the future.

Despite these limitations, our strengths included the study size, which is one of the largest among Japanese HEMS studies. Our analyzed population comprised the majority (~60%) of patients transported by Tochigi HEMS. Besides, the quality of medical treatment was reliable and standardized because our data included only emergency neurological patients treated in a high-volume university emergency center. To our best knowledge, this is the first study to document individual, geographical, and environmental characteristics of patients with neurological emergencies involving HEMS in Japan, which helps to further understand the broader picture of neurological emergencies.

In summary, we documented the characteristics of neurological emergencies involving HEMS in Tochigi, Japan. Geographical disparities may not impact the short-term outcomes of neurological emergencies. However, despite these advantages in emergency services, the onset of stroke and neurotrauma results in a poorer outcome, even with HEMS.

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Conflict of Interest

The authors declare no conflict of interest.

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