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The determinants of the time from emergency call to hospital arrival of ambulances

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ABSTRACT

Objectives: In Japan, ambulance staff sometimes must make request calls to find hospitals that can accept patients because of an inadequate information sharing system. This study aimed to quantify effects of the number of request calls on the time interval between an emergency call and hospital arrival.

Design and Setting: A cross-sectional study of an ambulance records database in Nara prefecture, Japan.

Participants: A total of 43,663 patients (50% women; 31.2% aged 80 and over) 1) transported by ambulance from April, 2013 to March, 2014, 2) aged 15 and over, and 3) with suspected major illness.

Primary outcome measures: The time from call to hospital arrival, defined as the time interval from receipt of an emergency call to ambulance arrival at a hospital.

Results: The mean time interval from emergency call to hospital arrival was 44.5 minutes, and the mean number of requests was 1.8. Multiple linear regression analysis showed that approximately 43.8% of variation in transportation times was explained by patient age, sex, season, day of the week, time, category of suspected illness, person calling for the ambulance, emergency status at request call, area, and number of request calls. A higher number of request calls was associated with longer time intervals to hospital arrival (addition of 6.3 minutes per request call; *p*<0.001). In an analysis dividing areas into three groups, there were differences in transportation time for diseases needing cardiologists, neurologists, neurosurgeons, and orthopedists.

Conclusions: The study revealed 6.3 additional minutes needed in transportation time for every refusal of a request call, and also revealed disease-specific delays among specific areas. An effective system should be collaboratively established by policymakers and physicians to ensure the rapid sharing of information about hospitals and emergency patients in order to reduce the time from the initial emergency call to hospital arrival.

Strength and Limitations of this study

- A strength of this study is that it examined a large database of patients transported by ambulance that included detailed information about the number of request calls and the time for transportation in Nara prefecture, Japan.
- This study suggested that one refusal of a request call extended the time from call to hospital arrival by 6.3 minutes.
- This study revealed that there is up to approximately a 30-minute difference between areas in the time from call to arrival and specifically pointed out disease-specific delays among specific areas.
- Limitations of this study were that patient emergency status was decided by ambulance crew and our data consisted of patients from one prefecture in Japan.

[INTRODUCTION]

Background

A request for the delivery of an emergency patient is sometimes rejected, and this is a social problem in Japan[1–4]. In Japan, the emergency transport system is managed by local governments[1,5,6]. The call from the emergency patient is directly accessed by the local fire defense headquarters and the nearest available ambulance is sent to the patient[6]. Ambulance crews search for hospitals which match patient emergency status on the site. Physicians are not able to refuse patients if requested, by article 19 of the Medical Practitioners Law. However, there is no penalty if the law is not followed.

The national average of the time from calling an ambulance to hospital arrival was 39.4 minutes in 2014, is increasing every year[7], and is a known predictor of outcomes of acute heart failure[8] and head trauma[9]. Japan has the most rapidly aging population in the world[10], and it is estimated that people aged 65 and over were 33,656,000 (26.5% of the population) in 2015[11]. As the number of elderly people will reach a peak of 33.78 million in 2042, the percentage of elderly people will reach 39.9 % in 2060[12]. The number of ambulance dispatches was nearly 6.0 million in 2014 and this reflected a trend of increases over the previous 6 years[7]. Because of advances in aging and an increase in ambulance dispatches, the time from call to hospital arrival also seems to be increasing.

One recent study showed that the number of request calls to hospitals had greater odds of an on-scene arrival time of over 30 minutes[13]. However, the direct effect of the number of request calls on the time from call to hospital arrival is unclear. The aim of this study was to evaluate factors affecting the time to hospital arrival of ambulances, especially the effect of the number of request calls.

METHODS

This was a cross-sectional study. The data sources were an ambulance transportation records database (transportation database) and an ambulance request call records database (request call database) in Nara prefecture, Japan. These databases consist of information about patient characteristics, time and date of each call, and hospital arrival.

Our inclusion criteria were transportation and request calls made by patients 1) transported from 1 April 2013, to 31 March 2014, 2) aged 15 and older, and 3) with suspected illness related to internal medicine, trauma, orthopedics, neurosurgery, abdominal pain, surgery, cardiology, cardiopulmonary arrest (CPA), stroke, acute coronary syndrome (ACS), and disturbance of consciousness (DOC). Patients' suspected illnesses were categorized into 10 important illnesses and other categories after assessment by EMS staff. The ten important illnesses were categorized as the following patient situations: CPA, stroke, DOC, ACS, abdominal pain, trauma, perinatal problem, pediatrics, and psychiatric illness. We excluded patients with suspected illness related to perinatal problems, pediatrics, and psychiatric illness because the number of hospitals which accepted these kind of patients was very small. Other categories were classified as names of specialties: internal medicine, neurosurgery except for stroke or DOC, surgery except for abdominal pain, orthopedics except for trauma, and cardiology except for ACS, and so on. We excluded patients with suspected illnesses, except for suspected illnesses related to internal medicine, orthopedics, neurosurgery, surgery, and cardiology, because the number of patients with these kinds of illnesses was not large. Nara prefecture has established a medical cooperation system for ten important illnesses. Patients were categorized with "other category of illnesses" if they were not categorized into one of these important illnesses.

We excluded transportation and request calls from hospital to hospital and from clinic to hospital. We decided upon these inclusion criteria because these illnesses are important in terms of health policy and affect many patients. We excluded patients who took longer than 1000 minutes for finding hospitals, driving to a hospital, or transportation as outliers. We also excluded children because the number of hospitals with transportation of children is very small, and we would have needed to conduct a separate study for children as distinct from adults. We treated missing data as null.

Variables

Time and date of hospital arrival and each call (call for ambulance and request call), patient characteristics (age and sex), person calling ambulance, district where the EMS belongs, and patient's emergency status and category of suspicious illness were recorded by EMS staff or operation staff of the EMS. We divided patients into three groups and created a categorical variable of age: 1) ≥15, ≤59; 2) ≥60, ≤79; and 3) ≥80. We defined the seasons as spring from March to May, summer from June to August, autumn from September to November, and winter from December to February. We also defined noon from 8am to 3pm, early night from 4pm to 11pm, and midnight from 12am to 7am. In terms of ambulance control, Nara prefecture is divided into 13 areas and these areas were used as places where ambulance calls were made.

Outcome measures

The primary outcome measure was the time from the initial emergency call to hospital arrival, or more simply, the time from call for ambulance to hospital arrival.

Statistical methods

The main results are given as means and standard deviations (SD) or interquartile ranges (IQR). To estimate time from call to hospital arrival after removing unsuccessful request calls, we defined useless request calls as 1) request calls to hospitals displaying a sign of “Accepting patients” that resulted in failure, and 2) request calls to hospitals displaying a sign of “Not accepting patients” that resulted in failure. To conduct this estimation, we merged the transportation database and the request call database. When the time for a request call was longer than the time from call to hospital, we decided these were entered incorrectly and then excluded them from calculations.

To evaluate the effect of the number of request calls on time from call to hospital arrival, we employed multiple linear regression analysis. The predictive variables were selected on the basis of previous research. To evaluate differences between areas, we also conducted other multiple linear regression analyses, dividing patients into three groups depending on the area in terms of urbanization and location: 1) urban areas which are more urbanized than other areas (Areas U1, U2, U3, U4, U5, U6, and U7), 2) the East rural area which consists of areas located in the east side of Nara prefecture (Areas E1, E2, and E3), and 3) the south rural area which consists of areas located in the south side of Nara prefecture (Areas S1, S2, and S3).

Data analysis was conducted using the statistical software package R, version 3.2.2. Prior to the study, the study procedures were reviewed and approved (#E1023) by the ethics review committee of Kyoto University Graduate School of Medicine.

RESULTS

Participants

From April 2013 to March 2014, the number of transportations by ambulance was 43,663. The patient characteristics during the study period are shown in Table 1. These results are from the transportation database. Slightly less than one-third of patients were 80 years old or older, and 50% were female. The percentage of patients transported during the noon time period was 44.8%, which was a greater proportion than during other time categories. The number of patients in each area ranged from 723 to 11,223, and the mean was 3358.7 (first and third quartile were 1499 and 4060, respectively). The time from call to hospital arrival in each area ranged from 36.3 minutes to 72.6 minutes, and the mean was 48.2 minutes (first and third quartile were

41.2 and 53.1, respectively). Almost one-half of the patients were suspected of internal disease, and patients who were suspected of neurosurgical disease experienced longer times than others. Almost 70% of ambulances were called by family members or patients themselves. More than half of the patients were categorized into lower emergency situations. There were no remarkable differences across seasons or days of the week.

Table 1. Distribution of risk factors and association with transportation time

	n N = 43,663	%	Time from call to hospital arrival, mean (SD)
Age, years			
≥15, <60	14,125	32.4	45.1 (22.7)
≥60, <80	15,915	36.4	44.4 (20.2)
≥80	13,623	31.2	43.9 (19.8)
Sex			
Male	21,833	50.0	45.1 (21.7)
Female	21,830	50.0	43.8 (20.1)
Season			
Spring (March-May)	10,406	23.8	44.2 (20.1)
Summer (June-August)	11,187	25.6	43.5 (20.2)
Autumn (September-November)	10,741	24.6	44.5 (20.8)
Winter (December-February)	11,329	25.9	45.7 (22.4)
Day of the week			
Monday	6,627	15.2	43.5 (20.1)
Tuesday	6,133	14.0	43.8 (20.8)
Wednesday	5,838	13.4	43.9 (20.1)
Thursday	5,899	13.5	44.0 (20.8)
Friday	6,134	14.0	43.7 (20.0)

Saturday	6,436	14.7	45.8 (21.4)
Sunday	6,596	15.1	46.5 (22.7)
Time category at ambulance call			
Noon (8-15)	19,558	44.8	41.8 (19.4)
Early night (16-23)	15,862	36.3	45.9 (21.6)
Midnight (0-7)	8,243	18.9	48.1 (22.1)
Category of suspected illness			
Abdominal pain	1,072	2.5	45.9 (21.2)
CPA	984	2.3	43.6 (20.3)
Stroke	850	1.9	49.9 (22.1)
ACS	686	1.6	42.6 (16.9)
DOC	498	1.1	47.6 (19.5)
Trauma	6,158	14.1	46.4 (21.4)
Internal medicine	21,197	48.5	42.3 (19.8)
Orthopedics except for trauma	5,895	13.5	45.5 (22.3)
Neurosurgery except for stroke and DOC	4,254	9.7	50.4 (22.4)
Surgery except for abdominal pain	1,066	2.4	42.6 (21.7)
Cardiology except for ACS	1,003	2.3	44.9 (20.4)
Person calling ambulance			
Family or self	27,041	70.3	44.4 (20.6)
Witness	9,501	24.7	44.9 (21.8)
Welfare facility	1,906	5.0	42.3 (19.6)
Emergency status at request call			
Less urgency	25,535	58.5	45.3 (21.0)
Urgency	5,243	12.0	45.8 (20.9)
Emergency	2,659	6.1	46.4 (22.0)
Resuscitation	241	0.6	42.4 (18.0)
Mid-assessment	9,983	22.9	41.4 (20.1)

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

Components of the time from call to hospital admission

Figure 1 shows components of the time from call to hospital admission from the transportation database. Our database did not include the time from completion of request calls to leaving the scene or the time from getting into the hospital and delivering a patient to hospital staff (hospital arrival for patient). It took 11.2 minutes to evaluate the patient, on average. A shaded area shows the time from the beginning to the ending of request calls. It took 9.0 min to find the hospital to which a patient was transferred at the scene.

Time and the number of request calls

The mean time from call to hospital arrival was 44.5 min, and the mean number of requests was 1.8. Table 2 shows the relationship between the number of request calls for each transport and the time from call to hospital arrival using the transportation database. It shows the more request calls made, the more time spent from call to hospital arrival.

Table 2. The number of request calls and time from call to hospital arrival for each patient

	n		Time from call to hospital arrival		
Number of request calls	N = 43,663	%	Mean	Median	1st Qu-3rd Qu
1	29,499	67.6	38.2	35.0	29.0-44.0
2	6,302	14.4	47.8	45.0	37.0-54.0
3	3,150	7.2	55.1	52.0	43.0-62.0
4	1,816	4.2	61.2	58.0	49.0-70.0

5	971	2.2	68.9	66.0	55.0-78.0
6	625	1.4	73.0	69.0	59.0-82.0
7	395	0.9	79.5	76.0	65.0-89.0
8	278	0.6	81.5	79.0	67.3-91.8
9	173	0.4	92.6	89.0	73.0-104.0
10	126	0.3	90.8	90.5	74.3-105.0
≥11	328	0.8	109.6	102.5	86.0-122.2

Request call: request call to hospital for transportation, Qu: quantile

Table 3 shows the numbers and the times for request calls, categorized by hospital situations and request results. There were 80,666 request calls for 43,663 transportations. The number of useless request calls was 36,403 (44.5%) and these took almost 230,000 minutes total. After calculations excluding request calls whose duration was longer than the time from call to hospital, there were no significant differences in the time for one request call between categories. When the mean time from call to hospital arrival was calculated without useless request calls, it was shortened by 3.5 minutes.

Table 3. The numbers and times for request calls, categorized by hospital situations and request results

	Number of request calls N = 80,066	N = 79,693*	
	n (%)	n (%)	Time for one request call, mean (SD)*

Request call for "ACCEPTING" hospital resulted in success	32,416 (40.5)	32,416 (40.7)	4.9 (3.4)
Request call for "NOT ACCEPTING" hospital resulted in success	11,247 (14.0)	11,247 (14.1)	4.5 (3.9)
Request call for "ACCEPTING" hospital resulted in failure	24,902 (31.1)	24,629 (30.9)	4.2 (3.1)
Request call "NOT ACCEPTING" hospital resulted in failure	11,501 (14.4)	11,401 (14.3)	4.2 (3.5)

SD: standard deviation, request call: request call to hospital for transportation, ACCEPTING: announced accepting ambulances for emergency medical services, NA: not applicable because of missing referral result

*: This result was from those request calls whose duration was not longer than the time from call to hospital.

Main results

We used a multiple linear regression model to describe time from call to hospital arrival. In this model, 44% of the variation was explained by the parameters age, sex, season, day of the week, time, area, category of suspicious illness, person calling ambulance, emergency status at request call, and the number of request calls (see Table 4). We found that the number of request calls affects time from call to hospital arrival (β= 6.3, p<0.001). We also found an association between time from call to hospital arrival and age, sex, season, and person calling ambulance. From the analyses dividing patients into three groups depending on the area, the south rural area took much longer times in neurosurgery, stroke, trauma, ACS, orthopedics, and cardiology, with reference to internal medicine, than the urban area, and it was prolonged 11.5, 10.0, 10.0, 9.9, 9.2, and 9.2 minutes, respectively. (See Supplementary Table 1). The east rural area took a much longer time in neurosurgery and trauma, with reference to internal medicine, than the urban area, and it was prolonged 9.1 and 8.1 minutes, respectively. The time in the south rural area was longer than in other areas.

Table 4. Time from call to hospital arrival: Multiple linear regression model

Explanatory valuable	Estimate (95%CI)	P-value	AIC	Radj2
Intercept	27.5 (26.5, 28.5)		211,448	0.44
Age				
≥15, <60	(ref)			
≥60, <80	1.14 (0.75, 1.53)	<0.001		
≥80	0.94 (0.52, 1.36)	<0.001		
Sex				
Female	(ref)			
Male	0.64 (0.32, 0.96)	<0.001		
Season				
Spring (March-May)	(ref)			
Summer (June-August)	-0.50 (-0.94, -0.05)	0.028		
Autumn (September-November)	0.57 (0.12, 1.02)	0.012		
Winter (December-February)	0.98 (0.54, 1.42)	<0.001		
Day of the week				
Monday	(ref)			
Tuesday	-0.38 (-0.96, 0.20)	0.20		
Wednesday	-0.18 (-0.77, 0.41)	0.55		
Thursday	0.31 (-0.28, 0.90)	0.30		
Friday	-0.16 (-0.74, 0.42)	0.59		
Saturday	0.71 (0.13, 1.28)	0.016		
Sunday	1.1 (0.48, 1.63)	<0.001		

Time category at ambulance call		
Noon (8-15)	(ref)	
Early night (16-23)	1.9 (1.58, 2.29)	<0.001
Midnight (0-7)	2.9 (2.49, 3.38)	<0.001
Area		
U1	(ref)	
U2	-6.7 (-7.4, -6.0)	<0.001
U3	-5.3 (-6.0, -4.6)	<0.001
U4	0.50 (-0.55, 1.6)	0.35
U5	-2.5 (-3.1, -1.9)	<0.001
U6	-5.4 (-5.9, -4.8)	<0.001
U7	-5.6 (-6.3, -4.9)	<0.001
E1	2.8 (2.0, 3.6)	<0.001
E2	15.9 (15.0, 16.7)	<0.001
E3	-1.4 (-2.0, -0.74)	0.01
S1	12.1 (11.2, 13.0)	<0.001
S2	26.1 (24.8, 27.3)	<0.001
S3	3.4 (2.4, 4.5)	<0.001
Category of suspected illness		
Abdominal pain	-0.93 (-2.0, 0.12)	0.082
CPA	0.06 (-1.0, 1.2)	0.92
Stroke	6.2 (5.1, 7.3)	<0.001
ACS	1.4 (0.14, 2.7)	0.03
DOC	3.7 (2.2, 5.2)	0.0038
Trauma	3.8 (3.3, 4.3)	<0.001
Internal medicine	(ref)	
Orthopedics except for trauma	2.7 (2.2, 3.2)	<0.001
Neurosurgery except for stroke and DOC	7.4 (6.8, 7.9)	<0.001
Surgery except for abdominal pain	-0.08 (-1.1, 0.97)	0.89
Cardiology except for ACS	5.0 (4.0, 6.1)	<0.001
Person calling ambulance		
Family or self	(ref)	
Witness	1.7 (0.95, 2.5)	<0.001
Welfare facility	2.4 (1.6, 3.2)	<0.001
Emergency status at request call		

Less urgency	(ref)	
Urgency	0.59 (0.08, 1.1)	0.022
Emergency	-0.16 (-0.86, 0.54)	0.66
Resuscitation	-1.8 (-4.0, 0.40)	0.11
During assessment	-1.5 (-2.0, -1.1)	<0.001
The number of request calls, mean (SD)	6.3 (6.2, 6.4)	<0.001

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

DISCUSSION

In this cross-sectional study, we evaluated the effect of the number of request calls to the time from call to hospital arrival. This study indicated that the time from call to hospital arrival would decrease by 4.6 minutes if all useless request calls were eliminated. Time from call to hospital arrival increases by 6.3 minutes for every request call from EMS to hospital, after adjusting for other variables. Time from call to hospital arrival is also related to age, sex, season, and person calling the ambulance.

Regarding the category of suspicious illness, abdominal pain is associated with the shortest transport time, followed by surgery. The Ministry of Health, Labour and Welfare asked the prefecture governments to establish medical cooperation systems for five diseases: acute myocardial infarction, stroke, cancer, diabetes mellitus, and psychiatric illness[14]. Nara prefecture established a medical cooperation system for

CPA, stroke, DOC, ACS, abdominal pain, trauma, perinatal problems, pediatrics, and psychiatric illness. In spite of national and prefectural efforts, ACS and stroke calls took 1.4 minutes and 6.2 minutes longer in transportation time compared to Internal medicine. Both acute coronary syndrome and stroke are diseases where time from onset to hospital arrival is important for treatment and outcome[15–17]. A shortage of appropriate healthcare facilities in the region might be the reason for prolonged times from call to hospital arrival for these diseases. Further research focusing on specific diseases or time series might be needed.

This study revealed that there is up to an approximately 30-minute difference in the time from call to hospital arrival among areas in the same prefecture (36.3 minutes in the shortest area and 72.6 min in the longest area). Nara is a prefecture that has a long north-south axis. There are three tertiary emergency hospitals in Nara prefecture, but all of them are located in urban areas (Areas U1, U3, and U6) that are far from the southern rural area. The southern area (Areas S1, S2, and S3) had longer transportation times than the other areas. In the southern area, categories of illnesses that seemed to need special facilities took longer times than in other areas. The distance from emergency hospital and appropriate healthcare facilities might be the cause of this difference between areas. One observational study discussed the shortage of emergency medical facilities in rural areas in Japan[18]. One geographical study pointed out that there was a regional gap in the number of tertiary care centers per million people between prefectures in Japan[19].

Our results also indicate that there are differences in transportation times for specific diseases among regions. In southern rural areas, there were longer transportation times for diseases which needed treatment by specialists such as cardiologists, neurologists, neurosurgeons, and orthopedists than in the other two areas. This might be associated with the shortage of medical facilities for specific illnesses in these regions. Indicating disease-specific problems that are specific to each area is helpful information for improving health care systems and is also a strength of our study.

Our database did not include socioeconomic information of patients, except for the person who called an ambulance. In the field of acute myocardial infarction and stroke, it is known that time from onset of symptoms to hospital arrival are influenced by many other factors such as living alone[20], being alone at onset of symptoms[21,22], being a nonwhite patient in the United States [23], and education level[24]. But, there are very few studies about the relationship between time from call to hospital arrival and socioeconomic factors. A cohort study showed only small statistically significant delays in time from call to hospital arrival in patients living in poorer communities and those of black race[25]. We think information about the person who called an ambulance would help to indicate the socioeconomic status of patients to some degree.

In our study, we found there are no substantial differences in time between days of the week or seasons. One study in Tennessee, USA, found that the prolongation of transportation time was influenced by seasons due to variations in traffic volume[26]. However, transportation conditions were completely different between these two regions and this might be one reason for differences in results between these two studies.

Our study revealed that time from call to hospital arrival increases by 6.3 minutes for every request call from EMS to hospital. Driving ambulances at high speed[27], helicopter transportation[28–30] and centralization of hospitals[31] might be solutions to reduce transportation time. However, the risk of traffic accidents[32], costs for helicopter emergency medical services[33,34], and time and cost for centralizing hospitals are difficult problems to solve. Hence, it seems important to create a system for determining hospital admissions more quickly. As emergency transport systems are managed by local governments, local governments ought to create a system to share information about hospitals and emergency patients more promptly. One recent cross-sectional study showed that services with tablet computers shortened the transportation time in Saga prefecture, Japan[35]. Even though there is no information about time from call to hospital arrival in this study, introducing these support systems would reduce time from call to hospital arrival or transportation time. In prefectures, such as Nara prefecture, where a support system with tablet computers was introduced, creating a more effective and convenient system is needed.

It was revealed that more than 45% of all request calls and 43 % of request calls to hospitals displaying a sign of “Accepting patients” result in failure. For physicians, they are required not only to accept patients if requested but also to display the hospital capacity for emergency patients appropriately. As the shortage of physicians is also discussed in Japan[36], effective posting of physicians and efficient working systems are needed.

Our study has several limitations. First, patient emergency status was decided by ambulance crew. Our data does not include vital signs for all patients, because ambulance crews are required to register vital signs of patients for only a limited number of suspected illnesses. We cannot analyze patient emergency status using vital signs. As ambulance crews assessed patients by rules depending on patient’s vital signs and they were also trained under the medical control system[5], the decisions made by ambulance crew were viewed as credible.

Second, our data consisted of patients in Nara prefecture. Nara prefecture is one of 47 prefectures in Japan. Our results may not be applicable to all prefectures in Japan. However, there is a discrepancy in urbanization between urbanized areas and mountainous areas such as the southern area. Therefore, we can discuss the differences between areas within one prefecture.

Conclusions

The study revealed 6.3 additional minutes were added to transportation time by every refusal of a request call and also revealed disease-specific delays among specific areas. A system that helps EMS to find hospitals should be effectively established to share information about hospitals and emergency patients promptly in partnership with policy makers and physicians for reducing the time from call to hospital arrival.

Contributors

NH has had the main responsibility for calculating statistics and writing the paper. YI is the principal investigator for the project, has planned the present paper jointly with NH, and has actively taken part in revising the paper. KY and SK have taken part in planning and analyzing data and revising paper.

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Competing interests

Kyoto University Department of Healthcare Economics and Quality Management had a financial contract with Nara prefecture to support analysis of its healthcare system. This study is out of the scope of the contract, and is not financed by Nara prefecture. Otherwise, all authors declare no financial relationships that are potentially relevant to this article.

Ethical approval

This study was approved by the Ethical Committee, Kyoto University Graduate School of Medicine, Japan

Data sharing statement

No additional data are available for sharing, because of data sharing policy.

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Legend of Figure 1

Figure 1. Components of time from call to hospital admission

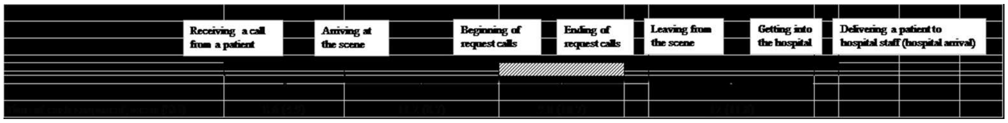

Figure 1. Components of time from call to hospital admission

314x36mm (96 x 96 DPI)

Supplement table 1. Difference between the areas of time from call to hospital arrival: Multiple linear regression model

	Urban area (n = 32657)		East rural area (n = 7661)		South rural area (n = 3345)	
Explanatory valuable	Estimate (95%CI)	P-value	Estimate (95%CI)	P-value	Estimate	P-value
Intercept	29.7 (28.6, 30.7)	<0.001	30.8 (28.3, 33.3)	<0.001	27.4 (22.0, 32.7)	
Category of suspicious illness						
Abdominal pain	-0.74 (-1.9, 0.41)	0.21	-1.5 (-3.6, 0.57)	0.15	1.9 (-4.1, 8.0)	0.53
CPA	-1.2 (12.4, -0.029)	0.044	4.6 (2.3, 6.8)	0.048	-0.12 (-6.6, 6.4)	0.97
Stroke	6.4 (5.1, 7.7)	<0.001	5.9 (3.8, 8.0)	0.0011	9.9 (0.54, 17.8)	0.0038
ACS	0.26 (-1.2, 1.8)	0.73	2.1 (-0.21, 4.4)	0.075	10.0 (3.5, 16.6)	0.0027
DOC	3.8 (2.0, 5.5)	0.01	4.4 (1.9, 7.0)	0.00065	4.7 (-6.2, 15.6)	0.40
Trauma	1.8 (1.2, 2.3)	<0.001	8.1 (7.1, 9.2)	<0.001	10.0 (6.7, 13.2)	<0.001
Internal medicine	(ref)		(ref)		(ref)	
Orthopedics except for Trauma	1.5 (1.0, 2.0)	<0.001	4.5 (3.2, 5.7)	<0.001	9.2 (6.2, 12.1)	<0.001
Neurosurgery except for Stroke and DOC	6.6 (6.0, 7.1)	<0.001	9.1 (7.7, 10.5)	<0.001	11.5 (8.0, 14.9)	<0.001
Surgery except for Abdominal pain	-0.081 (-1.1, 0.98)	0.88	-0.34 (-3.3, 2.6)	0.82	-0.48 (-6.6, 5.6)	0.88
Cardiology except for ACS	4.4 (3.4, 5.4)	<0.001	5.5 (1.9, 9.1)	0.0025	9.2 (0.54, 17.8)	0.37

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest,
DOC: disturbance of consciousness, referral call: referral call to hospital for transportation

Urban area, East rural area, and South rural area consists of 7, 3 and 3 areas respectively.
This table shows only the result of Category of suspicious illness.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract - p3 in abstract and p7 in METHODS
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found – p3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported -p6
Objectives	3	State specific objectives, including any prespecified hypotheses – p7
Methods		
Study design	4	Present key elements of study design early in the paper – p7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection –p7-8
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants - p7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – p9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group –p7
Bias	9	Describe any efforts to address potential sources of bias – p8
Study size	10	Explain how the study size was arrived at – p7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why - p10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding –p10
		(*b*) Describe any methods used to examine subgroups and interactions –p10
		(*c*) Explain how missing data were addressed –p9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy – p10
		(*e*) Describe any sensitivity analyses –p10

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed –p11
		(b) Give reasons for non-participation at each stage –p11
		(c) Consider use of a flow diagram – no use
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders –p11
		(b) Indicate number of participants with missing data for each variable of interest-p12 table1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure -p12
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included-p16
		(*b*) Report category boundaries when continuous variables were categorized –p12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period – noentry because
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses –p16 and supplement table 1
Discussion		
Key results	18	Summarise key results with reference to study objectives - p19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias –p23
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence –p19
Generalisability	21	Discuss the generalisability (external validity) of the study results –p23
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based –p24

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The effect of the number of request calls on the time from call to hospital arrival: a cross-sectional study of an ambulance record database in Nara prefecture, Japan

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Keywords: emergency medical service, transportation time, request call

Word count: 3728 words

ABSTRACT

Objectives: In Japan, ambulance staff sometimes must make request calls to find hospitals that can accept patients because of an inadequate information sharing system. This study aimed to quantify effects of the number of request calls on the time interval between an emergency call and hospital arrival.

Design and Setting: A cross-sectional study of an ambulance records database in Nara prefecture, Japan.

Cases: A total of 43,663 patients (50% women; 31.2% aged 80 and over) 1) transported by ambulance from April, 2013 to March, 2014, 2) aged 15 and over, and 3) with suspected major illness.

Primary outcome measures: The time from call to hospital arrival, defined as the time interval from receipt of an emergency call to ambulance arrival at a hospital.

Results: The mean time interval from emergency call to hospital arrival was 44.5 minutes, and the mean number of requests was 1.8. Multilevel linear regression analysis showed that approximately 43.8% of variations in transportation times were explained by patient age, sex, season, day of the week, time, category of suspected illness, person calling for the ambulance, emergency status at request call, area, and number of request calls. A higher number of request calls was associated with longer time intervals to hospital arrival (addition of 6.3 minutes per request call; $p<0.001$). In an analysis dividing areas into three groups, there were differences in transportation time for diseases needing cardiologists, neurologists, neurosurgeons, and orthopedists.

Conclusions: The study revealed 6.3 additional minutes needed in transportation time for every refusal of a request call, and also revealed disease-specific delays among specific areas. An effective system should be collaboratively established by policymakers and physicians to ensure the rapid identification of an available hospital for patient transportation in order to reduce the time from the initial emergency call to hospital arrival.

Strength and Limitations of this study

- A strength of this study is that it examined a large database of patients transported by ambulance that included detailed information about the number of request calls and the time for transportation in Nara prefecture, Japan.
- This study suggested that one refusal of a request call extended the time from call to hospital arrival by 6.3 minutes.
- This study revealed that there is up to approximately a 30-minute difference between areas in the time from call to arrival and specifically pointed out disease-specific delays among specific areas.
- Limitations of this study were that patient emergency status was decided by ambulance crew and our data consisted of patients from one prefecture in Japan.

[INTRODUCTION]

A request for the delivery of an emergency patient is sometimes rejected, and this is a social problem in Japan[1–4]. In Japan, the emergency transport system is managed by local governments[1,5,6]. Each prefecture establishes a medical care system to provide care to several medical care zones, each of which consists of several districts. Patients who require ambulance transport to hospitals can call for emergency services by dialing ('119'). The emergency call is directly received by the local fire defense headquarters, and the nearest available ambulance is dispatched to the patient[6]. Ambulance crews, who are trained paramedics belonging to the local fire departments, assess patients in accordance with local protocols that are based on national protocols[4]. After arriving on scene, an ambulance crew would first assess the patient and provide emergency medical treatment if required. Subsequently, the crew determines the most appropriate hospitals for the patient, and places request calls to these hospitals while still at the scene[4]. The patient is then transported by ambulance for free to the nearest emergency hospital that agrees to treat the patient. Emergency hospitals in Japan are classified into three levels: primary, secondary, and tertiary[1]. According to Article 19 of the Medical Practitioners' Law, physicians are unable to refuse patients without good reason.

The national average of the time from calling an ambulance to hospital arrival was 39.4 minutes in 2014, is increasing every year[7], and is a known predictor of outcomes of acute heart failure[8] and head trauma[9]. Japan has the most rapidly aging population in the world[10], and it is estimated that people aged 65 and over were 33,656,000 (26.5% of the population) in 2015[11]. As the number of elderly people will reach a peak of 33.78 million in 2042, the percentage of elderly people will reach 39.9 % in 2060[12]. The number of ambulance dispatches was nearly 6.0 million in 2014 and this reflected a trend of increases over the previous 6 years[7]. Because of rapidly aging population and an increase in ambulance dispatches, the time from call to hospital arrival will invariably increase unless major changes are implemented in the emergency care and resource distribution systems.

One recent study showed that the number of request calls to hospitals had greater odds of an on-scene arrival time of over 30 minutes[13]. However, the direct effect of the number of request calls on the time from call to hospital arrival is unclear. The aim of this study was to evaluate factors affecting the time to hospital arrival of ambulances, especially the effect of the number of request calls.

METHODS

Data and setting

This was a cross-sectional study. The data sources were an ambulance transportation records database (transportation database) and an ambulance request call records database (request call database) in Nara prefecture, Japan. The location and map of Nara prefecture are shown in Supplement Figure 1. The prefectural population was 1.36 million in 2015, with a population density of 369 per square kilometer[14]. Most of the prefecture is covered by mountains and forests, with the exception of the northwest area. Nara prefecture consists of five medical areas; there are almost 70 hospitals within the prefecture, three of which are tertiary hospitals[15][16]. All hospitals are requested to indicate admission acceptability according to patient severity and category of suspected illnesses by displaying this information in a web system.

The transportation database consists of information about patient characteristics, date and time of each call and hospital arrival, and time for each component of transportation (except for the time from the end of a request call to leaving the scene and the time from entering a hospital to delivering a patient to hospital staff [hospital arrival]). The request call database consists of information about patient characteristics, date and time of call for the suspected illness, name of hospital accepting request calls, whether or not the hospital indicated the admission acceptability of patients, and the result of the request call. In Nara prefecture, ambulance crews have a tablet-type portable computer for searching hospital statuses with regard to admission acceptability. Using these computers, the crew members input the date and time of each action for transportation and the assessment results (such as each patient's emergency situation and suspected illnesses).

Nara prefecture has established a medical cooperation system for these ten important illnesses through the formation of a medical institution network in order to provide coordinated care for patients. Under this system, patient emergency situations are categorized into five levels, and suspected illnesses are categorized into ten important illnesses and other categories. These categories are assessed by ambulance crews based on designated criteria and protocols. The ten important illnesses are categorized as follows: cardiopulmonary arrest (CPA), stroke, disturbance of consciousness (DOC), acute coronary syndrome (ACS), abdominal pain, trauma, sever burn, perinatal problem, pediatrics, and psychiatric illness. The other categories are classified according to medical specialties, including internal medicine, neurosurgery except for stroke or DOC, surgery except for abdominal pain, orthopedics except for trauma, and cardiology except for ACS. Patients were categorized into the "other category" if they were not categorized into one of these important illnesses.

Inclusion and exclusion criteria

Our inclusion criteria were transportation and request calls made by patients 1) transported from 1 April 2013, to 31 March 2014, 2) aged 15 and older, and 3) with suspected illness related to internal medicine, trauma, orthopedics, neurosurgery, abdominal pain, surgery, cardiology, cardiopulmonary arrest (CPA), stroke, acute coronary syndrome (ACS), and disturbance of consciousness (DOC). Patients' suspected illnesses were categorized into 10 important illnesses and other categories after assessment by EMS staff. The ten important illnesses were categorized as the following patient situations: CPA, stroke, DOC, ACS, abdominal pain, trauma, perinatal problem, pediatrics, and psychiatric illness. We excluded patients with suspected illness related to perinatal problems, pediatrics, and psychiatric illness because the number of hospitals which accepted these kind of patients was very small. We also excluded patients with suspected illnesses, except for those concerning internal medicine, orthopedics, neurosurgery, surgery, and cardiology, due to the low number of patients with these illnesses.

We excluded transportation and request calls from hospital to hospital and from clinic to hospital. We decided upon these inclusion criteria because these illnesses are important in terms of health policy and affect many patients. We excluded patients who took longer than 1000 minutes for finding hospitals, driving to a hospital, or transportation as outliers. We also excluded children because the number of hospitals with transportation of children is very small, and we would have needed to conduct a separate study for children as distinct from adults. We treated missing data as null values, while the cases retained in the analysis.

Variables

Date and time of hospital arrival, time from arrival on scene to the beginning of request calls, time from the beginning of request calls to the ending of the calls, time from the ending of the calls to hospital arrival, time from leaving the scene to hospital arrival, patient characteristics (age and sex), person calling ambulance, registered district of the EMS, and patient's emergency status and category of suspected illness as recorded by on-scene EMS staff or operational staff at the local fire defense headquarters. We divided patients into three groups according to age: 1) 15 to ≤59 years, 2) 60 to 79 years, and 3) 80 years or more; the cut-off at 60 years was selected as it is the traditional retirement age in Japan. We defined the seasons as spring from March to May, summer from June to August, autumn from September to November, and winter from December to February. We also defined noon from 8am to 3pm, early night from

4pm to 11pm, and late night from 12am to 7am. We defined on-scene time as the sum of the time from arrival on scene to the beginning of a request call and the time from the beginning of the request call to the ending of the call. With regard to ambulance administration, Nara prefecture is divided into 13 districts that were used to identify the places where ambulance calls were made.

Primary outcome measure

The primary outcome measure was the time from the initial emergency call by the patients to hospital arrival, i.e., the time from the call for an ambulance to hospital arrival.

Statistical methods

The main results were calculated as means and standard deviations (SD), and the baseline patient characteristics were compared using Student's t-test or the Kruskal-Wallis test. First, to estimate the effect of increasing the number of request calls on the time from call to hospital arrival, we conducted the Jonckheere-Terpstra trend test.

Second, in order to estimate the time from request call to hospital arrival after excluding unsuccessful request calls, we defined unsuccessful request calls as 1) request calls to hospitals indicated as “Accepting patients” that resulted in failure, and 2) request calls to hospitals indicated as “Not accepting patients” that resulted in failure. To conduct this estimation, we merged the transportation database and the request call database. When the time for a request call was longer than the time from call to hospital in request call database, we decided these were entered incorrectly and then excluded them from calculations.

Third, to evaluate the effect of the number of request calls on time from call to hospital arrival, we conducted a multilevel linear regression analysis with random effects to correct for patient clustering in the districts. The predictive variables were selected on the basis of previous research[17–23]. We also conducted a subgroup analysis for on-scene time and time from leaving the scene to hospital arrival.

Lastly, to evaluate differences in the time from request call to hospital arrival among various types of areas, we also conducted other multilevel linear regression analyses, where patients were divided into the following three groups depending on the level of urbanization and location of the registered district of the EMS: 1) urban area, which encompasses seven districts that are more urbanized than other areas in Nara prefecture (population was 1.08 million and the population density was 1,578 per square kilometer in 2015), 2) the eastern t rural area, which consists of three districts located in the east side of Nara prefecture (population was 0.21 million and the population density was 319 per square kilometer in 2015), and 3) the southern rural area, which consists of three districts located in the south side of Nara prefecture (population was 0.07 million and the population density was 30.9 per square kilometer in 2015).

Data analysis was conducted using the statistical software package R, version 3.2.2. Prior to the study, the study procedures were reviewed and approved (#E1023) by the ethics review committee of Kyoto University Graduate School of Medicine.

RESULTS

Cases

From April 2013 to March 2014, the number of transportations by ambulance was 43,663. The mean time from request call to hospital arrival was 44.5 (SD: 20.9) minutes. The distribution of risk factors and their association with transportation time are shown in Table 1. Slightly less than one-third of patients were 80 years old or older, and 50% were female. The percentage of patients transported during the noon time period was 44.8%, which was a greater proportion than during other time categories. The number of patients in each area ranged from 723 to 11,223, and the mean was

3358.7 (first and third quartile were 1499 and 4060, respectively). The time from call to hospital arrival in each district ranged from 36.3 minutes to 72.6 minutes, with a mean time of 48.2 minutes (the first and third quartiles were 41.2 and 53.1, respectively; data not shown). Almost one-half of the patients were suspected of internal disease, and patients who were suspected of neurosurgical disease experienced longer times than others. Almost 70% of ambulances were called by family members or patients themselves. More than half of the patients were categorized into lower emergency situations. There were no remarkable differences across seasons or days of the week.

Table 1. Risk Factors Distribution and Association with transportation time

	n N = 43,663	%	Time from call to hospital arrival, mean (SD)	P-value
Age,y				
≥15, <60	14,125	32.4	45.1 (22.7)	
≥60, <80	15,915	36.4	44.4 (20.2)	
≥80	13,623	31.2	43.9 (19.8)	<0.001*
Sex				
Male	21,833	50.0	45.1 (21.7)	
Female	21,830	50.0	43.8 (20.1)	<0.001†
Season				
Spring (March-May)	10,406	23.8	44.2 (20.1)	
Summer (June-August)	11,187	25.6	43.5 (20.2)	
Autumn (September-November)	10,741	24.6	44.5 (20.8)	
Winter (December-February)	11,329	25.9	45.7 (22.4)	<0.001*
Day of the week				
Monday	6,627	15.2	43.5 (20.1)	
Tuesday	6,133	14.0	43.8 (20.8)	

Wednesday	5,838	13.4	43.9 (20.1)	
Thursday	5,899	13.5	44.0 (20.8)	
Friday	6,134	14.0	43.7 (20.0)	
Saturday	6,436	14.7	45.8 (21.4)	
Sunday	6,596	15.1	46.5 (22.7)	<0.001†
Time category at ambulance call				
Noon (8-15)	19,558	44.8	41.8 (19.4)	
Early night (16-23)	15,862	36.3	45.9 (21.6)	
Late night (0-7)	8,243	18.9	48.1 (22.1)	<0.001†
Category of suspected illness				
Abdominal pain	1,072	2.5	45.9 (21.2)	
CPA	984	2.3	43.6 (20.3)	
Stroke	850	1.9	49.9 (22.1)	
ACS	686	1.6	42.6 (16.9)	
DOC	498	1.1	47.6 (19.5)	
Trauma	6,158	14.1	46.4 (21.4)	
Internal medicine	21,197	48.5	42.3 (19.8)	
Orthopedics except for Trauma	5,895	13.5	45.5 (22.3)	
Neurosurgery except for Stroke and DOC	4,254	9.7	50.4 (22.4)	
Surgery except for Abdominal pain	1,066	2.4	42.6 (21.7)	
Cardiology except for ACS	1,003	2.3	44.9 (20.4)	<0.001†
Person calling ambulance				
Family or self	27,041	70.3	44.4 (20.6)	
Witness	9,501	24.7	44.9 (21.8)	
Welfare facility	1,906	5.0	42.3 (19.6)	<0.001†
Emergency status at request call				
Less urgency	25,535	58.5	45.3 (21.0)	
Urgency	5,243	12.0	45.8 (20.9)	
Emergency	2,659	6.1	46.4 (22.0)	
Resuscitation	241	0.6	42.4 (18.0)	
During assessment	9,983	22.9	41.4 (20.1)	<0.001†

* P-value by Student t-test

† P-value by Kruskal-Wallis test

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

The detailed information about each area are not available for disclosing, because of data sharing policy.

Components of the time from call to hospital admission

Figure 1 shows components of the time from call to hospital admission from the transportation database. It took 21.5 (13.8) minutes on scene, on average. It took 14.3 (13.8) minutes from the scene to hospital arrival.

Time and the number of request calls

The mean time from call to hospital arrival was 44.5 min, and the mean number of requests was 1.8. Table 2 shows the relationship between the number of request calls for each transport and the time from call to hospital arrival using the transportation database. It shows the more request calls made, the more time spent from call to hospital arrival.

Table 2. The number of request call and time from call to hospital arrival for each patient

The number of request call	n N = 43,663	%	Time from call to hospital arrival mean (SD)	P-value
1	29,499	67.6	38.2 (16.2)	
2	6,302	14.4	47.8 (16.9)	
3	3,150	7.2	55.1 (18.4)	
4	1,816	4.2	61.2 (19.3)	
5	971	2.2	68.9 (20.7)	
6	625	1.4	73 (21.2)	

7	395	0.9	79.5 (23.5)	
8	278	0.6	81.5 (20.8)	
9	173	0.4	92.6 (29.2)	
10	126	0.3	90.8 (25.4)	
≥11	328	0.8	109.6 (25.9)	<0.001*

* P-value by Jonckheere-Terpstra trend test

request call: request call to hospital for transportation,

Qu: quantile, request call: request call to hospital for transportation

Table 3 shows the number and the time for request call categorized by hospital displayed acceptability and request results. There were 79,693 request calls for 43,663 transportations. The number of useless request calls was 36,030 (45.2 %) and these took more than 150,000 minutes total. The number of request calls to hospital displayed “Not accepting patients” was 22,648 (28.4%) and 11,401 (50.3%) request call were resulted in failure. When the mean time from call to hospital arrival was calculated without unsuccessful request calls, it was shortened by 3.5 minutes.

Table 3. The number and the time for request call categorized by hospital displayed acceptability and request results

Hospital Displayed Admission Acceptability	Result	Number of request call n (%) N = 79,693	Time for one request call, mean (SD)	P-value *
Accepting patients	Success	32,416 (40.7)	4.9 (3.4)	
Not accepting patients	Success	11,247 (14.1)	4.5 (3.9)	

Accepting patients	Failure	24,629 (30.9)	4.2 (3.1)	
Not accepting patients	Failure	11,401 (14.3)	4.2 (3.5)	<0.001†

* P-value by Kruskal-Wallis test

SD: standard deviation, request call: request call to hospital for transportation
ACCEPTABLE : announce accepting ambulance for emergency medical service

Main results

We conducted a multilevel linear regression analysis to describe time from call to hospital arrival. In this model, 44% of the variation was explained by the parameters age, sex, season, day of the week, time, area, category of suspected illness, person calling ambulance, emergency status at request call, and the number of request calls (see Table 4 and Supplement Table 1). The model that did not include the variable "the number of request calls" was only able to explain 11% of the observed variations (see Supplement Table 2). We found that the number of request calls affected time from call to hospital arrival (β= 6.3, $p<0.001$), which indicated that a refusal of a request call extended the time from call to hospital arrival by 6.3 minutes. We also observed associations between time from call to hospital arrival and age, sex, season, and person calling ambulance. In the subgroup analysis, we found that the number of request calls affected on-scene time (β= 5.3, $p<0.001$) and time from leaving the scene to hospital arrival (β= 1.6, p<0.001).

From the analyses dividing patients into three groups according to the location of the registered district of the EMS, the mean transportation times in the urban area, eastern rural area, and southern rural area were 42.1 (SD: 18.5), 48.6 (SD: 21.7), 57.8 (SD: 31.9), respectively. The southern rural area had much longer transportation times than other two areas. When compared with internal medicine, longer transportation times were observed for neurosurgery (+11.5 minutes), stroke (+9.9 minutes), trauma (+10.0 minutes), ACS (+10.0 minutes), orthopedics (+9.2 minutes), and cardiology (+9.2 minutes) in the southern rural area. (See Supplementary Table 3). The eastern rural area took a much longer time in neurosurgery and trauma, with reference to internal medicine, than the urban area, and it was prolonged 9.1 and 8.1 minutes, respectively.

Table 4. Time from Call to hospital arrival: multilevel linear regression analysis

Explanatory valuable	Estimate (95%CI)	P-value
Intercept	30.1 (24.5, 35.6)	
Fixed effects		
Age		
≥15, <60	(ref)	
≥60, <80	1.14 (0.75, 1.53)	<0.001
≥80	0.94 (0.52, 1.36)	<0.001
Sex		
Female	(ref)	

Male	0.64 (0.32, 0.96)	<0.001
Season		
Spring (March-May)	(ref)	
Summer (June-August)	-0.50 (-0.95, -0.05)	0.028
Autumn (September-November)	0.57 (0.12, 1.02)	0.012
Winter (December-February)	0.98 (0.54, 1.42)	<0.001
Day of the week		
Monday	(ref)	
Tuesday	-0.38 (-0.96, 0.20)	0.20
Wednesday	-0.18 (-0.77, 0.41)	0.55
Thursday	0.31 (-0.28, 0.90)	0.30
Friday	-0.16 (-0.74, 0.42)	0.59
Saturday	0.71 (0.13, 1.28)	0.016
Sunday	1.1 (0.48, 1.63)	<0.001
Time category at ambulance call		
Noon (8-15)	(ref)	
Early night (16-23)	1.9 (1.58, 2.29)	<0.001
Late night (0-7)	2.9 (2.49, 3.38)	<0.001
Category of suspected illness		
Abdominal pain	-0.93 (-2.0, 0.12)	0.082
CPA	0.06 (-1.0, 1.2)	0.92
Stroke	6.2 (5.1, 7.3)	<0.001
ACS	1.4 (0.14, 2.7)	0.03
DOC	3.7 (2.2, 5.2)	<0.001
Trauma	3.8 (3.3, 4.3)	<0.001
Internal medicine	(ref)	
Orthopedics except for Trauma	2.7 (2.2, 3.2)	<0.001
Neurosurgery except for Stroke and DOC	7.4 (6.8, 7.9)	<0.001
Surgery except for Abdominal pain	-0.08 (-1.1, 0.97)	0.89
Cardiology except for ACS	5.0 (4.0, 6.1)	<0.001
Person calling ambulance		
Family or self	(ref)	
Witness	-1.7 (-2.5, -0.95)	<0.001
Welfare facility	0.6 (0.27, 1.1)	<0.001
Emergency status at request call		
Less urgency	(ref)	

Urgency	0.59 (0.08, 1.1)	0.022
Emergency	-0.16 (-0.86, 0.54)	0.66
Resuscitation	-1.8 (-4.0, 0.40)	0.11
During assessment	-1.5 (-2.0, -1.1)	<0.001
The number of request call	6.3 (6.2, 6.4)	<0.001
Random effects		
Variance of (SD)	95.52 (9.8)	
AIC	320,647	
Radj2	0.44	

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

DISCUSSION

In this cross-sectional study, we evaluated the effect of the number of request calls to the time from call to hospital arrival. This study indicated that the time from call to hospital arrival would decrease by 4.6 minutes if all unsuccessful request calls were eliminated. Time from call to hospital arrival increases by 6.3 minutes for every request call from EMS to hospital, after adjusting for other variables. Time from call to hospital arrival is also related to age, sex, season, and person calling the ambulance.

Regarding the category of suspected illness, abdominal pain is associated with the shortest transport time, followed by surgery. The Ministry of Health, Labour and Welfare asked the prefecture governments to establish medical cooperation systems for five diseases: acute myocardial infarction, stroke, cancer, diabetes mellitus, and psychiatric illness[24]. Nara prefecture established a medical cooperation system for CPA, stroke, DOC, ACS, abdominal pain, trauma, perinatal problems, pediatrics, and psychiatric illness. In spite of national and prefectural efforts, ACS and stroke calls took 1.4 minutes and 6.2 minutes longer in transportation time compared to Internal medicine. Both acute coronary syndrome and stroke are diseases where time from onset to hospital arrival is important for treatment and outcome[25–27]. A shortage of appropriate healthcare facilities in the region might be the reason for prolonged times from call to hospital arrival for these diseases. As the number of patients with cardiovascular diseases increases in Japan's aging society, further research that focuses on specific diseases or time series may be required.

This study revealed that transportation times varied depending on the location of patient when the emergency call was made. There was approximately 30-minute difference in the time from request call to hospital arrival among the 13 districts (minimum of 36.3 minutes and maximum of 72.6 min) in a single prefecture. Nara prefecture has a long north-south axis with three tertiary emergency hospitals. However, all there of these hospitals are located in urban areas that are geographically distant from the southern rural area. As a result, the southern rural area was found to have longer transportation times than the other areas. In that area, the categories of illnesses that require special facilities such as coronary care units or stroke care units had longer transportation times than in other areas. The distance from emergency hospital and appropriate healthcare facilities might be the cause of this difference between areas. One observational study discussed the shortage of emergency medical facilities in rural areas in Japan[28]. One geographical study pointed out that there was a regional gap in the number of tertiary care centers per million people between prefectures in Japan[29].

Our results also indicate that there are differences in transportation times for specific diseases among regions. In southern rural areas, there were longer transportation times for diseases which needed treatment by specialists such as cardiologists, neurologists, neurosurgeons, and orthopedists than in the other two areas. This might be associated with the shortage of medical facilities for specific illnesses in these regions. Indicating disease-specific problems that are specific to each area is helpful information for improving health care systems and is also a strength of our study.

Our database did not include socioeconomic information of patients, except for the person who called an ambulance. In the field of acute myocardial infarction and stroke, it is known that time from onset of symptoms to hospital arrival are influenced by many other factors such as living alone[18], being alone at onset of symptoms[19,20], being a nonwhite patient in the United States [21], and education level[22]. In addition, indicators of patient socioeconomic status, such as mean income of the residential area[30,31] and race[30], have also been reported to influence the time from an emergency call to hospital arrival. We think information about the person who called an ambulance would help to indicate the socioeconomic status of patients to some degree.

In our study, we found there are no substantial differences in time between days of the week or seasons. One study in Tennessee, USA, found that the prolongation of transportation time was influenced by seasons due to variations in traffic volume[23]. However, transportation conditions were very different between Tennessee and Nara, which may explain in part the observed differences in results between these two studies.

Our study revealed that time from call to hospital arrival increases by 6.3 minutes for every request call from EMS to hospital. It also revealed that more than 45% of all request calls and 43% of request calls to hospitals indicating a status of "Accepting patients" resulted in failure. Driving ambulances at high speed[32], helicopter transportation[33–35] and centralization of hospitals[36] might be solutions to reduce transportation time. However, the risk of traffic accidents[37], costs for helicopter emergency medical services[38,39], and time and cost for centralizing hospitals are difficult problems to solve. Hence, it may be important to create a system for quickly determining appropriate hospitals and ensuring faster admissions to decrease the number of request calls.

It may be beneficial for policymakers to create a system to share information about hospitals and emergency patients more promptly especially for an aging society with an increasing number of ambulance dispatches. One recent cross-sectional study showed that services with tablet computers shortened the transportation time in Saga prefecture, Japan[40]; even though there was no information about time from call to hospital arrival in that study, introducing these support systems would reduce time from call to hospital arrival or transportation time. In prefectures, such as Nara prefecture, where a support system with tablet computers was introduced, creating a more effective and convenient system is needed. Physicians, are not only required to accept patients if requested, but must also appropriately indicate the hospital's capacity for emergency patients appropriately. As a result, this places an additional burden on physicians. Due to the shortage of physicians in Japan[41], there is a need for more effective posting of physicians and efficient working systems.

Our study has several limitations. First, patient emergency status was decided by ambulance crew. Our data does not include vital signs for all patients, because ambulance crews are required to register vital signs of patients for only a limited number of suspected illnesses. We cannot analyze patient emergency status using vital signs. As ambulance crews assessed patients by rules depending on patient's vital signs and they were also trained under the medical control system[5], the decisions made by ambulance crew were viewed as credible.

Second, our data consisted of patients in Nara prefecture. Nara prefecture is one of 47 prefectures in Japan. Our results may not be applicable to all prefectures in Japan. However, there is a discrepancy in urbanization between urbanized areas and mountainous areas such as the southern area. Therefore, we can discuss the differences between areas within one prefecture.

Lastly, there are several factors that are known to influence the time from request calls to hospital arrival, but we were unable to include them in analysis due to data limitations. These factors include prehospital strategies[42], level of training of ambulance crews[43], and hospital capacity[44]. Future studies should address the influence of these factors.

Conclusions

The study revealed 6.3 additional minutes were added to transportation time by every refusal of a request call and also revealed disease-specific delays among specific areas. A system that helps EMS to find hospitals should be effectively established to share information about hospitals and emergency patients promptly in partnership with policymakers and physicians for reducing the time from call to hospital arrival.

Contributors

NH has had the main responsibility for calculating statistics and writing the paper. YI is the principal investigator for the project, has planned the present paper jointly with NH, and has actively taken part in revising the paper. KY and SK have taken part in planning and analyzing data and revising paper.

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Competing interests

Kyoto University Department of Healthcare Economics and Quality Management had a financial contract with Nara prefecture to support analysis of its healthcare system. This study is out of the scope of the contract, and is not financed by Nara prefecture. Otherwise, all authors declare no financial relationships that are potentially relevant to this article.

Ethical approval

This study was approved by the Ethical Committee, Kyoto University Graduate School of Medicine, Japan

Data sharing statement

No additional data are available for sharing, because of data sharing policy.

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Figure Legends

Figure 1. Components of time from request call to hospital admission

Supplement Figure 1. Location and map of Nara prefecture

The left side of the figure shows a map of Japan. The lines represent prefectural borders, and Nara prefecture is indicated in black. The right side of the figure shows a map of Nara prefecture. The light gray area is the eastern rural area and the black area is the southern rural area. The black circles indicate the location of the tertiary emergency hospitals in Nara prefecture.

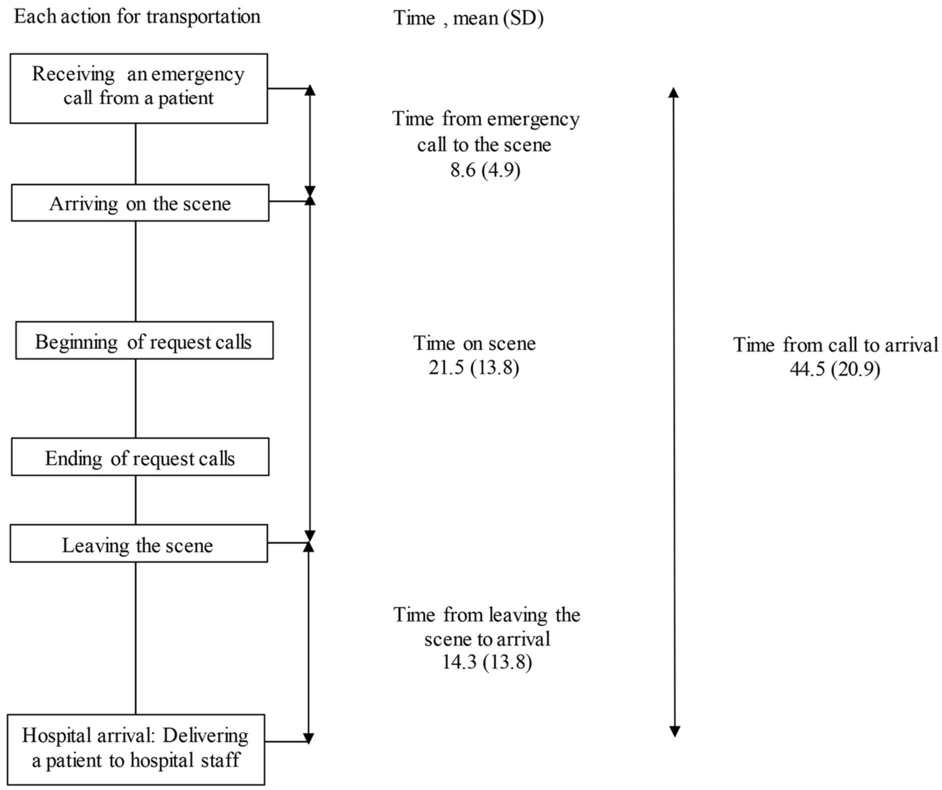
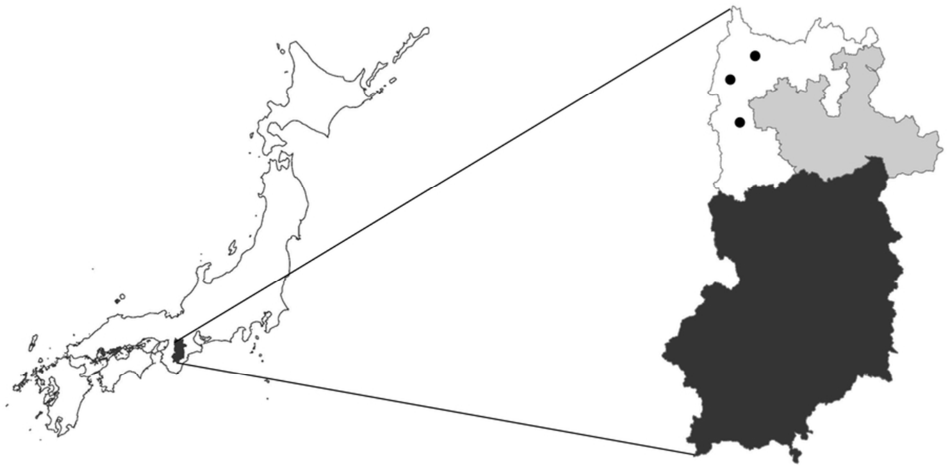


Figure 1. Components of time from request call to hospital admission

139x112mm (300 x 300 DPI)



Supplement Figure 1. Location and map of Nara prefecture
The left side of the figure shows a map of Japan. The lines represent prefectural borders, and Nara prefecture is indicated in black. The right side of the figure shows a map of Nara prefecture. The light gray area is the eastern rural area and the black area is the southern rural area. The black circles indicate the location of the tertiary emergency hospitals in Nara prefecture.

80x37mm (300 x 300 DPI)

Supplement table 1. Difference between the areas of time from call to hospital arrival: Multiple linear regression model

	Urban area (n = 32657)		East rural area (n = 7661)		South rural area (n = 3345)	
Explanatory valuable	Estimate (95%CI)	P-value	Estimate (95%CI)	P-value	Estimate	P-value
Intercept	29.7 (28.6, 30.7)	<0.001	30.8 (28.3, 33.3)	<0.001	27.4 (22.0, 32.7)	
Category of suspicious illness						
Abdominal pain	-0.74 (-1.9, 0.41)	0.21	-1.5 (-3.6, 0.57)	0.15	1.9 (-4.1, 8.0)	0.53
CPA	-1.2 (12.4, -0.029)	0.044	4.6 (2.3, 6.8)	0.048	-0.12 (-6.6, 6.4)	0.97
Stroke	6.4 (5.1, 7.7)	<0.001	5.9 (3.8, 8.0)	0.0011	9.9 (0.54, 17.8)	0.0038
ACS	0.26 (-1.2, 1.8)	0.73	2.1 (-0.21, 4.4)	0.075	10.0 (3.5, 16.6)	0.0027
DOC	3.8 (2.0, 5.5)	0.01	4.4 (1.9, 7.0)	0.00065	4.7 (-6.2, 15.6)	0.40
Trauma	1.8 (1.2, 2.3)	<0.001	8.1 (7.1, 9.2)	<0.001	10.0 (6.7, 13.2)	<0.001
Internal medicine	(ref)		(ref)		(ref)	
Orthopedics except for Trauma	1.5 (1.0, 2.0)	<0.001	4.5 (3.2, 5.7)	<0.001	9.2 (6.2, 12.1)	<0.001
Neurosurgery except for Stroke and DOC	6.6 (6.0, 7.1)	<0.001	9.1 (7.7, 10.5)	<0.001	11.5 (8.0, 14.9)	<0.001
Surgery except for Abdominal pain	-0.081 (-1.1, 0.98)	0.88	-0.34 (-3.3, 2.6)	0.82	-0.48 (-6.6, 5.6)	0.88
Cardiology except for ACS	4.4 (3.4, 5.4)	<0.001	5.5 (1.9, 9.1)	0.0025	9.2 (0.54, 17.8)	0.37

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest,

DOC: disturbance of consciousness, referral call: referral call to hospital for transportation

Urban area, East rural area, and South rural area consists of 7, 3 and 3 areas respectively.

This table shows only the result of Category of suspicious illness.

Supplement Table 1. On scene time and time from scene to hospital arrival: multilevel linear regression analysis

Explanatory valuable	On scene Estimate (95%CI)	On scene P-value	From scene to hospital arrival Estimate (95%CI)	From scene to hospital arrival P-value
Intercept	9.9 (7.8, 11.9)	<0.001	12.8 (7.3, 18.4)	<0.001
Fixed effects				
Age				
≥15, <60	(ref)		(ref)	
≥60, <80	0.44 (0.18, 0.69)	<0.001	0.66 (0.40, 0.92)	<0.001
≥80	0.85 (0.58, 1.1)	<0.001	-0.007 (-0.29, 0.28)	0.96
Sex				
Female	(ref)		(ref)	
Male	-0.12 (-0.33, 0.093)	0.28	0.69 (0.47, 0.90)	<0.001
Season				
Spring (March-May)	(ref)		(ref)	
Summer (June-August)	-0.50 (-0.79, -0.20)	<0.001	-0.12 (-0.42, 0.18)	0.43
Autumn (September-November)	0.29 (-0.0030, 0.59)	0.052	0.11 (-0.19, 0.41)	0.48
Winter (December-February)	0.85 (0.56, 1.1)	<0.001	0.082 (-0.22, 0.38)	0.59
Day of the week				
Monday	(ref)		(ref)	
Tuesday	-0.074 (-0.46, 0.31)	0.71	-0.15 (-0.54, 0.24)	0.46
Wednesday	-0.0015 (-0.39, 0.39)	0.99	-0.062 (-0.46, 0.33)	0.76
Thursday	0.015 (-0.37, 0.40)	0.94	0.24 (-0.15, 0.64)	0.23
Friday	-0.11 (-0.49, 0.27)	0.58	0.022 (-0.37, 0.41)	0.91
Saturday	-0.040 (-0.42, 0.34)	0.83	0.75 (0.37, 1.1)	<0.01

Sunday	-0.032 (-0.41, 0.34)	0.87	1.2 (0.77, 1.5)	<0.001
Time category at ambulance call				
Noon (8-15)	(ref)		(ref)	
Early night (16-23)	0.87 (0.64, 1.1)	<0.001	0.93 (0.69, 1.2)	<0.001
Late night (0-7)	2.0 (1.7, 2.2)	<0.001	0.51 (0.22, 0.81)	<0.01
Category of suspected illness				
Abdominal pain	-1.2 (-1.9, -0.48)	<0.001	0.21 (-0.49, 0.92)	0.55
CPA	-4.6 (-1.2, 0.27)	0.22	-0.019 (-0.76, 0.72)	0.96
Stroke	2.6 (1.9, 3.4)	<0.001	3.4 (2.6, 4.0)	<0.001
ACS	-1.6 (-2.5, -0.78)	<0.01	3.2 (2.3, 4.0)	<0.001
DOC	2.8 (1.8, 3.8)	<0.001	0.81 (-0.20, 1.8)	0.12
Trauma	1.5 (1.2, 1.8)	<0.001	2.0 (1.7, 2.4)	<0.001
Internal medicine	(ref)		(ref)	
Orthopedics except for Trauma	0.74 (0.41, 1.1)	<0.001	1.6 (1.3, 2.0)	<0.001
Neurosurgery except for Stroke and DOC	3.2 (2.9, 3.6)	<0.001	4.1 (3.8, 4.5)	<0.001
Surgery except for Abdominal pain	0.43 (-0.26, 1.1)	0.22	-0.32 (-1.0, 0.38)	0.37
Cardiology except for ACS	-0.14 (-0.84, 0.56)	0.69	4.2 (3.5, 4.9)	<0.001
Person calling ambulance				
Family or self	(ref)		(ref)	
Witness	2.0 (1.7, 2.2)	<0.001	-0.85 (-1.1, -0.58)	<0.001
Welfare facility	-1.2 (-1.7, -0.74)	<0.001	0.28 (-0.23, 0.79)	0.29
Emergency status at request call				
Less urgency	(ref)		(ref)	
Urgency	0.64 (0.30, 0.97)	<0.01	-0.055 (-0.39, 0.28)	0.75
Emergency	-0.0071 (-0.47, 0.45)	0.98	-0.013 (-0.46, 0.48)	0.96
Resuscitation	-0.015 (-1.4, 1.4)	0.98	-1.3 (-2.7, 0.20)	0.092
During assessment	-1.4 (-1.6, -1.1)	<0.001	-0.24 (-0.52, -0.41)	0.11

The number of request call	4.6 (4.6, 4.7)	<0.001	1.6 (1.6, 1.7)	<0.001
Random effects				
Variance of (SD)	12.7 (3.6)		96.9 (9.8)	
AIC	288,604		290,048	
Radj2	0.44	_	0.31	_

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest,
DOC: disturbance of consciousness, request call: request call to hospital for transportation

Supplement Table 2. Time from call to hospital arrival without variable "the number of request call " : multilevel linear regression analysis

Explanatory valuable	From Call to hospital arrival Estimate (95%CI)	P-value
Intercept	42.1 (36.1, 48.0)	<0.001
Fixed effects		
Age		
≥15, <60	(ref)	
≥60, <80	-0.21 (-0.69, 0.75)	0.039
≥80	-0.44 (-0.95, 0.081)	0.098
Sex		
Female	(ref)	
Male	0.71 (0.32, 1.1)	<0.001
Season		
Spring (March-May)	(ref)	
Summer (June-August)	-0.93 (-1.5, -0.38)	<0.001
Autumn (September-November)	0.19 (-0.37, 0.74)	0.50
Winter (December-February)	1.68 (1.1, 2.2)	<0.001
Day of the week		
Monday	(ref)	
Tuesday	0.030 (-0.69, 0.75)	0.93
Wednesday	0.18 (-0.55, 0.90)	0.63
Thursday	0.52 (-0.20, 1.2)	0.16
Friday	0.097 (-0.61, 0.81)	0.79
Saturday	1.8 (1.1, 2.5)	<0.001
Sunday	2.8 (2.1, 3.5)	<0.001
Time category at ambulance call		
Noon (8-15)	(ref)	
Early night (16-23)	4.6 (4.1, 5.0)	<0.001
Late night (0-7)	7.1 (6.6, 7.6)	<0.001
Category of suspected illness		
Abdominal pain	2.0 (0.75, 3.3)	<0.01
CPA	1.5 (0.18, 2.9)	0.026
Stroke	7.6 (6.1, 9.0)	<0.001

ACS	-0.87 (-2.4, 0.71)	0.28
DOC	5.9 (4.1, 7.8)	<0.001
Trauma	4.3 (3.6, 4.9)	<0.001
Internal medicine	(ref)	
Orthopedics except for Trauma	3.8 (2.2, 4.9)	<0.001
Neurosurgery except for Stroke and DOC	5.9 (7.6, 9.0)	<0.001
Surgery except for Abdominal pain	0.47 (3.6, 4.9)	0.47
Cardiology except for ACS	3.5 (2.2, 4.9)	<0.001
Person calling ambulance		
Family or self	(ref)	
Witness	1.1 (0.59, 1.6)	<0.001
Welfare facility	-1.7 (-2.6, -0.72)	<0.001
Emergency status at request call		
Less urgency	(ref)	
Urgency	0.96 (0.071, 1.3)	0.029
Emergency	0.69 (-0.17, 1.6)	0.12
Resuscitation	-2.4 (-5.0, 0.31)	0.083
During assessment	-3.2 (-3.6, -2.6)	<0.001
The number of request call		
Random effects		
Variance of (SD)	109.5 (10.5)	_ _
AIC	336,767	
Radj2	0.11	_ _

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

Supplement table 3. Difference between the areas of time from call to hospital arrival: multilevel linear regression analysis

Explanatory valuable	Urban area (n = 32657)		Eastern rural area (n = 7661)		Southern rural area (n = 3345)	
	Estimate (95%CI)	P-value	Estimate (95%CI)	P-value	Estimate (95%CI)	P-value
Intercept	26.1 (24.5, 29.3)	<0.001	32.5 (20.5, 44.5)	<0.001	36.1 (20.9, 51.3)	<0.001
Age						
≥15, <60	(ref)		(ref)		(ref)	
≥60, <80	1.19 (0.79, 1.60)	<0.001	1.90 (1.02, 2.77)	<0.001	-0.84 (-3.4, 1.7)	0.52
≥80	0.83 (0.46, 1.33)	<0.001	1.22 (0.27, 2.17)	0.0012	1.2 (-1.4, 3.9)	0.36
Sex						
Female	(ref)		(ref)		(ref)	
Male	0.31 (0.32, 0.96)	0.066	0.31 (-0.40, 1.02)	0.39	4.2 (2.3, 6.2)	<0.001
Season						
Spring (March-May)	(ref)		(ref)		(ref)	
Summer (June-August)	-0.85 (-1.32, -0.39)	<0.001	-0.023 (-1.02, 0.98)	0.960	2.3 (-0.50, 5.0)	0.110
Autumn (September-November)	0.16 (-0.31, 0.63)	0.510	0.82 (-0.18, 1.81)	0.110	3.6 (0.81, 6.4)	0.012
Winter (December-February)	0.68 (0.22, 1.14)	0.004	1.67 (0.68, 2.66)	0.001	2.8 (0.027, 5.5)	0.049
Day of the week						
Monday	(ref)		(ref)		(ref)	
Tuesday	-0.16 (-0.77, 0.44)	0.60	-1.22 (-2.52,0.080)	0.07	-0.55 (-4.1, 3.0)	0.76
Wednesday	0.028 (-0.59, 0.64)	0.93	0.028 (-1.30, 1.36)	0.97	-2.1 (-5.7, 1.5)	0.26
Thursday	0.48 (-0.13, 1.09)	0.12	0.11 (-1.21, 1.44)	0.87	-0.93 (-4.6, 2.7)	0.62

Friday	-0.080 (-0.69, 0.53)	0.80	-0.68 (-1.98, 0.62)	0.31	0.41 (-3.2, 4.0)	0.82
Saturday	0.62 (0.024, 1.22)	0.042	0.11 (-1.18, 1.41)	0.87	3.6 (0.12, 7.1)	0.044
Sunday	0.700 (0.10, 1.20)	0.022	0.99 (-0.30, 2.28)	0.13	4.3 (0.88, 7.6)	<0.001
Time category at ambulance call						
Noon (8-15)	(ref)		(ref)		(ref)	
Early night (16-23)	1.7 (1.3, 2.1)	<0.001	2.6 (1.78, 3.37)	<0.001	4.2 (2.0, 6.4)	<0.001
Late night (0-7)	2.8 (2.3, 3.3)	<0.001	3.1 (2.06, 4.07)	<0.001	4.8 (2.0, 7.5)	<0.001
Category of suspected illness						
Abdominal pain	-0.73 (-1.9, 0.42)	0.21	-1.5 (-3.6, 0.57)	0.15	2.0 (-4.1, 8.0)	0.53
CPA	-1.2 (-2.4, -0.023)	0.046	4.6 (2.3, 6.8)	<0.001	-0.087 (-6.5, 6.4)	0.98
Stroke	6.4 (5.1, 7.7)	<0.001	5.9 (3.8, 8.0)	<0.001	9.9 (3.3 16.6)	0.0038
ACS	0.26 (-1.2, 1.8)	0.73	2.1 (-0.21, 4.4)	0.076	10.0 (3.5, 16.6)	0.0027
DOC	3.8 (2.0, 5.5)	<0.001	4.4 (1.9, 7.0)	<0.001	4.7 (-6.1, 15.5)	0.40
Trauma	1.8 (1.2, 2.3)	<0.001	8.1 (7.1, 9.2)	<0.001	10.0 (6.7, 13.2)	<0.001
Internal medicine	(ref)		(ref)		(ref)	
Orthopedics except for Trauma	1.5 (1.0, 2.0)	<0.001	4.5 (3.2, 5.7)	<0.001	9.2 (6.3, 12.1)	<0.001
Neurosurgery except for Stroke and DOC	6.6 (6.0, 7.1)	<0.001	9.1 (7.7, 10.5)	<0.001	11.5 (8.0, 14.9)	<0.001
Surgery except for Abdominal pain	-0.084 (-1.1, 0.98)	0.88	-0.33 (-3.3, 2.6)	0.82	-0.46 (-6.5, 5.6)	0.88
Cardiology except for ACS	4.4 (3.4, 5.4)	<0.001	5.5 (1.9, 9.1)	0.0025	9.2 (0.59, 17.8)	0.37

Person calling ambulance						
Family or self	(ref)		(ref)		(ref)	
Witness	0.35 (-0.068, 0.76)	0.1	0.98 (0.11, 1.8)	0.027	2.3 (-0.23, 4.9)	0.075
Welfare facility	-0.79 (-1.6, 0.021)	0.056	1.1 (-0.80, 3.1)	0.25	-7.3 (-10.8, -3.9)	<0.001
Emergency status at request call						
Less urgency	(ref)		(ref)		(ref)	
Urgency	0.84 (0.30, 1.4)	0.0023	1.7 (0.66, 2.8)	0.002	-3.3 (-6.2, -0.35)	0.029
Emergency	-0.033 (-0.78, 0.72)	0.93	0.012 (-1.5, 1.5)	0.99	-2.7 (-6.7, 1.3)	0.19
Resuscitation	-0.99 (-3.2, 1.2)	0.37	-3.2 (-9.2, 2.7)	0.29	-5.5 (-19.3, 8.4)	0.44
During assessment	-1.24 (-1.7, -0.80)	<0.001	-1.9 (-2.8, -1.0)	<0.001	-3.6 (-6.3, -0.94)	0.0088
The number of request call (mean (SD))	6.2 (6.1, 6.3)	<0.001	6.5 (6.3, 6.7)	<0.001	6.7 (6.2, 7.2)	<0.001
Random effects						
Variance of (SD)	8,5 (2.9)	_	81.7 (9.0)	_	126.4 (11.2)	_
AIC	231005		58625		27533	
Radj2	0.41	_	0.52	_	0.32	_

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest,
DOC: disturbance of consciousness, request call: request call to hospital for transportation

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract -p2, p4 in abstract and p9 in METHODS
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found – p4
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported -p7
Objectives	3	State specific objectives, including any prespecified hypotheses – p8
Methods		
Study design	4	Present key elements of study design early in the paper – p9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection –p9-11
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants – p11
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – p12-13
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group –p9
Bias	9	Describe any efforts to address potential sources of bias – p9-10
Study size	10	Explain how the study size was arrived at – p9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why - p12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding –p13
		(*b*) Describe any methods used to examine subgroups and interactions –p15
		(*c*) Explain how missing data were addressed –p12
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy – p14
		(*e*) Describe any sensitivity analyses –p14

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed –p15
		(b) Give reasons for non-participation at each stage –not applicable
		(c) Consider use of a flow diagram – no use
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders –p15-17
		(b) Indicate number of participants with missing data for each variable of interest-p16 table1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures -p16
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included -p21-23
		(*b*) Report category boundaries when continuous variables were categorized –p13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period – not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses –p21 and supplement table 3

Discussion

Key results	18	Summarise key results with reference to study objectives – p23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias –p27-28
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence –p26-27
Generalisability	21	Discuss the generalisability (external validity) of the study results –p28

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based –p30

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The effect of the number of request calls on the time from call to hospital arrival: a cross-sectional study of an ambulance record database in Nara prefecture, Japan

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Title: The effect of the number of request calls on the time from call to hospital arrival: a cross-sectional study of an ambulance record database in Nara prefecture, Japan

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ABSTRACT

Objectives: In Japan, ambulance staff sometimes must make request calls to find hospitals that can accept patients because of an inadequate information sharing system. This study aimed to quantify effects of the number of request calls on the time interval between an emergency call and hospital arrival.

Design and Setting: A cross-sectional study of an ambulance records database in Nara prefecture, Japan.

Cases: A total of 43,663 patients (50% women; 31.2% aged 80 and over): (1) transported by ambulance from April 2013 to March 2014, (2) aged 15 and over, and (3) with suspected major illness.

Primary outcome measures: The time from call to hospital arrival, defined as the time interval from receipt of an emergency call to ambulance arrival at a hospital.

Results: The mean time interval from emergency call to hospital arrival was 44.5 minutes, and the mean number of requests was 1.8. Multilevel linear regression analysis showed that approximately 43.8% of variations in transportation times were explained by patient age, sex, season, day of the week, time, category of suspected illness, person calling for the ambulance, emergency status at request call, area, and number of request calls. A higher number of request calls was associated with longer time intervals to hospital arrival (addition of 6.3 minutes per request call; $p<0.001$). In an analysis dividing areas into three groups, there were differences in transportation time for diseases needing cardiologists, neurologists, neurosurgeons, and orthopedists.

Conclusions: The study revealed 6.3 additional minutes needed in transportation time for every refusal of a request call, and also revealed disease-specific delays among specific areas. An effective system should be collaboratively established by policymakers and physicians to ensure the rapid identification of an available hospital for patient transportation in order to reduce the time from the initial emergency call to hospital arrival.

Strengths and Limitations of this study

- A strength of this study is that it examined a large database of patients transported by ambulance that included detailed information about the number of request calls and the time for transportation in Nara prefecture, Japan.
- This study suggested that one refusal of a request call extended the time from call to hospital arrival by 6.3 minutes.
- This study revealed that there is a difference of up to approximately 30 minutes between areas in the time from call to arrival and specifically pointed out disease-specific delays among specific areas.
- Limitations of this study were that patient emergency status was decided by ambulance crew and our data consisted of patients from one prefecture in Japan.

[INTRODUCTION]

A request for the delivery of an emergency patient is sometimes rejected, and this is a social problem in Japan[1–4]. In Japan, the emergency transport system is managed by local governments[1,5,6]. Each prefecture establishes a medical care system to provide care to several medical care zones, each of which consists of several districts. Patients who require ambulance transport to hospitals can call for emergency services by dialing ”119.” The emergency call is directly received by the local fire defense headquarters, and the nearest available ambulance is dispatched to the patient[6]. Ambulance crews, who are trained paramedics belonging to the local fire departments, assess patients in accordance with local protocols that are based on national protocols[4]. After arriving on scene, an ambulance crew would first assess the patient and provide emergency medical treatment if required. Subsequently, the crew determines the most appropriate hospitals for the patient, and places request calls to these hospitals while still at the scene[4]. The patient is then transported by ambulance for free to the nearest emergency hospital that agrees to treat the patient. Emergency hospitals in Japan are classified into three levels: primary, secondary, and tertiary[1]. According to Article 19 of the Medical Practitioners' Law, physicians are unable to refuse patients without good reason.

The national average of the time from calling an ambulance to hospital arrival was 39.4 minutes in 2014, is increasing every year[7], and is a known predictor of outcomes of acute heart failure[8] and head trauma[9]. Japan has the most rapidly aging population in the world[10], and it is estimated that there were 33,656,000 people aged 65 and over (26.5% of the population) in 2015[11]. As the number of elderly people will reach a peak of 33.78 million in 2042, the percentage of elderly people will reach 39.9 % in 2060[12]. The number of ambulance dispatches was nearly 6.0 million in 2014 and this reflected a trend of increases over the previous 6 years[7]. Because of the rapidly aging population and an increase in ambulance dispatches, the time from call to hospital arrival will invariably increase unless major changes are implemented in the emergency care and resource distribution systems.

One recent study showed that the number of request calls to hospitals had greater odds of an on-scene arrival time of over 30 minutes[13]. However, the direct effect of the number of request calls on the time from call to hospital arrival is unclear. The aim of this study was to evaluate factors affecting the time to hospital arrival of ambulances, especially the effect of the number of request calls.

METHODS

Data and setting

This was a cross-sectional study. The data sources were an ambulance transportation records database (transportation database) and an ambulance request call records database (request call database) in Nara prefecture, Japan. The location and map of Nara prefecture are shown in Supplement Figure 1. The prefectural population was 1.36 million in 2015, with a population density of 369 per square kilometer[14]. Most of the prefecture is covered by mountains and forests, with the exception of the northwest area. Nara prefecture consists of five medical areas; there are almost 70 hospitals within the prefecture, three of which are tertiary hospitals[15][16]. All hospitals are requested to indicate admission acceptability according to patient severity and category of suspected illnesses by displaying this information in a web system.

The transportation database consists of information about patient characteristics, date and time of each call and hospital arrival, and time for each component of transportation (except for the time from the end of a request call to leaving the scene and the time from entering a hospital to delivering a patient to hospital staff [hospital arrival]). The request call database consists of information about patient characteristics, date and time of call for the suspected illness, name of the hospital accepting request calls, whether or not the hospital indicated the admission acceptability of patients, and the result of the request call. In Nara prefecture, ambulance crews have a tablet-type portable computer for searching hospital statuses with regard to admission acceptability. Using these computers, the crew members input the date and time of each action for transportation and the assessment results (such as each patient's emergency situation and suspected illnesses).

Nara prefecture has established a medical cooperation system for these ten important illnesses through the formation of a medical institution network in order to provide coordinated care for patients. Under this system, patient emergency situations are categorized into five levels, and suspected illnesses are categorized into ten important illnesses and other categories. These categories are assessed by ambulance crews based on designated criteria and protocols. The ten important illnesses are categorized as follows: cardiopulmonary arrest (CPA), stroke, disturbance of consciousness (DOC), acute coronary syndrome (ACS), abdominal pain, trauma, severe burn, perinatal problem, pediatrics, and psychiatric illness. The other categories are classified according to medical specialties, including internal medicine, neurosurgery except for stroke or DOC, surgery except for abdominal pain, orthopedics except for trauma, and cardiology except for ACS. Patients were categorized into the "other category" if they were not categorized into one of these important illnesses.

Inclusion and exclusion criteria

Our inclusion criteria were transportation and request calls made by patients 1) transported from 1 April 2013 to 31 March 2014, 2) aged 15 and older, and 3) with suspected illness related to internal medicine, trauma, orthopedics, neurosurgery, abdominal pain, surgery, cardiology, CPA, stroke, ACS, and DOC. Patients' suspected illnesses were categorized into 10 important illnesses and other categories after assessment by EMS staff. The ten important illnesses were categorized as the following patient situations: CPA, stroke, DOC, ACS, abdominal pain, trauma, perinatal problem, pediatrics, and psychiatric illness. We excluded patients with suspected illness related to perinatal problems, pediatrics, and psychiatric illness because the number of hospitals that accepted these kind of patients was very small. We also excluded patients with suspected illnesses, except for those concerning internal medicine, orthopedics, neurosurgery, surgery, and cardiology, due to the low number of patients with these illnesses.

We excluded transportation and request calls from hospital to hospital and from clinic to hospital. We decided upon these inclusion criteria because these illnesses are important in terms of health policy and affect many patients. We excluded patients who took longer than 1000 minutes for finding hospitals, driving to a hospital, or transportation as outliers. We also excluded children because the number of hospitals allowing transportation of children is very small, and we would have needed to conduct a separate study for children as distinct from adults. We treated missing data as null values, while the cases were retained in the analysis.

Variables

Date and time of hospital arrival, time from arrival on scene to the beginning of request calls, time from the beginning of request calls to the ending of the calls, time from the ending of the calls to hospital arrival, time from leaving the scene to hospital arrival, patient characteristics (age and sex), person calling ambulance, registered district of the EMS, and patient's emergency status and category of suspected illness as recorded by on-scene EMS staff or operational staff at the local fire defense headquarters. We divided patients into three groups according to age: (1) 15 to ≤59 years, (2) 60 to 79 years, and (3) 80 years or more; the cut-off at 60 years was selected as it is the traditional retirement age in Japan. We defined the seasons as spring from March to May, summer from June to August, autumn from September to November, and winter from December to February. We also defined noon from 8am to 3pm, early night from 4pm to 11pm, and late night from 12am to 7am. We defined on-scene time as the sum of the time from arriving on the scene to leaving the scene.

With regard to ambulance administration, Nara prefecture is divided into 13 districts that were used to identify the places where ambulance calls were made. Thirteen districts were divided into the following three groups depending on the level of urbanization and location of the registered district of the EMS: 1) urban area, which encompasses seven districts that are more urbanized than other areas in Nara prefecture (population was 1.08 million and the population density was 1,578 per square kilometer in 2015), 2) the eastern rural area, which consists of three districts located in the east side of Nara prefecture (population was 0.21 million and the population density was 319 per square kilometer in 2015), and 3) the southern rural area, which consists of three districts located in the south side of Nara prefecture (population was 0.07 million and the population density was 30.9 per square kilometer in 2015).

Primary outcome measure

The primary outcome measure was the time from the initial emergency call by the patients to hospital arrival, that is, the time from the call for an ambulance to hospital arrival.

Statistical methods

The main results were calculated as means and standard deviations (SD), and the baseline patient characteristics were compared using Student's t-test or the Kruskal-Wallis test. First quartile and third quartile were calculated to show the distribution of data.

First, to estimate the effect of increasing the number of request calls on the time from call to hospital arrival, we conducted the Jonckheere-Terpstra trend test.

Second, in order to estimate the time from request call to hospital arrival after excluding unsuccessful request calls, we defined unsuccessful request calls as 1) request calls to hospitals indicated as "Accepting patients" that resulted in failure, and 2) request calls to hospitals indicated as "Not accepting patients" that resulted in failure. To conduct this estimation, we merged the transportation database and the request call database. When the time for a request call was longer than the time from call to hospital in request call database, we decided these were entered incorrectly and then excluded them from calculations.

Third, to evaluate the effect of the number of request calls on time from call to hospital arrival, we conducted a multilevel linear regression analysis with a random intercept model that allowed different intercepts with 13 districts. The predictive variables were selected on the basis of previous research[17–23]. To evaluate the differences of time from call to hospital arrival between the three areas, we conducted a multilevel linear regression analysis with a random intercept model that allowed different intercepts with the three areas. We also conducted a subgroup analysis for on-scene time and time from leaving the scene to hospital arrival.

Lastly, to evaluate the differences of time from call to hospital arrival between the three areas, we conducted a multilevel linear regression analysis with a random intercept model that allowed different intercepts with the three areas. To evaluate differences in the time from request call to hospital arrival among the three areas, we also conducted another multilevel linear regression analysis with a random intercept model to correct for patient clustering in the districts where patients were divided into three areas.

Data analysis was conducted using the statistical software package R, version 3.2.2. Prior to the study, the study procedures were reviewed and approved (#E1023) by the ethics review committee of Kyoto University Graduate School of Medicine.

RESULTS

Cases

From April 2013 to March 2014, the number of transportations by ambulance was 43,663. The mean (SD) of time from request call to hospital arrival was 44.5 (SD: 20.9) minutes. The distribution of risk factors and their association with transportation time are shown in Table 1. Slightly less than one-third of patients were 80 years old or older, and 50% were female. The percentage of patients transported during the noon time period was 44.8%, which was a greater proportion than during other time categories. The number of patients in each area ranged from 723 to 11,223, and the mean (SD) was 3,358.7 (SD: 3,046.3) (the first and third quartile were 1,499 and 4,060, respectively). The mean (SD) time from call to hospital arrival in each district ranged from 36.3 (SD: 12.4) minutes to 72.6 (SD: 32.9) minutes, with a mean time of 48.2 (SD: 10.4) minutes (the first and third quartiles were 41.2 and 53.1, respectively; data not shown). Almost one-half of the patients were suspected of internal disease, and patients who were suspected of neurosurgical disease experienced longer times than others. Almost 70% of ambulances were called by family members or patients themselves. More than half of the patients were categorized into lower emergency situations. There were no remarkable differences across seasons or days of the week.

Table 1. Risk Factors Distribution and Association with transportation time

	n N = 43,663	%	Time from call to hospital arrival mean (SD)	1st Qu-3rd Qu	P-value
Age,y					
≥15, <60	14,125	32.4	45.1 (22.7)	31.0-53.0	
≥60, <80	15,915	36.4	44.4 (20.2)	31.0-52.0	
≥80	13,623	31.2	43.9 (19.8)	31.0-51.0	<0.001*
Sex					
Male	21,833	50.0	45.1 (21.7)	31.0-51.0	
Female	21,830	50.0	43.8 (20.1)	31.0-53.0	<0.001†
Season					
Spring (March-May)	10,406	23.8	44.2 (20.1)	31.0-52.0	
Summer (June-August)	11,187	25.6	43.5 (20.2)	31.0-51.0	
Autumn (September-November)	10,741	24.6	44.5 (20.8)	32.0-53.0	
Winter (December-February)	11,329	25.9	45.7 (22.4)	32.0-53.0	<0.001*
Day of the week					
Monday	6,627	15.2	43.5 (20.1)	30.0-51.0	
Tuesday	6,133	14.0	43.8 (20.8)	31.0-51.0	
Wednesday	5,838	13.4	43.9 (20.1)	31.0-52.0	
Thursday	5,899	13.5	44.0 (20.8)	31.0-52.0	
Friday	6,134	14.0	43.7 (20.0)	31.0-51.0	
Saturday	6,436	14.7	45.8 (21.4)	32.0-54.0	
Sunday	6,596	15.1	46.5 (22.7)	32.0-54.0	<0.001*
Time category at ambulance call					
Noon (8-15)	19,558	44.8	41.8 (19.4)	30.0-48.0	
Early night (16-23)	15,862	36.3	45.9 (21.6)	32.0-56.0	
Late night (0-7)	8,243	18.9	48.1 (22.1)	34.0-56.0	<0.001*
Category of suspected illness					
Abdominal pain	1,072	2.5	45.9 (21.2)	32.0-53.0	
CPA	984	2.3	43.6 (20.3)	31.0-49.0	
Stroke	850	1.9	49.9 (22.1)	35.0-58.0	
ACS	686	1.6	42.6 (16.9)	32.0-49.0	
DOC	498	1.1	47.6 (19.5)	33.0-54.0	
Trauma	6,158	14.1	46.4 (21.4)	33.0-54.0	
Internal medicine	21,197	48.5	42.3 (19.8)	30.0-49.0	

Orthopedics except for Trauma	5,895	13.5	45.5 (22.3)	31.0-54.0	
Neurosurgery except for Stroke and DOC	4,254	9.7	50.4 (22.4)	36.0-60.0	
Surgery except for Abdominal pain	1,066	2.4	42.6 (21.7)	29.0-51.0	
Cardiology except for ACS	1,003	2.3	44.9 (20.4)	33.0-53.0	<0.001*
Person calling ambulance					
Family or self	27,041	70.3	44.4 (20.6)	31.0-52.0	
Witness	9,501	24.7	44.9 (21.8)	31.0-52.0	
Welfare facility	1,906	5.0	42.3 (19.6)	30.0-49.0	<0.001*
Emergency status at request call					
Less urgency	25,535	58.5	45.3 (21.0)	32.0-53.0	
Urgency	5,243	12.0	45.8 (20.9)	32.0-53.0	
Emergency	2,659	6.1	46.4 (22.0)	32.0-54.0	
Resuscitation	241	0.6	42.4 (18.0)	31.0-47.0	
During assessment	9,983	22.9	41.4 (20.1)	29.0-48.0	<0.001*
Area where ambulance calls were made					
Urban area	32,657	74.8	42.1 (18.5)	30.0-49.0	
Eastern rural area	7,661	17.5	48.6 (21.7)	34.0-58.0	
Southern rural area	3,345	7.7	57.8 (31.9)	35.0-72.0	<0.001*

* P-value by Kruskal-Wallis test

† P-value by Student's t-test

SD: standard deviation, Qu: quartile, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

The detailed information about each area are not available for disclosing, because of data sharing policy.

Components of the time from call to hospital admission

Figure 1 shows components of the time from call to hospital admission from the transportation database. It took 21.5 (SD: 13.8) minutes to arrive on the scene, on average. It took 14.3 (SD: 13.8) minutes from the scene to hospital arrival.

Effect of increasing the number of request calls on the time from call to hospital arrival

The mean (SD) time from call to hospital arrival was 44.5 (SD: 20.9) min, and the mean (SD) number of requests was 1.8 (SD: 1.8). Table 2 shows the relationship between the number of request calls for each transport and the time from call to hospital arrival using the transportation database. It shows the more request calls made, the more time spent from call to hospital arrival.

Table 2. The number of request call and time from call to hospital arrival for each patient

The number of request call	n N = 43,663	%	Time from call to hospital arrival mean (SD)	1st Qu-3rd Qu	P-value
1	29,499	67.6	38.2 (16.2)	29.0-44.0	
2	6,302	14.4	47.8 (16.9)	37.0-54.0	
3	3,150	7.2	55.1 (18.4)	43.0-62.0	
4	1,816	4.2	61.2 (19.3)	49.0-70.0	
5	971	2.2	68.9 (20.7)	55.0-78.0	
6	625	1.4	73 (21.2)	59.0-82.0	
7	395	0.9	79.5 (23.5)	65.0-89.0	
8	278	0.6	81.5 (20.8)	67.3-91.8	
9	173	0.4	92.6 (29.2)	73.0-104.0	
10	126	0.3	90.8 (25.4)	74.3-105.0	
≥11	328	0.8	109.6 (25.9)	86.0-122.2	<0.001*

* P-value by Jonckheere-Terpstra trend test

request call: request call to hospital for transportation,

SD: standard deviation, Qu: quartile

Effect of unsuccessful request calls on the time from request call to hospital arrival

Table 3 shows the number and the time for request call categorized by hospital displayed acceptability and request results. There were 79,693 request calls for 43,663 transportations. The number of unsuccessful request calls was 36,030 (45.2 %) and these took more than 150,000 minutes in total. The number of request calls to hospitals that displayed "Not accepting patients" was 22,648 (28.4%) and 11,401 (50.3%) request calls resulted in failure. When the mean time from call to hospital arrival was calculated without unsuccessful request calls, it was shortened by 3.5 minutes.

Table 3. The number and the time for request call categorized by hospital displayed acceptability and request results

Hospital Displayed Admission Acceptability	Result	Number of request call n (%) N = 79,693	Time from call to hospital arrival mean (SD)	1st Qu-3rd Qu	P-value *
Accepting patients	Success	32,416 (40.7)	4.9 (3.4)	2.0-6.0	
Not accepting patients	Success	11,247 (14.1)	4.5 (3.9)	2.0-6.0	
Accepting patients	Failure	24,629 (30.9)	4.2 (3.1)	2.0-5.7	
Not accepting patients	Failure	11,401 (14.3)	4.2 (3.5)	2.0-5.3	<0.001†

* P-value by Kruskal-Wallis test

request call: request call to hospital for transportation, SD: standard deviation, Qu: quartile

Effect of the number of request calls on the time from call to hospital arrival

We conducted a multilevel linear regression analysis to describe time from call to hospital arrival. In this model, 44% of the variation was explained by the parameters age, sex, season, day of the week, time, area, category of suspected illness, person calling ambulance, emergency status at request call, and the number of request calls (see Table 4 and Supplement Table 1). The model that did not include the variable "the number of request calls" was only able to explain 11% of the observed variations (see Supplement Table 2). We found that the number of request calls affected time from call to hospital arrival ($\beta = 6.3$, $p<0.001$), which indicated that a refusal of a request call extended the time from call to hospital arrival by 6.3 minutes. We also observed associations between time from call to hospital arrival and age, sex, season, and person calling ambulance. In the subgroup analysis, we found that the number of request calls affected on-scene time ($\beta = 4.6$, $p<0.001$) and time from leaving the scene to hospital arrival ($\beta = 1.6$, $p<0.001$).

District differences in the time from request call to hospital arrival

From the results of multilevel linear regression analysis, we found that there were significant dispersions in transportation time between the 13 districts (z-score = 23.4) and the 3 areas (z-score = 6.8). (See Table 4 and Supplement table 3.) From the analyses dividing patients into three groups according to the location of the registered district of the EMS, the mean (SD) transportation times in the urban area, eastern rural area, and southern rural area were 42.1 (SD: 18.5), 48.6 (SD: 21.7), and 57.8 (SD: 31.9), respectively. The southern rural area had much longer transportation times than the other two areas. When compared with internal medicine, longer transportation times were observed for neurosurgery (+11.5 minutes), stroke (+9.9 minutes), trauma (+10.0 minutes), ACS (+10.1 minutes), orthopedics (+9.2 minutes), and cardiology (+9.2 minutes) in the southern rural area. (See Supplementary Table 4.) The eastern rural area took a much longer time in neurosurgery and trauma, with reference to internal medicine, than the urban area, and it was prolonged by 9.1 and 8.1 minutes, respectively.

Table 4. Time from Call to hospital arrival: multilevel linear regression analysis: with random effects to correct for patients clustering in the 13 districts

Explanatory valuable	Estimate (95%CI)	P-value
Fixed effects		
Intercept	31.8 (26.4, 37.2)	<0.001

Age		
≥15, <60	(ref)	
≥60, <80	1.1 (0.75, 1.5)	<0.001
≥80	0.94 (0.52, 1.4)	<0.001
Sex		
Female	(ref)	
Male	0.64 (0.32, 0.96)	<0.001
Season		
Spring (March-May)	(ref)	
Summer (June-August)	-0.50 (-0.95, -0.053)	0.028
Autumn (September-November)	0.57 (0.12, 1.0)	0.012
Winter (December-February)	0.98 (0.54, 1.4)	<0.001
Day of the week		
Monday	(ref)	
Tuesday	-0.38 (-0.96, 0.20)	0.20
Wednesday	-0.18 (-0.77, 0.41)	0.55
Thursday	0.31 (-0.28, 0.90)	0.30
Friday	-0.16 (-0.74, 0.42)	0.59
Saturday	0.71 (0.13, 1.3)	0.016
Sunday	1.1 (0.48, 1.6)	<0.001
Time category at ambulance call		
Noon (8-15)	(ref)	
Early night (16-23)	1.9 (1.6, 2.3)	<0.001
Late night (0-7)	2.9 (2.5, 3.9)	<0.001
Category of suspected illness		
Abdominal pain	-0.93 (-2.0, 0.12)	0.082
CPA	0.062 (-1.0, 1.2)	0.92
Stroke	6.2 (5.1, 7.3)	<0.001
ACS	1.4 (0.14, 2.7)	0.03
DOC	3.7 (2.2, 5.2)	<0.001
Trauma	3.8 (3.3, 4.3)	<0.001
Internal medicine	(ref)	
Orthopedics except for Trauma	2.7 (2.2, 3.2)	<0.001
Neurosurgery except for Stroke and DOC	7.4 (6.8, 7.9)	<0.001
Surgery except for Abdominal pain	-0.076 (-1.1, 0.97)	0.89
Cardiology except for ACS	5.0 (4.0, 6.1)	<0.001

Person calling ambulance		
Family or self	(ref)	
Witness	-1.7 (-2.5, -0.95)	<0.001
Welfare facility	0.6 (0.27, 1.1)	<0.001
Emergency status at request call		
Less urgency	(ref)	
Urgency	0.59 (0.08, 1.1)	0.022
Emergency	-0.16 (-0.86, 0.54)	0.66
Resuscitation	-1.8 (-4.0, 0.40)	0.11
During assessment	-1.5 (-2.0, -1.1)	<0.001
The number of request call	6.3 (6.2, 6.4)	<0.001
Random effects, variance [SD]		
Intercept	95.5 [9.8]	
z-score	23.4	
AIC	320,647	
Radj2	0.44	

SD: standard deviation, ACS: acute coronary syndromes,
CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness,
request call: request call to hospital for transportation

DISCUSSION

In this cross-sectional study, we evaluated the effect of the number of request calls on the time from call to hospital arrival. This study indicated that the time from call to hospital arrival would decrease by 4.6 minutes if all unsuccessful request calls were eliminated. The time from call to hospital arrival increases by 6.3 minutes for every request call from EMS to hospital, after adjusting for other variables. The time from call to hospital arrival is also related to age, sex, season, and person calling the ambulance.

Regarding the category of suspected illness, abdominal pain is associated with the shortest transport time, followed by surgery. The Ministry of Health, Labour and Welfare asked the prefecture governments to establish medical cooperation systems for five diseases: acute myocardial infarction, stroke, cancer, diabetes mellitus, and psychiatric illness[24]. Nara prefecture established a medical cooperation system for CPA, stroke, DOC, ACS, abdominal pain, trauma, perinatal problems, pediatrics, and psychiatric illness. In spite of national and prefectural efforts, ACS and stroke calls took 1.4 minutes and 6.2 minutes longer in transportation time compared to internal medicine. Both acute coronary syndrome and stroke are diseases where time from onset to hospital arrival is important for treatment and outcome[25–27]. A shortage of appropriate healthcare facilities in the region might be the reason for prolonged times from call to hospital arrival for these diseases. As the number of patients with cardiovascular diseases increases in Japan's aging society, further research that focuses on specific diseases or time series may be required.

This study revealed that transportation times varied depending on the patient's location when the emergency call was made. There was an approximately 30-minute difference in the time from request call to hospital arrival among the 13 districts (minimum of 36.3 minutes and maximum of 72.6 min) in a single prefecture. Nara prefecture has a long north-south axis with three tertiary emergency hospitals. However, all of these hospitals are located in urban areas that are geographically distant from the southern rural area. As a result, the southern rural area was found to have longer transportation times than the other areas. In that area, the categories of illnesses that require special facilities such as coronary care units or stroke care units had longer transportation times than in other areas. The distance from emergency hospital and appropriate healthcare facilities might be the cause of this difference between areas. One observational study discussed the shortage of emergency medical facilities in rural areas in Japan[28]. One geographical study pointed out that there was a regional gap in the number of tertiary care centers per million people between prefectures in Japan[29].

Our results also indicate that there are differences in transportation times for specific diseases among regions. In southern rural areas, there were longer transportation times for diseases that needed treatment by specialists such as cardiologists, neurologists, neurosurgeons, and orthopedists than in the other two areas. This might be associated with the shortage of medical facilities for specific illnesses in these regions. Indicating disease-specific problems that are specific to each area is helpful information for improving health care systems and is also a strength of our study.

Our database did not include patients' socioeconomic information, except for the person who called an ambulance. In the field of acute myocardial infarction and stroke, it is known that the time from onset of symptoms to hospital arrival is influenced by many other factors such as living alone[18], being alone at the onset of symptoms[19,20], being a nonwhite patient in the United States [21], and education level[22]. In addition, indicators of patient socioeconomic status, such as mean income of the residential area[30,31] and race[30], have also been reported to influence the time from an emergency call to hospital arrival. We think information about the person who called an ambulance would help to indicate the socioeconomic status of patients to some degree.

In our study, we found there were no substantial differences in times between days of the week or seasons. One study in Tennessee, USA, found that the prolongation of transportation time was influenced by seasons due to variations in traffic volume[23]. However, transportation conditions are very different between Tennessee and Nara, which may explain in part the observed differences in results between these two studies.

Our study revealed that time from call to hospital arrival increases by 6.3 minutes for every request call from EMS to hospital. It also revealed that more than

45% of all request calls and 43% of request calls to hospitals indicating a status of "Accepting patients" resulted in failure. Driving ambulances at high speed[32], helicopter transportation[33–35], and centralization of hospitals[36] might be solutions to reduce transportation time. However, the risk of traffic accidents[37], costs for helicopter emergency medical services[38,39], and time and cost for centralizing hospitals are difficult problems to solve. Hence, it may be important to create a system for quickly determining appropriate hospitals and ensuring faster admissions to decrease the number of request calls.

It may be beneficial for policymakers to create a system to share information about hospitals and emergency patients more promptly especially for an aging society with an increasing number of ambulance dispatches. One recent cross-sectional study showed that services with tablet computers shortened the transportation time in Saga prefecture, Japan[40]; even though there was no information about time from call to hospital arrival in that study, introducing these support systems would reduce time from call to hospital arrival or transportation time. In prefectures, such as Nara prefecture, where a support system with tablet computers was introduced, creating a more effective and convenient system is needed. Physicians are not only required to accept patients if requested, but must also appropriately indicate the hospital's capacity for emergency patients appropriately. As a result, this places an additional burden on physicians. Due to the shortage of physicians in Japan[41], there is a need for more effective posting of physicians and efficient working systems.

Our study has several limitations. First, patient emergency status was decided by the ambulance crew. Our data do not include vital signs for all patients, because ambulance crews are required to register vital signs of patients for only a limited number of suspected illnesses. We therefore cannot analyze patient emergency status using vital signs. As ambulance crews assessed patients by rules depending on patient's vital signs and they were also trained under the medical control system[5], the decisions made by ambulance crews were viewed as credible.

Second, our data consisted of patients in Nara prefecture. Nara prefecture is one of 47 prefectures in Japan. Our results may not be applicable to all prefectures in Japan. However, there is a discrepancy in urbanization between urbanized areas and mountainous areas such as the southern area. Therefore, we can discuss the differences between areas within one prefecture.

Lastly, there are several factors that are known to influence the time from request calls to hospital arrival, but we were unable to include them in the analysis due to data limitations. These factors include prehospital strategies[42], level of training of ambulance crews[43], and hospital capacity[44]. Future studies should address the influence of these factors.

Conclusions

The study revealed that 6.3 additional minutes were added to transportation time by every refusal of a request call and also revealed disease-specific delays among specific areas. A system that helps EMS to find hospitals should be effectively established to share information about hospitals and emergency patients promptly in partnership with policymakers and physicians for reducing the time from call to hospital arrival.

Contributors

NH has had the main responsibility for calculating statistics and writing the paper. YI is the principal investigator for the project, planned the present paper jointly with NH, and has actively taken part in revising the paper. KY and SK have taken part in planning and analyzing data and revising the paper.

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Competing interests

Kyoto University Department of Healthcare Economics and Quality Management had a financial contract with Nara prefecture to support analysis of its healthcare system. This study is out of the scope of the contract, and is not financed by Nara prefecture. Otherwise, all authors declare no financial relationships that are potentially relevant to this article.

Ethical approval

This study was approved by the Ethical Committee, Kyoto University Graduate School of Medicine, Japan

Data sharing statement

No additional data are available for sharing, because of data sharing policy.

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Figure Legends

Figure 1. Components of time from request call to hospital admission

Data for the time from the ending of request calls to leaving the scene and the time from entering a hospital to delivering a patient to hospital staff were not available.

SD: standard deviation, Qu: quartile

Supplement Figure 1. Location and map of Nara prefecture

The left side of the figure shows a map of Japan. The lines represent prefectural borders, and Nara prefecture is indicated in black. The right side of the figure shows a map of Nara prefecture. The light gray area is the eastern rural area and the black area is the southern rural area. The black circles indicate the location of the tertiary emergency hospitals in Nara prefecture.

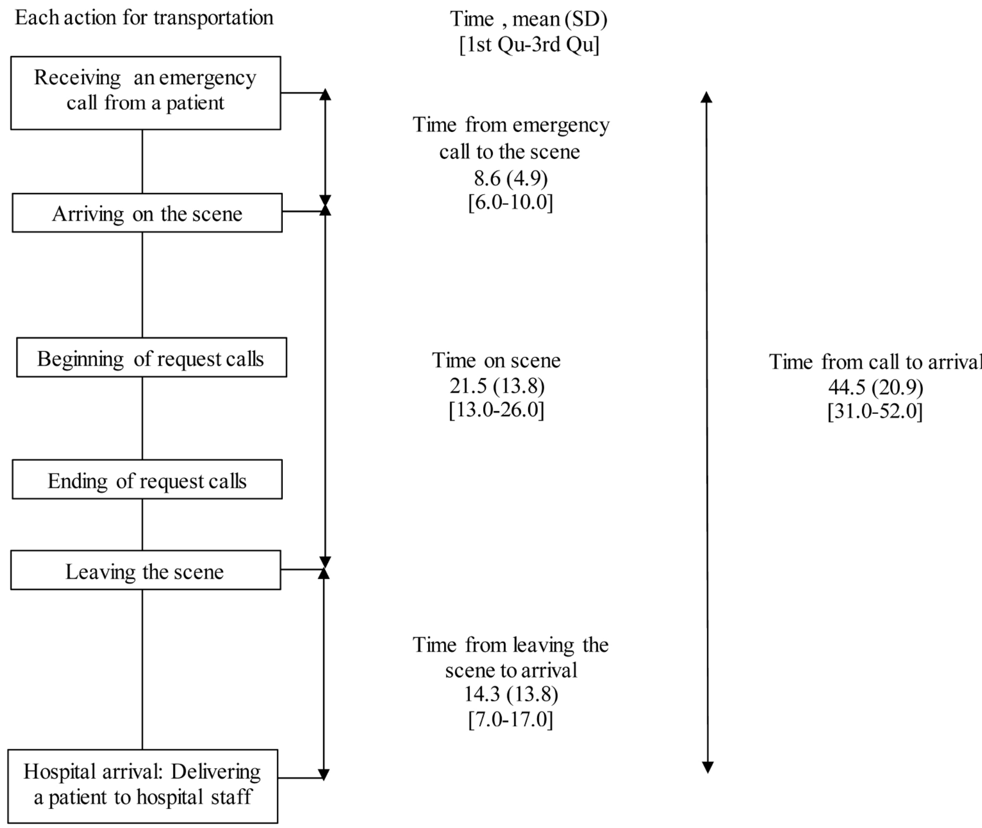
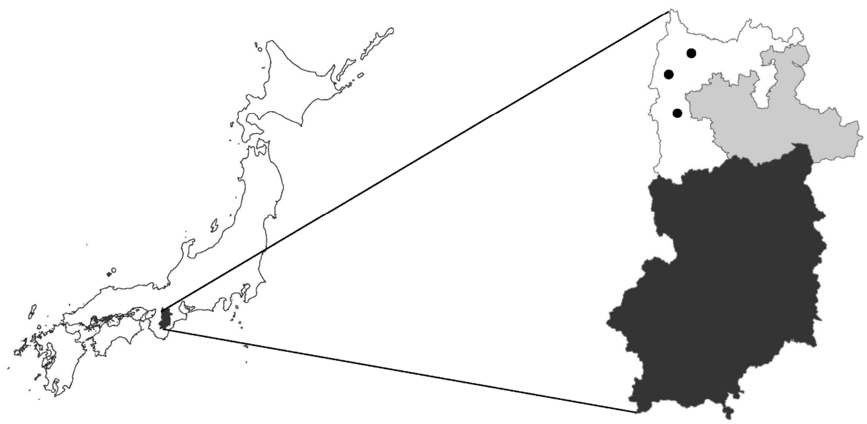


Figure 1. Components of time from request call to hospital admission
Data for the time from the ending of request calls to leaving the scene and the time from entering a hospital to delivering a patient to hospital staff were not available.
SD: standard deviation, Qu: quartile

201x168mm (300 x 300 DPI)



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297x210mm (226 x 223 DPI)

Supplement Table 1. On scene time and time from scene to hospital arrival: multilevel linear regression analysis

	On scene		From scene to hospital arrival	
Explanatory valuable	Estimate (95%CI)	P-value	Estimate (95%CI)	P-value
Fixed effects				
Intercept	9.9 (7.8, 11.9)	<0.001	12.8 (7.3, 18.4)	<0.001
Age				
≥15, <60	(ref)		(ref)	
≥60, <80	0.44 (0.18, 0.69)	<0.001	0.66 (0.40, 0.92)	<0.001
≥80	0.85 (0.58, 1.1)	<0.001	-0.007 (-0.29, 0.28)	0.96
Sex				
Female	(ref)		(ref)	
Male	-0.12 (-0.33, 0.093)	0.28	0.69 (0.47, 0.90)	<0.001
Season				
Spring (March-May)	(ref)		(ref)	
Summer (June-August)	-0.50 (-0.79, -0.20)	<0.001	-0.12 (-0.42, 0.18)	0.43
Autumn (September-November)	0.29 (-0.0030, 0.59)	0.052	0.11 (-0.19, 0.41)	0.48
Winter (December-February)	0.85 (0.56, 1.1)	<0.001	0.082 (-0.22, 0.38)	0.59
Day of the week				
Monday	(ref)		(ref)	
Tuesday	-0.074 (-0.46, 0.31)	0.71	-0.15 (-0.54, 0.24)	0.46
Wednesday	-0.0015 (-0.39, 0.39)	0.99	-0.062 (-0.46, 0.33)	0.76
Thursday	0.015 (-0.37, 0.40)	0.94	0.24 (-0.15, 0.64)	0.23
Friday	-0.11 (-0.49, 0.27)	0.58	0.022 (-0.37, 0.41)	0.91

Saturday	-0.040 (-0.42, 0.34)	0.83	0.75 (0.37, 1.1)	<0.01
Sunday	-0.032 (-0.41, 0.34)	0.87	1.2 (0.77, 1.5)	<0.001
Time category at ambulance call				
Noon (8-15)	(ref)		(ref)	
Early night (16-23)	0.87 (0.64, 1.1)	<0.001	0.93 (0.69, 1.2)	<0.001
Late night (0-7)	2.0 (1.7, 2.2)	<0.001	0.51 (0.22, 0.81)	<0.01
Category of suspected illness				
Abdominal pain	-1.2 (-1.9, -0.48)	<0.001	0.21 (-0.49, 0.92)	0.55
CPA	-4.6 (-1.2, 0.27)	0.22	-0.019 (-0.76, 0.72)	0.96
Stroke	2.6 (1.9, 3.4)	<0.001	3.4 (2.6, 4.0)	<0.001
ACS	-1.6 (-2.5, -0.78)	<0.01	3.2 (2.3, 4.0)	<0.001
DOC	2.8 (1.8, 3.8)	<0.001	0.81 (-0.20, 1.8)	0.12
Trauma	1.5 (1.2, 1.8)	<0.001	2.0 (1.7, 2.4)	<0.001
Internal medicine	(ref)		(ref)	
Orthopedics except for Trauma	0.74 (0.41, 1.1)	<0.001	1.6 (1.3, 2.0)	<0.001
Neurosurgery except for Stroke and DOC	3.2 (2.9, 3.6)	<0.001	4.1 (3.8, 4.5)	<0.001
Surgery except for Abdominal pain	0.43 (-0.26, 1.1)	0.22	-0.32 (-1.0, 0.38)	0.37
Cardiology except for ACS	-0.14 (-0.84, 0.56)	0.69	4.2 (3.5, 4.9)	<0.001
Person calling ambulance				
Family or self	(ref)		(ref)	
Witness	2.0 (1.7, 2.2)	<0.001	-0.85 (-1.1, -0.58)	<0.001
Welfare facility	-1.2 (-1.7, -0.74)	<0.001	0.28 (-0.23, 0.79)	0.29
Emergency status at request call				
Less urgency	(ref)		(ref)	
Urgency	0.64 (0.30, 0.97)	<0.01	-0.055 (-0.39, 0.28)	0.75
Emergency	-0.0071 (-0.47, 0.45)	0.98	-0.013 (-0.46, 0.48)	0.96
Resuscitation	-0.015 (-1.4, 1.4)	0.98	-1.3 (-2.7, 0.20)	0.092
During assessment	-1.4 (-1.6, -1.1)	<0.001	-0.24 (-0.52, -0.41)	0.11

The number of request call	4.6 (4.6, 4.7)	<0.001	1.6 (1.6, 1.7)	<0.001
Random effects, variance [SD]				
Intercept	12.7 [3.6]		96.9 [9.8]	
AIC	288,604		290,048	
Radj2	0.44		0.31	

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

Supplement Table 2. Time from call to hospital arrival without variable "the number of request call " : multilevel linear regression analysis

Explanatory valuable	From Call to hospital arrival Estimate (95%CI)	P-value
Fixed effects		
Intercept	42.1 (36.1, 48.0)	<0.001
Age		
≥15, <60	(ref)	
≥60, <80	-0.21 (-0.69, 0.75)	0.039
≥80	-0.44 (-0.95, 0.081)	0.098
Sex		
Female	(ref)	
Male	0.71 (0.32, 1.1)	<0.001
Season		
Spring (March-May)	(ref)	
Summer (June-August)	-0.93 (-1.5, -0.38)	<0.001
Autumn (September-November)	0.19 (-0.37, 0.74)	0.50
Winter (December-February)	1.68 (1.1, 2.2)	<0.001
Day of the week		
Monday	(ref)	
Tuesday	0.030 (-0.69, 0.75)	0.93
Wednesday	0.18 (-0.55, 0.90)	0.63
Thursday	0.52 (-0.20, 1.2)	0.16
Friday	0.097 (-0.61, 0.81)	0.79
Saturday	1.8 (1.1, 2.5)	<0.001
Sunday	2.8 (2.1, 3.5)	<0.001
Time category at ambulance call		
Noon (8-15)	(ref)	
Early night (16-23)	4.6 (4.1, 5.0)	<0.001
Late night (0-7)	7.1 (6.6, 7.6)	<0.001
Category of suspected illness		
Abdominal pain	2.0 (0.75, 3.3)	<0.01
CPA	1.5 (0.18, 2.9)	0.026
Stroke	7.6 (6.1, 9.0)	<0.001

ACS	-0.87 (-2.4, 0.71)	0.28
DOC	5.9 (4.1, 7.8)	<0.001
Trauma	4.3 (3.6, 4.9)	<0.001
Internal medicine	(ref)	
Orthopedics except for Trauma	3.8 (2.2, 4.9)	<0.001
Neurosurgery except for Stroke and DOC	5.9 (7.6, 9.0)	<0.001
Surgery except for Abdominal pain	0.47 (3.6, 4.9)	0.47
Cardiology except for ACS	3.5 (2.2, 4.9)	<0.001
Person calling ambulance		
Family or self	(ref)	
Witness	1.1 (0.59, 1.6)	<0.001
Welfare facility	-1.7 (-2.6, -0.72)	<0.001
Emergency status at request call		
Less urgency	(ref)	
Urgency	0.96 (0.071, 1.3)	0.029
Emergency	0.69 (-0.17, 1.6)	0.12
Resuscitation	-2.4 (-5.0, 0.31)	0.083
During assessment	-3.2 (-3.6, -2.6)	<0.001
The number of request call		
Random effects, variance [SD]		
Intercept	109.5 [10.5]	
AIC	336,767	
Radj2	0.11	

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

Supplement table 3. Time from Call to hospital arrival: multilevel linear regression analysis: with random effects to correct for patients clustering in the 3 areas

Explanatory valuable	Estimate (95%CI)	P-value
Fixed effects		
Intercept	33.8 (24.9, 42.7)	0.016
Age		
≥15, <60	(ref)	
≥60, <80	1.3 (0.77, 1.6)	<0.001
≥80	1.1 (0.71, 1.6)	<0.001
Sex		
Female	(ref)	
Male	0.76 (0.43, 1.1)	<0.001
Season		
Spring (March-May)	(ref)	0.14
Summer (June-August)	-0.35 (-0.81, 0.11)	0.026
Autumn (September-November)	0.53 (0.064, 0.99)	<0.01
Winter (December-February)	0.89 (0.43, 1.3)	<0.001
Day of the week		
Monday	(ref)	
Tuesday	-0.30 (-0.90, 0.30)	0.33
Wednesday	-0.054 (-0.66, 0.55)	0.86
Thursday	0.34 (-0.26, 0.95)	0.27
Friday	-0.12 (-0.72, 0.48)	0.7
Saturday	0.85 (0.26, 1.4)	<0.01
Sunday	1.1 (0.55, 1.7)	<0.001
Time category at ambulance call		
Noon (8-15)	(ref)	
Early night (16-23)	1.8 (1.4, 2.1)	<0.001
Late night (0-7)	2.6 (2.2, 3.1)	<0.001
Category of suspected illness		
Abdominal pain	-1.2 (-2.3, -0.13)	0.028
CPA	1.3 (0.17, 2.4)	0.024
Stroke	5.6 (4.5, 6.8)	<0.001
ACS	0.66 (-0.66, 2.0)	0.33
DOC	2.9 (1.4, 4.5)	<0.001

Trauma	4.3 (3.8, 4.8)	<0.001
Internal medicine	(ref)	
Orthopedics except for Trauma	3.0 (2.5, 3.5)	<0.001
Neurosurgery except for Stroke and DOC	7.3 (6.7, 7.9)	<0.001
Surgery except for Abdominal pain	0.25 (-0.83, 1.3)	0.65
Cardiology except for ACS	4.4 (3.3, 5.5)	<0.001
Person calling ambulance		
Family or self	(ref)	
Witness	-0.34 (-0.75, -0.065)	0.10
Welfare facility	-1.7 (-2.5, -0.93)	<0.001
Emergency status at request call		
Less urgency	(ref)	
Urgency	1.2 (0.71, 1.7)	<0.001
Emergency	0.24 (-0.48, 0.96)	0.51
Resuscitation	-1.0 (-3.3, 1.2)	0.36
During assessment	-3.9 (-4.4, -3.5)	<0.001
The number of request call	6.3 (6.2, 6.4)	<0.001
Random effects, variance [SD]		
Intercept	61.2 [7.8]	
z-score	6.8	
AIC	323,132	
Radj2	0.40	

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

Supplement table 4. Difference between the areas of time from call to hospital arrival: multilevel linear regression analysis

Explanatory valuable	Urban area (n = 32,657) Estimate (95%CI)	P-value	Eastern rural area (n = 7,661) Estimate (95%CI)	P-value	Southern rural area (n = 3,345) Estimate (95%CI)	P-value
Fixed effects						
Intercept	26.1 (24.5, 29.3)	<0.001	32.5 (20.5, 44.5)	0.023	36.1 (20.9, 51.3)	0.022
Age						
≥15, <60	(ref)		(ref)		(ref)	
≥60, <80	1.2 (0.79, 1.60)	<0.001	1.90 (1.0, 2.8)	<0.001	-0.84 (-3.4, 1.7)	0.52
≥80	0.89 (0.46, 1.33)	<0.001	1.22 (0.27, 2.2)	<0.01	1.2 (-1.4, 3.9)	0.36
Sex						
Female	(ref)		(ref)		(ref)	
Male	0.31 (-0.021, 0.64)	0.066	0.31 (-0.40, 1.0)	0.39	4.2 (2.3, 6.2)	<0.001
Season						
Spring (March-May)	(ref)		(ref)		(ref)	
Summer (June-August)	-0.85 (-1.3, -0.39)	<0.001	-0.023 (-1.0, 0.98)	0.96	2.3 (-0.50, 5.0)	0.110
Autumn (September-November)	0.16 (-0.31, 0.63)	0.50	0.82 (-0.18, 1.8)	0.11	3.6 (0.81, 6.4)	0.012
Winter (December-February)	0.68 (0.22, 1.1)	<0.01	1.67 (0.68, 2.7)	<0.01	2.8 (0.027, 5.5)	0.049
Day of the week						
Monday	(ref)		(ref)		(ref)	

Tuesday	-0.16 (-0.77, 0.44)	0.60	-1.2 (-2.5,0.080)	0.066	-0.55 (-4.1, 3.0)	0.76
Wednesday	0.028 (-0.59, 0.64)	0.93	0.028 (-1.30, 1.4)	0.97	-2.1 (-5.7, 1.5)	0.26
Thursday	0.48 (-0.13, 1.1)	0.12	0.11 (-1.2, 1.4)	0.87	-0.93 (-4.6, 2.7)	0.62
Friday	-0.080 (-0.69, 0.53)	0.80	-0.68 (-2.0, 0.62)	0.31	0.41 (-3.2, 4.0)	0.82
Saturday	0.62 (0.024, 1.2)	0.042	0.11 (-1.2, 1.4)	0.87	3.6 (0.12, 7.1)	0.044
Sunday	0.70 (0.10, 1.3)	0.022	0.99 (-0.30, 2.3)	0.13	4.3 (0.88, 7.6)	0.014
Time category at ambulance call						
Noon (8-15)	(ref)		(ref)		(ref)	
Early night (16-23)	1.7 (1.3, 2.1)	<0.001	2.6 (1.8, 3.4)	<0.001	4.2 (2.0, 6.4)	<0.001
Late night (0-7)	2.8 (2.3, 3.3)	<0.001	3.1 (2.1, 4.1)	<0.001	4.8 (2.0, 7.5)	<0.001
Category of suspected illness						
Abdominal pain	-0.73 (-1.9, 0.42)	0.21	-1.5 (-3.6, 0.55)	0.15	2.0 (-4.1, 8.0)	0.53
CPA	-1.2 (-2.4, -0.023)	0.046	4.6 (2.3, 6.8)	<0.001	-0.087 (-6.5, 6.4)	0.98
Stroke	6.4 (5.1, 7.7)	<0.001	5.9 (3.8, 8.0)	<0.001	9.9 (3.3 16.6)	<0.01
ACS	0.26 (-1.2, 1.8)	0.73	2.1 (-0.21, 4.4)	0.076	10.1 (3.5, 16.6)	<0.01
DOC	3.8 (2.1, 5.5)	<0.001	4.4 (1.9, 7.0)	<0.001	4.7 (-6.1, 15.5)	0.40

Trauma	1.8 (1.3, 2.3)	<0.001	8.1 (7.1, 9.2)	<0.001	10.0 (6.7, 13.2)	<0.001
Internal medicine	(ref)		(ref)		(ref)	
Orthopedics except for Trauma	1.5 (1.0, 2.0)	<0.001	4.5 (3.2, 5.7)	<0.001	9.2 (6.3, 12.1)	<0.001
Neurosurgery except for Stroke and DOC	6.6 (6.0, 7.1)	<0.001	9.1 (7.7, 10.5)	<0.001	11.5 (8.0, 14.9)	<0.001
Surgery except for Abdominal pain	-0.084 (-1.1, 0.98)	0.88	-0.33 (-3.3, 2.6)	0.82	-0.46 (-6.5, 5.6)	0.88
Cardiology except for ACS	4.4 (3.4, 5.4)	<0.001	5.5 (1.9, 9.1)	<0.01	9.2 (0.59, 17.8)	0.037
Person calling ambulance						
Family or self	(ref)		(ref)		(ref)	
Witness	0.35 (-0.068, 0.76)	0.10	0.98 (0.11, 1.8)	0.027	2.3 (-0.23, 4.9)	0.075
Welfare facility	-0.79 (-1.6, 0.021)	0.056	1.1 (-0.80, 3.1)	0.25	-7.3 (-10.8, -3.9)	<0.001
Emergency status at request call						
Less urgency	(ref)		(ref)		(ref)	
Urgency	0.84 (0.30, 1.4)	<0.01	1.7 (0.66, 2.8)	<0.01	-3.3 (-6.2, -0.35)	0.029
Emergency	-0.033 (-0.78, 0.72)	0.93	0.012 (-1.5, 1.5)	0.99	-2.7 (-6.7, 1.3)	0.19
Resuscitation	-0.99 (-3.2, 1.2)	0.37	-3.2 (-9.2, 2.7)	0.29	-5.5 (-19.4, 8.4)	0.44
During assessment	-1.2 (-1.7, -0.80)	<0.001	-1.9 (-2.8, -1.0)	<0.001	-3.6 (-6.3, -0.94)	<0.01

The number of request call (mean (SD))	6.2 (6.1, 6.3)	<0.001	6.5 (6.3, 6.7)	<0.001	6.7 (6.2, 7.2)	<0.001
Random effects, variance [SD]						
Intercept	8.5 [2.9]		81.7 [9.0]		126.4 [11.2]	
AIC	231,005		58,625		27,533	
Radj2	0.41		0.52		0.32	

SD: standard deviation, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract -p2, p4 in abstract and p9 in METHODS
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found – p4
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported -p7
Objectives	3	State specific objectives, including any prespecified hypotheses – p8
Methods		
Study design	4	Present key elements of study design early in the paper – p9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection –p9-11
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants – p11
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable – p12-13
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group –p9
Bias	9	Describe any efforts to address potential sources of bias – p9-10
Study size	10	Explain how the study size was arrived at – p9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why - p12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding –p13
		(*b*) Describe any methods used to examine subgroups and interactions –p14
		(*c*) Explain how missing data were addressed –p11
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy – p13
		(*e*) Describe any sensitivity analyses –p13

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed –p15
		(b) Give reasons for non-participation at each stage –not applicable
		(c) Consider use of a flow diagram – no use
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders –p15-17
		(b) Indicate number of participants with missing data for each variable of interest-p16 table1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures -p16
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included -p21-23
		(*b*) Report category boundaries when continuous variables were categorized –p13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period – not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses –p21 and supplement table 1, supplement table 2, supplement table 3, supplement table 4
Discussion		
Key results	18	Summarise key results with reference to study objectives – p23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias –p27-28
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence –p28-29
Generalisability	21	Discuss the generalisability (external validity) of the study results –p28
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based –p30

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Correction

Hanaki N, Yamashita K, Kunisawa S, *et al.* Effect of the number of request calls on the time from call to hospital arrival: a cross-sectional study of an ambulance record database in Nara prefecture, Japan. *BMJ Open* 2016;6:e012194.

The baseline patient characteristics were compared using analysis of variance (ANOVA), not the Kruskal–Wallis test. Therefore the corrected Table 1 footnote should read:

*P-value by ANOVA
†P-value by Student's t-test
SD: standard deviation, Qu: quartile, ACS: acute coronary syndromes, CPA: Cardiopulmonary arrest, DOC: disturbance of consciousness, request call: request call to hospital for transportation
The detailed information about each area are not available for disclosing, because of data sharing policy.

In table 3 the column header "Time from call to hospital arrival" should read "Time for request call". The corrected Table 3 is shown below.

Table 3 The number and the time for request call categorized by hospital displayed acceptability and request results

Hospital Displayed Admission Acceptability	Result	Number of request call n (%) N=79,693	Time for request call mean (SD)	Time for request call 1st Qu-3rd Qu	P-value*
Accepting patients	Success	32,416 (40.7)	4.9 (3.4)	2.0–6.0	
Not accepting patients	Success	11,247 (14.1)	4.5 (3.9)	2.0–6.0	
Accepting patients	Failure	24,629 (30.9)	4.2 (3.1)	2.0–5.7	
Not accepting patients	Failure	11,401 (14.3)	4.2 (3.5)	2.0–5.3	<0.001

*P-value by ANOVA.
Request call: request call to hospital for transportation, SD: standard deviation, Qu: quartile.

BMJ Open 2017;**7**:e012194corr1. doi:10.1136/bmjopen-2016-012194corr1

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