




Original Article

Risk factors for cancellation after dispatch of rapid response cars for prehospital emergency care: a single-center, case–control study

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Abstract

Aim: The objective of this study is to identify the risk factors for cancellation after dispatch of rapid response cars (RRC) for prehospital emergency care.

Methods: We retrospectively extracted data from all RRC cases dispatched from our hospital between April 2017 and March 2019. A total of 1,440 cases were included in our study and divided into either the “cancelled” group ($n = 723$) or the “treated” group ($n = 717$), based on the occurrence of cancellation. The variables obtained from the request calls for RRC included patient characteristics, distance from the hospital to the scene, and reasons for RRC request. The variables were compared between the two groups and logistic regression analysis was carried out to identify the risk factors for RRC cancellation.

Results: Multivariable analysis showed that distance from the hospital to the scene (odds ratio [OR] 1.25; 95% confidence interval [CI], 1.21–1.28), suspicion of cardiopulmonary arrest with no witness information (OR 7.61; 95% CI, 4.13–14.00), dyspnea (OR 2.22; 95% CI, 1.19–4.11), and suicide by hanging (OR 3.49; 95% CI, 1.37–8.89) were independent risk factors for cancellation.

Conclusions: In our study, a greater distance from the hospital to the scene, suspicion of cardiopulmonary arrest with no witness information, dyspnea, and suicide by hanging were identified as independent risk factors for cancellation after dispatch of RRC. Evaluating the risk factors for cancellation at individual facilities could help hospitals adjust their dispatch criteria to allocate limited medical resources more effectively.

Key words: cancellation, dispatch, physician-staffed emergency medical service, prehospital emergency care, rapid response car

INTRODUCTION

PHYSICIAN-staffed emergency medical services (P-EMS) using helicopters or rapid response cars (RRC) are well established in many developed countries, especially in Europe.^{1–5} Although the operational concept of P-EMS may differ among countries or institutions, a common feature is the involvement of a physician trained in the prehospital care of critically ill or injured patients. Physician-staffed emergency medical services by helicopter are considered to be effective in remote areas,^{6,7} whereas

RRC-based P-EMS appear to be more applicable in urban areas.⁸

Because P-EMS are usually dispatched based on incomplete information received during emergency calls from citizens, cancellation after dispatch sometimes happens, resulting in a waste of human and financial resources. Although there have been many studies evaluating the effects of P-EMS on patient outcomes,^{9–14} few studies have focused on P-EMS cancellation after dispatch. Giannakopoulos et al. assessed the cancellation rate of mobile medical teams transported by helicopter or vehicle¹⁵ and defined the criteria for cancelling helicopter emergency medical services (HEMS) to reduce unjustified HEMS dispatches.¹⁶ However, there might be different risk factors for cancellation of RRC-based P-EMS compared to HEMS because of the different features in transportation.

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According to the Japanese Ministry of Health, Labor and Welfare, as of March 2017, there are 239 RRC operated at critical care centers in Japan. Although individual facilities operate their RRC according to their own dispatch criteria, in the absence of specific guidelines, institutions often follow the HEMS criteria defined by the government. Our hospital is no exception. However, due to the very high cancellation rate, it might be unsuitable to apply the dispatch criteria for HEMS to RRC-based P-EMS.

In this study, we aimed to clarify the risk factors for cancellation of RRC using data extracted from the RRC requests received by our hospital.

METHODS

Data sources and RRC system

OUR HOSPITAL IS a tertiary care facility with 785 inpatient beds, including 21 beds for intensive care. Our emergency department accepted 22,257 emergency patients and 5,769 ambulances in 2019. We have been operating one RRC covering all the districts of Urayasu city and Ichikawa city in Chiba prefecture, Japan. The map and basic characteristics of our medical control area are shown in Figure 1. The total population of the combined area is 660,435, and the total area is 74.69 km². At our hospital, RRC is dispatched upon request from the fire department between 9:00 a.m. and 5:00 p.m. on weekdays. The crew members include one or two emergency physicians, one nurse, and two paramedics. The dispatch criteria for our RRC system are listed in Table 1. The fire department requests our RRC dispatch by the keywords of the criteria immediately after receiving the emergency call from a citizen. The criteria allow over-triage, and the ambulance crew can suggest cancellation of RRC upon their arrival at the emergency scene in cases where the RRC appears not to be necessary. Information such as the date, age and gender of the patient, reason for RRC request, location of the scene, occurrence of cancellation, reason for cancellation, and the hospital to which the patient has been transported are recorded after each RRC activity. The reasons for the RRC request are recorded as per the initial request call, rather than the final diagnosis (e.g., if the reason for the initial request call was “suspected cardiopulmonary arrest [CPA]”, we record “suspected CPA”, even if the final diagnosis was found to be syncope).

Study design and selection of participants

We undertook a retrospective study of cases in which the RRC was dispatched from our hospital between April 2017

and March 2019. All of the requests for dispatch by the fire department were reviewed. We excluded cases in which the RRC was not dispatched to the scene for some reason, cases that did not meet dispatch criteria, and cases where no sufficient information on the location of the scene was given. The cases finally included were divided into either the “cancelled” group or the “treated” group, based on the occurrence of cancellation.

Study variables

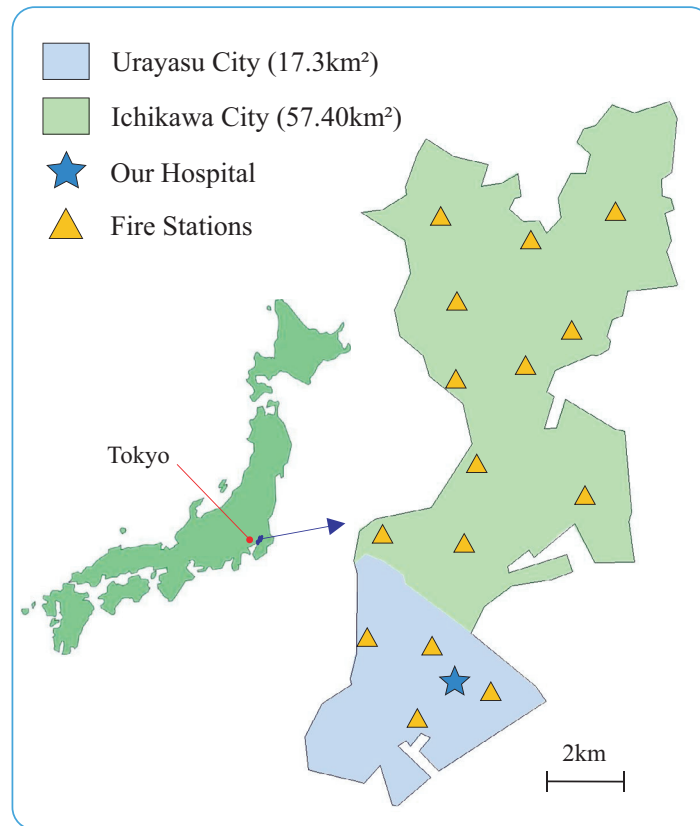
Study variables included information that we could obtain from a request call, such as the age and gender of the patient, distance from the hospital to the scene, and reasons for RRC request. Although the dispatch criteria did not include the presence of witnesses, we divided the cases of suspected CPA into either the “witnessed CPA” or the “CPA with no witness information” variable based on the record, because the presence of witnesses was regarded as an important factor for cancellation.

Statistical analysis

The median with interquartile range is used to present patient data that were continuous variables with nonparametric statistical distribution. Categorical variables are displayed as raw values followed by percentages in parentheses. The Mann–Whitney *U*-test was used to compare the medians of the two samples. The χ^2 -test was used to compare frequencies. Odds ratios (OR) and 95% confidence intervals (CI) for cancellation were determined using multivariable logistic regression, adjusted for the following covariates: age, gender, distance from our hospital, reasons for request including suspected CPA (witnessed or with no witness information), acute coronary syndrome or acute aortic syndrome, dyspnea, stroke, unconsciousness, status epilepticus, traffic injury, fall from heights, suicide by hanging, and anaphylaxis. The two-sided significance level for all tests was set at 5% ($P < 0.05$). All analyses were carried out using EZR software, version 3.3.2 (Easy R; Saitama Medical Center, Jichi Medical University, Saitama, Japan).¹⁷ We used listwise deletion for missing values existing in the age and gender.

Calculation of costs and working time

We calculated the fuel costs per kilometer by dividing the total fuel costs (in Japanese yen) by the total distance that the RRC had run in the study period. The mean additional fuel costs for cancellation were



	Urayasu city	Ichikawa city
Population	170,142	490,293
Area	17.29 km ²	57.40 km ²
Number of ambulances	6	12
Number of dispatches of ambulance (per year)	8,592	23,850
Mean time from emergency calls to the scenes	7min.	8min.31sec.
Mean time from emergency calls to the hospitals	28min.	31min.29sec.
Number of all emergency hospitals	4	8
Number of critical care centers	1	0

Figure 1. Map of the location in Japan where the study was carried out, and basic characteristics of our medical control area. Our physician-staffed emergency medical service using the rapid response car system covers all the districts of Urayasu city and Ichikawa city in Chiba prefecture, Japan. Our hospital is the only critical care center in this area.

calculated using the fuel costs per kilometer and the mean distance that the RRC had run for cancelled cases. There were no additional labor costs for cancelled cases because crew members are salaried employees at our institute. The mean working time for cancelled cases was calculated as the mean time from dispatch to arrival at our hospital.

Proposal of the modified dispatch criteria and its evaluation

Following the result of multivariable analysis, we tentatively modified the dispatch criteria, considering not only the reduction of the cancellation rate but also sustainable practicability for us and the fire department. We applied the

Table 1. Dispatch criteria for a Japanese physician-staffed emergency medical service using the rapid response car system

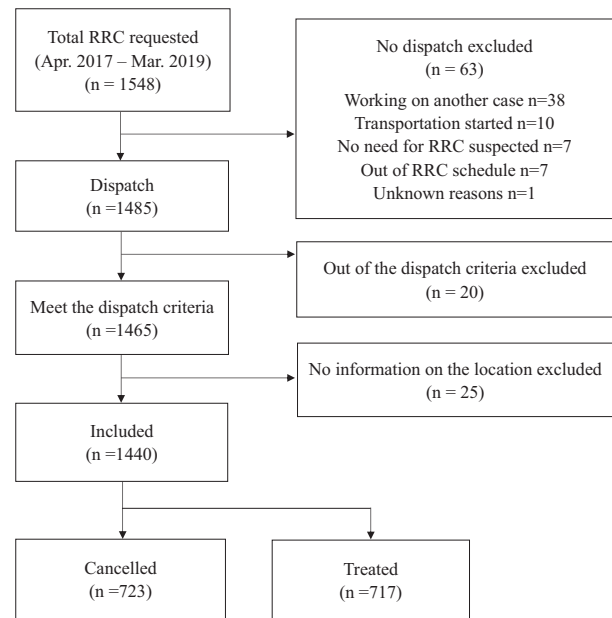
Suspected cardiopulmonary arrest
Internal diseases or conditions
Severe chest and/or back pain (suspected acute coronary syndrome or acute aortic syndrome)
Dyspnea (suspected severe respiratory failure)
Unconsciousness
Sudden neurological deficit or severe headache (suspected stroke)
Status epilepticus
Hematemesis (suspected hemorrhagic shock)
External causes
High-risk traffic accident
Fall from heights
Crush injury of extremities
Penetrating trauma
Accidents involving trains
Severe burn
Suicide by hanging
Drowning
Asphyxia
Poisoning
Anaphylaxis

revised criteria to the same dataset of the current study (our RRC data between April 2017 and March 2019), and then estimated the alteration of the number of the treated or cancelled cases as well as the cancellation rate.

RESULTS

Subject characteristics

DURING THE STUDY period, a total of 1,548 requests for dispatch by the fire department were recorded. A total of 1,440 cases were finally included in our study after excluding 108 cases (Fig. 2). Among all the included cases, 723 cases were cancelled after dispatch (cancelled group) and 717 cases were treated by physicians on the scene (treated group). The distribution of cases in each group on the map are also shown Figure 3. The main characteristics of each group are shown in Table 2. Male patients accounted for 57.6%. The median age was 74 (60–84) years in the cancelled group and 70 (45–81) years in the treated group ($P < 0.001$). The median distance from the hospital was 13.0 (5.7–15.0) km in the cancelled group and 4.8 (2.4–9.0) km in the treated group ($P < 0.001$). In terms of the reasons for request, CPA with no witness

**Figure 2.** Flow diagram of participant selection in this study of risk factors for cancellation of the physician-staffed emergency medical service using the rapid response car (RRC) system.

information was significantly higher in the cancelled group (43.6% and 12.0%, $P < 0.001$). Witnessed CPA (0.3% and 4.9%, $P < 0.001$), stroke (7.6% and 12.3%, $P = 0.004$), unconsciousness (7.9% and 12.8%, $P = 0.002$), status epilepticus (2.2% and 5.0%, $P = 0.005$), traffic injury (0.8% and 5.9%, $P < 0.001$), fall from heights (1.2% and 6.3%, $P < 0.001$), crush injury (0.1% and 1.5%, $P = 0.003$), asphyxia (1.0% and 2.6%, $P = 0.018$), and anaphylaxis (2.2% and 5.4%, $P = 0.001$) were significantly higher in the treated group.

Multivariable analysis

The results of the multivariable logistic regression for cancellation are shown in Table 3. Distance from the hospital was significantly related to cancellation (OR 1.25; 95% CI, 1.21–1.28; $P < 0.001$). In terms of the reasons for request, CPA with no witness information (OR 7.61; 95% CI, 4.13–14.00; $P < 0.001$), dyspnea (OR 2.22; 95% CI, 1.19–4.11; $P = 0.01$), and suicide by hanging (OR 3.49; 95% CI, 1.37–8.89; $P = 0.009$) were independent risk factors for cancellation. Conversely, witnessed CPA (OR 0.11; 95% CI, 0.02–0.52; $P < 0.001$), traffic injury (OR 0.14; 95% CI, 0.04–0.49; $P = 0.002$), and fall from heights (OR 0.30; 95% CI, 0.12–0.76; $P = 0.012$) decreased the risk of cancellation.

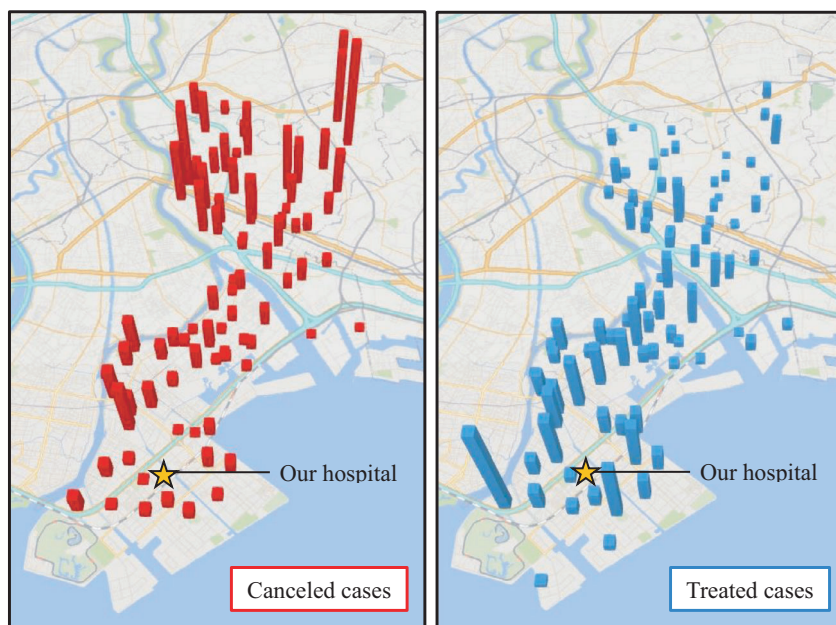


Figure 3. Distribution of cases for whom rapid response cars were dispatched for prehospital emergency care. Columns show the distribution of cases in each group the towns in our medical control area. Left panel, cases for whom the RRC was cancelled; right panel, cases treated by RRC personnel.

Reasons for cancellation

The details of actual reasons for cancellation, which were recorded in our data, are shown in Table 4. The top three reasons, which were starting transportation to another hospital (33.2%, 240/723), postmortem changes (32.1%, 232/723), and mild conditions (22.2%, 161/723) accounted for the majority of all cancelled cases. Among the identified risk factors for cancellation (CPA with no witness information, dyspnea, suicide by hanging, and distance from the hospital), 62.9% (198/315) of cancelled cases of CPA with no witness information, and 84.0% (21/25) of cancelled cases of suicide by hanging had no indication for resuscitation because of postmortem changes, such as rigor mortis or decomposition. The major reasons for cancellation in cases of dyspnea were starting transportation to another hospital (46.2%, 61/132) and mild conditions (35.6%, 47/132). In addition, the median distance from the hospital was greater when the actual reason for cancellation was due to starting transportation to another hospital.

Additional fuel costs and working time for cancelled cases

The mean fuel cost for cancelled cases in the study period was ¥283 (~\$2.57), resulting in a total loss of ¥102,305

(~\$930.05) per year. The mean working time (as measured by the duration the health workers spent outside the hospital) corresponding to the cancelled cases in the study period was 31 minutes, resulting in a total loss of approximately 187 hours per person per year.

Our proposal of the modified dispatch criteria and its evaluation

Based on the risk factors for RRC cancellation revealed by the multivariable analysis, we decided to remove only CPA with no witness information in the modified dispatch criteria, after discussion. Thus, suspected CPA is limited to only witnessed cases in the proposed dispatch criteria. The comparison between the modified dispatch criteria and the original is described in Table 5. Using the modified criteria, the number of total RRC dispatches would decrease from 1,440 to 1,039. The number of treated and cancelled cases would decrease from 717 to 631, and from 723 to 408, respectively. Consequently, the cancellation rate would decline from 50.2% to 39.2%.

DISCUSSION

TO THE BEST of our knowledge, this is the first study to evaluate the risk factors for cancellation after

Table 2. Main characteristics of the study subjects, for whom rapid response cars were dispatched for prehospital emergency care

Variable	Cancelled (<i>n</i> = 723)	Treated (<i>n</i> = 717)	<i>P</i> -value	Missing data
Age (years)	74 (60–84)	69 (45–81)	<0.001	63
Gender (male)	385/668 (57.6)	434/717 (60.5)	0.275	55
Distance from hospital (km)	13.0 (5.7–15.0)	4.8 (2.4–9.0)	<0.001	
Reason for request				
CPA	317 (43.8)	121 (16.9)	<0.001	
Witnessed	2 (0.3)	35 (4.9)	<0.001	
No witness information	315 (43.6)	86 (12.0)	<0.001	
Internal disease	325 (45.0)	412 (57.5)	<0.001	
ACS/AAS	56 (7.7)	72 (10.0)	0.139	
Dyspnea	132 (18.3)	110 (15.3)	0.159	
Stroke	55 (7.6)	88 (12.3)	0.004	
Unconsciousness	57 (7.9)	92 (12.8)	0.002	
Status epilepticus	16 (2.2)	36 (5.0)	0.005	
Hematemesis	7 (1.0)	9 (1.3)	0.626	
External cause	81 (11.2)	184 (25.7)	<0.001	
Traffic injury	6 (0.8)	42 (5.9)	<0.001	
Fall from height	9 (1.2)	45 (6.3)	<0.001	
Crush injury	1 (0.1)	11 (1.5)	0.003	
Penetrating trauma	0 (0)	2 (0.3)	0.248	
Accidents involving trains	3 (0.4)	0 (0)	0.249	
Burn	1 (0.1)	4 (0.6)	0.216	
Suicide by hanging	25 (3.5)	15 (2.1)	0.148	
Drowning	8 (1.1)	4 (0.6)	0.386	
Asphyxia	7 (1.0)	19 (2.6)	0.018	
Poisoning	5 (0.7)	3 (0.4)	0.726	
Anaphylaxis	16 (2.2)	39 (5.4)	0.001	

Data are shown as *n* (% of total number of each group) or median (interquartile range). Missing data are age (*n* = 63) and gender (*n* = 55). AAS, acute aortic syndrome; ACS, acute coronary syndrome; CPA, cardiopulmonary arrest.

dispatch of RRC-based P-EMS. Our multivariable analysis using our single-center RRC data revealed that distance from the hospital to the scene, suspected CPA with no witness information, dyspnea, and hanging were independent risk factors for RRC cancellation.

For each identified risk factor, the reason why RRC was cancelled seemed to be different. A greater distance to the scene resulted in cancellation because of the early determination of a closer transport destination before our RRC arrived at the scene. With regard to the reasons for request, a large number of cases of CPA with no witness information and suicide by hanging were cancelled because of post-mortem changes. However, in most of cancelled cases of dyspnea, either transport had started or the condition was mild. Mild cases of dyspnea rarely require the involvement of P-EMS. Moreover, mild cases usually have a greater choice of hospitals to be transported to than severe cases; thus, the transport destination was easy to select. For these

reasons, cases of dyspnea might be more likely to include over-triage cases for RRC requests than other conditions.

The consideration of cost is an important issue in P-EMS. Several studies have estimated the cost-effectiveness of HEMS as the cost per life-year saved.^{18–20} However, most of these studies did not focus on the additional costs of cancelled cases. One exception is Giannakopoulos et al., who calculated that the mean additional costs of HEMS and the mean additional working time were €239.2 and 5.98 minutes per cancelled flight, respectively.¹⁵ To our knowledge, there are no reported estimations of the additional costs of cancelled cases of RRC-based P-EMS. Our single-center study using RRC data showed for the first time that the mean additional fuel costs were ¥283 (~\$2.57) per cancelled dispatch, which were much lower than for HEMS. However, the cancellation of RRC after dispatch resulted in the loss of not only financial but also human resources. The mean working time of cancelled cases in our study period was

Table 3. Multivariable logistic regression analysis of risk factors for cancellation of physician-staffed emergency medical services using rapid response cars

Variable	OR	95% CI	P-value
Age (years)	1.00	0.99–1.01	0.750
Gender (male)	0.93	0.71–1.23	0.620
Distance from the hospital	1.25	1.21–1.28	<0.001
Reason for request			
CPA			
Witnessed	0.11	0.02–0.52	<0.001
No witness information	7.61	4.13–14.00	<0.001
Internal disease			
ACS/AAS	1.39	0.70–2.74	0.350
Dyspnea	2.22	1.19–4.11	0.010
Stroke	0.83	0.42–1.62	0.590
Unconsciousness	1.35	0.69–2.61	0.380
Status epilepticus	0.84	0.34–2.06	0.700
External cause			
Traffic injury	0.14	0.04–0.49	0.002
Fall from height	0.30	0.12–0.76	0.012
Suicide by hanging	3.49	1.37–8.89	0.009
Anaphylaxis	0.82	0.32–2.11	0.680

AAS, acute aortic syndrome; ACS, acute coronary syndrome; CI, confidence interval; CPA, cardiopulmonary arrest; OR, odds ratio.

31 minutes, resulting in a huge loss of approximately 187 hours per person per year. Although the time value is generally difficult to evaluate compared with the financial cost, we assume that the impact of the wasted time of crew members is not negligible. Reducing the number of crew

Table 5. Comparison between modified criteria and original criteria for dispatch of physician-staffed emergency medical services using rapid response cars (RRC)

	Modified	Original
Total RRC dispatch	1,039	1,440
Treated cases	631	717
Cancelled cases	408	723
Cancellation rate (%)	39.2	50.2
Fuel cost for cancelled cases (per year)	\$504.44	\$930.05
Working time of cancelled cases (per person per year)	~102 h	~187 h

members on RRC could lead to a reduction in the total labor cost.

Optimization of the dispatch criteria to maintain a fine balance between therapeutic effectiveness and resource consumption is challenging. A reduction in the cancellation rate could lead to an increase of under-triage (increased cases of no RRC dispatch in which RRC involvement would have had beneficial effects on patient outcome). In fact, we did not remove the detected risk factors for cancellation, such as dyspnea or the greater distance from the hospital to the scene, in our modified dispatch criteria. If we excluded all dyspnea cases from the dispatch criteria, 110 cases in the study period that had actual RRC involvement would be excluded. In addition, including the information about the distance from the hospital in the dispatch criteria would not be a good strategy because it could cause the delay of RRC requests from the fire department and thus lead to the delay of prehospital care for

Table 4. Details of reasons for cancellation of physician-staffed emergency medical services using rapid response cars

	Starting transport to another hospital	Postmortem changes	Mild condition	Dispatch to another case	DNAR	Absence of patient	Missing data
All cancelled cases (n = 723)	237 (33.2)	232 (32.1)	161 (22.2)	36 (5.0)	4 (0.6)	3 (0.4)	50 (6.9)
Reason for request							
CPA with no witness information (n = 315)	48 (15.2)	198 (62.9)	33 (10.5)	4 (1.3)	3 (1.0)	3 (1.0)	26 (8.3)
Dyspnea (n = 132)	61 (46.2)	0 (0.0)	47 (35.6)	13 (9.8)	1 (0.8)	0 (0.0)	10 (7.6)
Suicide by hanging (n = 25)	1 (4.0)	21 (84.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (12.0)
Median distance from hospital (km)	13.5	8.7	9.5	11.8	8.9	3.4	11.3

Data are shown as n (% of total number of all cancelled cases or each reason for request). CPA, cardiopulmonary arrest; DNAR, do not attempt resuscitation.

patients. Criteria should be changed specifically to the medical control area. These are the reasons why we excluded only CPA with no witness information when we modified the dispatch criteria. The cancellation rate of 39.2% in the modified criteria might still seem high, however, we consider it to be acceptable for our individual medical control area and human resources in the institution.

LIMITATIONS

THERE ARE SEVERAL limitations to our study. First, there is a selection bias because the final decision for cancellation was dependent on the emergency physician on the RRC, except in the case of postmortem changes. Second, this was a single-center study, and our results cannot guarantee generalizability. There is a large variety of contexts that could influence RRC operation across countries and regions (such as population characteristics, geographical conditions, the distribution and capacity of medical institutions, and EMS systems). Thus, we recommend individual facilities to evaluate their risk factors for RRC cancellation and to adjust their dispatch criteria by referring to the results of the current study.

CONCLUSIONS

IN CONCLUSION, THE greater distance from the hospital to the scene, suspicion of CPA with no witness information, dyspnea, and suicide by hanging were detected as independent risk factors for cancellation after dispatch of RRC in our study. Evaluating the risk factors for cancellation at individual facilities would help them adjust their RRC systems, including dispatch criteria, and allocate limited human and financial resources more effectively.

ACKNOWLEDGMENT

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DISCLOSURE

Approval of the research protocol: This study protocol was approved by the ethics committee at our institution (approval no. 2-064).

Informed consent: The need for informed consent was waived by the ethics committee at our institution due to the retrospective observational design of the study.

Registry and the registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None.

DATA AVAILABILITY STATEMENT

THE DATA SUPPORTING the findings of this study are available upon reasonable request.

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