Original Article

Physician-manned prehospital emergency care in tertiary emergency centers in Japan

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Aim: Use of a physician-manned prehospital emergency medical service (EMS) has recently become widespread in Japan. Understanding the epidemiology of critically ill patients is essential for planning national and regional physician-manned prehospital EMS systems. However, current knowledge on patients receiving physician-manned prehospital EMS is sparse. The present study aimed to determine the clinical features of critically ill patients with and without physician-manned prehospital EMS, using a national inpatient database in Japan.

Methods: Using the Japanese Diagnosis Procedure Combination inpatient database, we identified all hospitalized patients transported to tertiary emergency centers by physician-manned EMS or EMS without a physician from April 2014 to March 2015. We collected data on patient characteristics, in-hospital mortality, admission diagnoses, advanced life support interventions, and incidence of critical illnesses.

Results: We identified 497,911 hospitalized patients transported to tertiary emergency centers by EMS. Of these, 15,507 (3%) patients were hospitalized by physician-manned EMS. The majority of admission diagnoses in the physician-manned EMS group were classified "diseases of the circulatory system" (45%) and "injury, poisoning and certain other consequences of external causes" (34%). The rates of in-hospital mortality, advanced life support interventions, and critical illnesses in the physician-manned EMS group were 22%, 51%, and 53%, respectively. The median incidences of hospitalized patients by physician-manned EMS, advanced life support interventions, and critical illnesses were 12, 137, and 205 per 100,000 persons per year in facilities with physician-manned EMS, respectively.

Conclusion: Our study indicates that physician-manned EMS is dispatched to a relatively small proportion of critically ill patients in Japan.

Key words: Critical illness, emergency medical service, physician-manned ambulance, physician-manned helicopter, prehospital care

INTRODUCTION

THE UNDERLYING CONCEPT for a physician-manned prehospital emergency medical service (EMS) is the improvement of outcomes in selected patients who are likely to require critical care in the prehospital phase. The first physician-manned mobile intensive care unit was put into service in Heidelberg in 1957,[1] and the first physician-manned helicopter became operational in Munich in 1968.[2] Many European and Australasian countries have started to deploy physicians in the prehospital scene.[3,4]

In Japan, physician-manned EMS systems, including physician-manned ambulances and physician-manned helicopters, have been spreading rapidly, mainly in association with tertiary emergency centers.[5] The number of prehospital dispatches of physicians to emergency scenes doubled within 5 years from 2011 (n = 19,102/year) to 2016 (n = 35,719/year).[6,7] Nevertheless, this number failed to

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reach 0.6% (35,719/6,209,964) of the total number of ambulance dispatches in 2016.[7]

Understanding the epidemiology of critically ill patients could allow rational planning strategies for national and regional physician-manned prehospital EMS systems. However, little is known about the characteristics and incidence of critically ill patients who received physician-manned prehospital EMS in Japan. The aim of this study was to determine the characteristics and incidence of critically ill patients who were transported to tertiary emergency centers with and without physician-manned prehospital EMS, using a national inpatient database in Japan.

METHODS

Data source

RELEVANT DATA WERE obtained from the Japanese Diagnosis Procedure Combination inpatient database, which includes discharge abstracts and administrative claims data. The database includes information on patient age, sex, smoking history, body height, body weight, diagnoses, procedures, prescriptions, and costs. Diagnoses are recorded by International Classification of Diseases, 10th Revision (ICD-10) codes and text in the Japanese language. The sensitivity and specificity of the primary diagnoses were 78.9% and 93.2%, respectively.[8]

We also extracted data from the Annual Report for Functions of Medical Institutions 2014 regarding health facility information and statistics as follows: population of "medical area level two," number of tertiary emergency centers in each "medical area level two," annual number of EMS accepted, and type of emergency facilities (primary, secondary, or tertiary).[9]

Study cohort

We extracted all hospitalized patients who were transferred by EMS from April 2014 to March 2015. We then combined their data with the data extracted from the Annual Report for Functions of Medical Institutions 2014 using unique facility codes. Patients whose data were not able to be combined with the Annual Report for Functions of Medical Institutions 2014 were excluded. Only patients who were transferred to tertiary emergency facilities were included. Hospitalized patients who received either physician-manned ambulance or physician-manned helicopter services were allocated to the physician-manned EMS group, and hospitalized patients who received ordinary prehospital EMS without a physician were allocated to the EMS without physician group.

Study variables

The following patient characteristics were collected: age, sex, body mass index at admission, smoking history (non-smoker, current/past smoker, missing data), pregnancy, Japan Coma Scale status at admission,[10] Charlson comorbidity index score,[11] death in emergency room, and in-hospital mortality. Japan Coma Scale status was shown to be well correlated with Glasgow Coma Scale score.[10] Charlson comorbidity index was calculated from the recorded diagnoses for each patient and categorized as 0, 1, 2, 3, 4, or ≥5.[11]

Because there were no previous reports on diagnostic patterns among hospitalized patients who received EMS and physician-manned EMS in Japan, the admission ICD-10 diagnosis codes were evaluated using all ICD-10 chapters to determine the entire diagnostic patterns.[12]

We used the scale of acuity verification (SAVE) for emergency patients.[13] This scale categorizes cases as "red" when patients receive advanced life support interventions, undergo intensive care unit admission, or die on admission day. The variables for the SAVE red category are listed in Table S1. These items refer to life-saving interventions in the Emergency Severity Index,[14] Therapeutic Intervention Scoring System,[15] and criteria for intensive care unit admission.[16]

We also evaluated the five critical conditions defined as the First Hour Quintet (FHQ) (respiratory failure, stroke, cardiac chest pain, cardiac arrest, and trauma).[17] These conditions are life-threatening and economically important, and are also key indicators for the EMS system.[17] Respiratory failure, stroke, cardiac chest pain, and cardiac arrest were defined using specific ICD-10 diagnosis codes listed by the European Emergency Data Project.[17] Trauma was defined by ICD-10 trauma diagnosis categories with a mortality regression coefficient of >0.5, based on a previous study that generated an ICD-10-based trauma mortality prediction scoring system using a Japanese national inpatient database.[18] All ICD-10 codes for FHQ diagnoses are listed in Tables S2 and S3.

We calculated the incidence of critical illness using the number of SAVE red cases, all FHQ diagnoses, and population of "medical area level two" divided by the number of tertiary emergency facilities. We also calculated the incidence of admission by EMS, admission by physician-manned EMS, and in-hospital mortality. The resulting incidence rates were reported as numbers of events per 100,000 persons per year.

Statistical analysis

Categorical variables are presented as number and percentage. Continuous variables are expressed as median and interquartile range. We compared the incidences of admission by EMS, in-hospital mortality, SAVE red cases, and FHQ diagnoses between facilities with and without physician-manned EMS by the Wilcoxon rank-sum test. Values of $P < 0.05$ were considered statistically significant. All analyses were undertaken with Stata/MP 14.2 software (StataCorp, College Station, TX, USA).

RESULTS

USING THE JAPANESE Diagnosis Procedure Combination inpatient database and the Annual Report for Functions of Medical Institutions 2014, we were able to link 228 (82%) of 277 tertiary emergency facilities in Japan. During the 12-month study period, a total of 1,062,541 patients receiving EMS were transferred to these tertiary emergency facilities. Of these, 497,911 (47%) patients were admitted to hospital by EMS. The numbers of hospitalized patients who received physician-manned EMS and non-physician-manned EMS were 15,507 (3%) and 482,854 (97%), respectively. Interhospital transfer was provided for 2,566 (17%) of 15,507 patients who received physician-manned EMS. Finally, 11,263 patients were allocated to the physician-manned EMS group and 406,066 patients were allocated to the EMS without physician group for further analysis (Fig. 1).

Table 1 shows the patient baseline characteristics. The median age was 69 years in the physician-manned EMS group and 72 years in the EMS without physician group. In-hospital mortality was 22% in the physician-manned EMS group and 14% in the EMS without physician group. The SAVE red cases comprised 51% in the physician-manned EMS group and 26% in the EMS without physician group. Additional information for the SAVE system is provided in Table S4.

Table 2 shows the admission diagnoses according to the ICD-10 chapters. The majority of diagnoses at admission in the physician-manned EMS group were “diseases of the circulatory system” (45%) and “injury, poisoning, and certain other consequences of external causes” (34%).

Table 3 shows the FHQ (respiratory failure, stroke, cardiac chest pain, cardiac arrest, and trauma) diagnoses. The proportion of FHQ admissions was 53% of all hospitalized patients by physician-manned EMS. The most frequently observed FHQ diagnosis was stroke and the second was trauma in both groups. The proportions of SAVE red cases and in-hospital mortality were highest for cardiac arrest and lowest for trauma in both groups. Additional information for the FHQ diagnoses is provided in Table S5.

Table 4 shows the characteristics and incidence of critically ill patients in the 228 tertiary emergency facilities. In 120 facilities with physician-manned EMS, the median (interquartile range) admission by physician-manned EMS per 100,000 persons per year was 12 (2.2–36). The numbers of SAVE red cases and FHQ diagnoses per 100,000 persons per year in facilities with physician-manned EMS were 137 and 205, respectively. The χ^2-test showed no significant difference in the incidence of in-hospital mortality, SAVE red

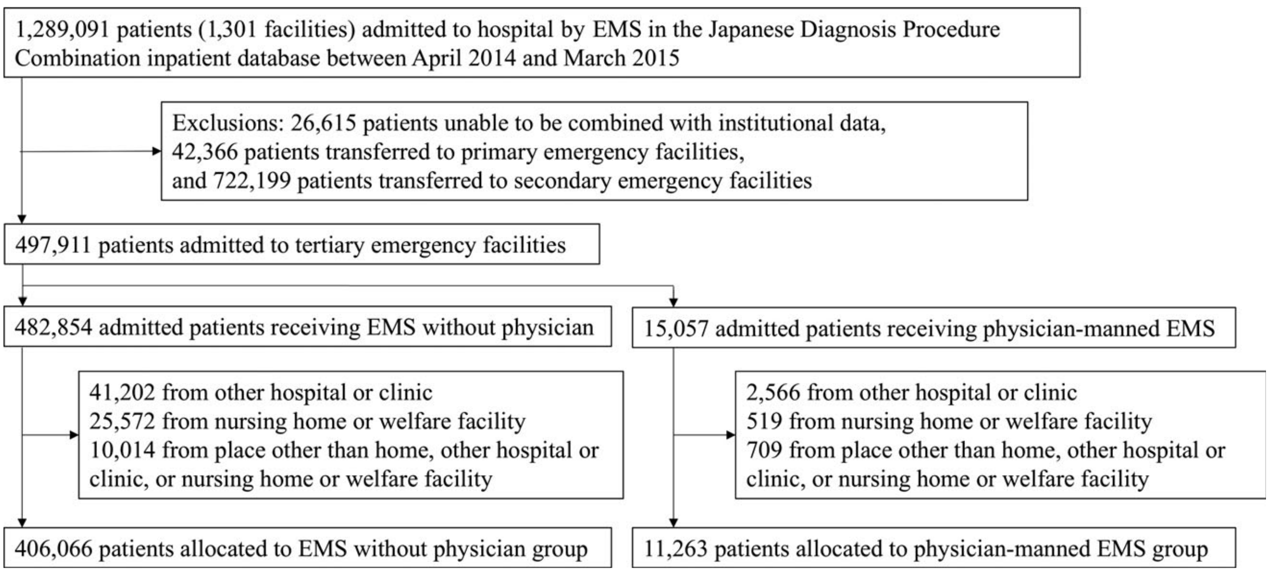

Fig. 1. Flowchart of critically ill patients admitted to tertiary emergency centers in Japan by physician-manned or non-physician-manned emergency medical service (EMS).

Table 1. Baseline characteristics of hospitalized patients transported to tertiary emergency centers by physician-manned emergency medical service (EMS) or EMS without a physician

Characteristics	Physician-manned EMS (*n* = 11,263)	EMS without physician (*n* = 406,066)
Age (years), median (IQR)	69 (53–80)	72 (55–82)
Age in 10-year groups		
0–9	555 (4.9)	17,545 (4.3)
10–19	351 (3.1)	9,892 (2.4)
20–29	394 (3.5)	14,568 (3.6)
30–39	401 (3.6)	18,056 (4.4)
40–49	767 (6.8)	25,463 (6.3)
50–59	1,165 (10.3)	33,685 (8.3)
60–69	2,156 (19.1)	64,424 (15.9)
70–79	2,611 (23.2)	95,791 (23.6)
80–89	2,396 (21.3)	100,520 (24.8)
90–99	455 (4.0)	25,297 (6.2)
≥100	12 (0.1)	825 (0.2)
Male sex	7,220 (64.0)	230,078 (57.0)
Body mass index (kg/m^2)		
<18.5	1,716 (15.0)	76,979 (19.0)
18.5–24.9	5,508 (49.0)	198,350 (49.0)
25.0–29.9	1,721 (15.0)	54,671 (14.0)
≥30.0	382 (3.4)	13,734 (3.4)
Missing	1,936 (17.0)	62,332 (15.0)
Smoking history		
Non-smoker	5,515 (49.0)	221,082 (54.0)
Current/past smoker	3,059 (27.0)	110,340 (27.0)
Unknown	2,689 (24.0)	74,644 (18.0)
Pregnant	24 (0.2)	5,517 (1.4)
Japan coma scale at admission, *n* (%)		
Alert	4,773 (42.0)	238,911 (59.0)
Dizziness	2,305 (21.0)	88,235 (22.0)
Somnolence	949 (8.4)	27,924 (6.9)
Coma	3,236 (29.0)	50,996 (13.0)
Charlson comorbidity index		
0	7,324 (65.0)	223,922 (55.0)
1	2,414 (21.0)	93,178 (23.0)
2	992 (8.8)	50,002 (12.0)
3	342 (3.0)	19,881 (4.9)
4	100 (0.9)	7,143 (1.8)
≥5	91 (0.8)	11,940 (2.9)
Death in emergency room	922 (8.2)	15,556 (3.8)
In-hospital mortality	2,481 (22.0)	58,619 (14.0)
SAVE red	5,709 (51.0)	105,342 (26.0)

Data are shown as *n* (%) unless otherwise indicated.
IQR, interquartile range; SAVE, scale of acuity verification.

cases, or FHQ diagnoses between facilities with and without physician-manned EMS.

DISCUSSION

OUR STUDY HAS determined the characteristics and incidence of critically ill patients with and without physician-manned EMS in tertiary emergency centers in Japan. The proportions of in-hospital mortality, SAVE red cases, and FHQ diagnoses were higher in the physician-manned EMS group. The number of hospitalized patients by physician-manned EMS was 12 per 100,000 persons per year in 120 facilities with physician-manned EMS. There were no significant differences in in-hospital mortality, SAVE red cases, or FHQ diagnoses between facilities with and without physician-manned EMS. Approximately half of the tertiary emergency facilities did not provide a physician-manned EMS system.

Previous studies from Scandinavian countries showed that the prehospital population incidences of critical illness and injury were 250–300 per 100,000 persons per year.[19,20] The incidence of critical illness in our study was comparable with that in Scandinavian countries. However, the incidence of physician-manned EMS in areas equipped with physician-manned EMS in our study (12 per 100,000 persons per year) was very low compared with that in Denmark (749 per 100,000 persons per year), followed by Finland (146 per 100,000 persons per year), Norway (110 per 100,000 persons per year), and Sweden (50 per 100,000 persons per year).[20] The previous study also indicated that a physician-manned EMS incidence of 600–800 per 100,000 persons per year appeared adequate to address all critically ill or injured patients.[20] Compared with these data, our findings imply that physician-manned EMS served relatively few critically ill patients in Japan.

In the present study, the proportion of critically ill patients with physician-manned EMS classified as SAVE red (51%) was higher than that in a previous study, in which the proportion of patients with non-life-threatening diseases (National Committee on Aeronautics ≤3) was nearly 80% in Norway.[19] Our results suggest a lower probability of "over-triage" in Japan.

Our study showed that in-hospital mortality per 100,000 persons per year did not differ between facilities with and without physician-manned EMS, despite critically ill patients being equally transported to facilities with and without physician-manned EMS. This result should be interpreted with caution. First, we did not evaluate the causal treatment effect of physician-manned EMS on individual patients. Second, the low utilization rate of physician-manned EMS might have dampened its effectiveness.

Table 2. Pattern of admission diagnoses according to International Classification of Diseases, 10th Revision (ICD-10) chapters

ICD-10 chapter	Diagnosis group	ICD-10 codes	Physician-manned EMS			EMS without physician		
			Number (%) (n = 11,263)	SAVE red, %	In-hospital mortality, %	Number (%) (n = 406,066)	SAVE red, %	In-hospital mortality, %
I	Certain infectious and parasitic diseases	A00–B99	116 (1.0)	56.0	26.0	10,428 (2.6)	21.0	15.0
II	Neoplasms	C00–D48	117 (1.0)	38.0	44.0	17,505 (4.3)	14.0	39.0
III	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	D50–D89	26 (0.2)	31.0	23.0	2,311 (0.6)	12.0	14.0
IV	Endocrine, nutritional, and metabolic diseases	E00–E90	149 (1.3)	16.0	6.7	11,606 (2.9)	6.8	7.8
V	Mental and behavioral disorders	F00–F99	46 (0.4)	17.0	2.2	3,040 (0.7)	3.7	0.6
VI	Diseases of the nervous system	G00–G99	475 (4.2)	26.0	11.0	17,372 (4.3)	10.0	4.4
VII	Diseases of the eye and adnexa	H00–H59	1 (0.0)	100.0	0.0	290 (0.1)	22.0	0.0
VIII	Diseases of the ear and mastoid process	H60–H95	14 (0.1)	0.0	0.0	4,702 (1.2)	0.0	0.3
IX	Diseases of the circulatory system	I00–I99	5,026 (45.0)	68.0	35.0	119,727 (30.0)	49.0	26.0
X	Diseases of the respiratory system	J00–J99	468 (4.2)	41.0	23.0	39,696 (9.8)	15.0	16.0
XI	Diseases of the digestive system	K00–K93	352 (3.1)	42.0	8.8	43,488 (11.0)	29.0	6.5
XII	Diseases of the skin and subcutaneous tissue	L00–L99	8 (0.1)	25.0	0.0	2,065 (0.5)	5.6	4.5
XIII	Diseases of the musculoskeletal system and connective tissue	M00–M99	28 (0.2)	29.0	3.5	5,450 (1.3)	5.2	3.9
XIV	Diseases of the genitourinary system	N00–N99	73 (0.6)	21.0	12.0	12,314 (3.0)	9.0	6.4
XV	Pregnancy, childbirth, and the puerperium	O00–O99	26 (0.2)	23.0	0.0	5,609 (1.4)	14.0	0.1
XVI	Certain conditions originating in the perinatal period	P00–P96	99 (0.9)	22.0	1.0	407 (0.1)	14.0	2.5
XVII	Congenital malformations, deformations, and chromosomal abnormalities	Q00–Q99	25 (0.2)	28.0	0.0	334 (0.1)	31.0	7.2
XVIII	Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	R00–R99	420 (3.7)	32.0	9.3	22,987 (5.7)	16.0	9.2
XIX	Injury, poisoning, and certain other consequences of external causes	S00–T98	3,793 (34.0)	38.0	10.0	86,649 (21.0)	16.0	5.3
XX	External causes of morbidity and mortality	V01–Y98	0 (0.0)	0.0	0.0	40 (0.0)	43.0	25.0
XXI	Factors influencing health status and contact with health services	Z00–Z99	1 (0.0)	0.0	0.0	41 (0.0)	9.8	40.0
XXII	Codes for special purposes	U00–U85	0 (0.0)	0.0	0.0	5 (0.0)	20.0	20.0

EMS, emergency medical service; SAVE, scale of acuity verification.

Table 3. First Hour Quintet (FHQ) diagnoses of hospitalized patients transported to tertiary emergency centers by physician-manned emergency medical service (EMS) or EMS without a physician

FHQ diagnoses	Physician-manned EMS			EMS without physician		
	Number (%) (n = 11,263)	SAVE red, %	In-hospital mortality, %	Number (%) (n = 406,066)	SAVE red, %	In-hospital mortality, %
Overall	6,019 (53.0)	62.0	29.0	148,715 (37.0)	39.0	21.0
Respiratory failure	537 (4.8)	51.0	16.0	30,800 (7.6)	32.0	14.0
Stroke	1,578 (14.0)	45.0	20.0	45,576 (11.0)	25.0	14.0
Cardiac chest pain	960 (8.5)	80.0	11.0	17,569 (4.3)	71.0	8.0
Cardiac arrest	1,352 (12.0)	98.0	83.0	19,871 (4.9)	98.0	91.0
Trauma	1,592 (14.0)	42.0	9.2	34,899 (8.6)	14.0	5.0

SAVE, scale of acuity verification.

Table 4. Characteristics and incidence of scale of acuity verification (SAVE) red cases and First Hour Quintet (FHQ) diagnoses between facilities with and without physician-manned emergency medical service (EMS)

Variable	Facilities with physician-manned EMS (n = 120)	Facilities without physician-manned EMS (n = 108)	P-value
Population of medical area level 2 divided by number of tertiary emergency facilities	349,246 (238,059–507,239)	369,841 (234,233–471,010)	0.81
Number of EMS per 100,000 persons per year	1,231 (727–2,040)	1,283 (770–1,848)	0.75
Admission by EMS per 100,000 persons per year	554 (329–782)	506 (329–742)	0.21
Admission by physician-manned EMS per 100,000 persons per year	12 (2.2–36)	–	–
In-hospital mortality per 100,000 persons per year	74 (49–112)	69 (45–116)	0.56
SAVE red cases per 100,000 persons per year	137 (90–203)	121 (86–173)	0.16
All FHQ diagnoses per 100,000 persons per year	205 (124–302)	178 (113–293)	0.20

–, Not applicable.

There could be several issues with the current dispatch policies in Japan. First, although the present study showed that only a small proportion of critically ill patients were transferred by physician-manned EMS, the EMS systems did not selectively target the diseases with established evidence, including out-of-hospital cardiac arrest,[21] major trauma,[22] and ischemic heart disease.[23] Second, the "injury, poisoning, and certain other consequences of external causes" subgroup did not have higher rates of SAVE red cases and in-hospital mortality, suggesting overtriage of this subgroup for physician-manned EMS. Finally, "stroke" was most frequently observed among the FHQ diagnoses in our study, whereas a previous study in Scandinavia showed that stroke was the least frequently observed FHQ diagnosis in physician-manned EMS.[20] A reduction in time from occlusion to vessel opening might be an important predictor for good functional outcomes in patients with acute ischemic stroke.[24] However, whether physician-manned EMS can improve outcomes in patients with "stroke" remains unclear. Further studies are needed in this subgroup.

The present study has some limitations. First, our study only included patients who were hospitalized by EMS, and thus, our findings cannot be generalized to prehospital emergency patients who were not hospitalized. Second, our study only included tertiary emergency facilities, based on the assumption that primary and secondary emergency facilities do not provide physician-manned EMS or care for critically ill patients. However, some secondary emergency facilities might provide physician-manned EMS and care for critically ill patients. Third, the SAVE system for emergency patients was not validated for representation of degree of urgency. Previous studies used other acuity scales such as the National Committee on Aeronautics[19] and ESI triage system,[14] which include prehospital symptoms or vital signs, but these data were not available for the present study. Fourth, we did not distinguish physician-manned ambulance services from physician-manned helicopter services because of data availability. Finally, we could not compare both the population-based incidence of physician-manned EMS and critically ill patients being served with countries other than those in northern Europe, also because of data availability.

CONCLUSIONS

OUR STUDY INDICATED that physician-manned EMS was dispatched to a relatively small proportion of critically ill patients in Japan. Our findings could assist physicians and health-care policymakers when discussing better resource allocation for EMS based on real-world data.

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DISCLOSURE

Approval of the research protocol: The Institutional Review Board of the University of Tokyo approved the study.
Informed consent: No information allowing identification of individual patients, hospitals, or physicians was obtained. The requirement for informed consent was waived because of the anonymous nature of the data.
Registry and the registration no. of the study/Trial: N/A.
Animal studies: N/A.
Conflict of interest: None declared.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. Variables for scale of acuity verification (SAVE) red classification

Table S2. International Classification of Diseases, 10th Revision (ICD-10) definitions for First Hour Quintet diagnoses

Table S3. Injury site and type categories

Table S4. Additional information for scale of acuity verification (SAVE) red cases

Table S5. Additional information for First Hour Quintet diagnoses