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Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS)☆

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ABSTRACT

Background: The Pan Asian Resuscitation Outcomes Study (PAROS) Clinical Research Network (CRN) was established in collaboration with emergency medical services (EMS) agencies and academic centers in Japan, Singapore, South Korea, Malaysia, Taiwan, Thailand, and UAE-Dubai and aims to report out-of-hospital cardiac arrests (OHCA) and provide a better understanding of OHCA trends in Asia.

Methods and results: This is a prospective, international, multi-center cohort study of OHCA across the Asia-Pacific. Each participating country provided between 1.5 and 2.5 years of data from January 2009 to December 2012. All OHCA cases conveyed by EMS or presenting at emergency departments were captured.

66,780 OHCA cases were submitted to the PAROS CRN; 41,004 cases were presumed cardiac etiology. The mean age OHCA occurred varied from 49.7 to 71.7 years. The proportion of males ranged from 57.9% to 82.7%. Proportion of unwitnessed arrests ranged from 26.4% to 67.9%. Presenting shockable rhythm rates ranged from 4.1% to 19.8%. Bystander cardiopulmonary resuscitation (CPR) rates varied from 10.5% to 40.9%, however <1.0% of these arrests received bystander defibrillation. For arrests that were with cardiac etiology, witnessed arrest and VF, the survival rate to hospital discharge varied from no reported survivors to 31.2%. Overall survival to hospital discharge varied from 0.5% to 8.5%. Survival with good neurological function ranged from 1.6% to 3%.

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Conclusions: Survival to hospital discharge for Asia varies widely and this may be related to patient and system differences. This implies that survival may be improved with interventions such as increasing bystander CPR, public access defibrillation and improving EMS.

1. Introduction

1.1. Background and rationale

Out-of-hospital cardiac arrest (OHCA) is a global disease with outcomes that may be dependent on pre-hospital and emergency systems.[1] It has been shown that wide variations in survival outcomes exist between communities, and it has been suggested that these differences are mainly due to differences in how pre-hospital emergency care is delivered.[2] The Asia-Pacific has relatively undeveloped and diverse emergency medical services (EMS) systems.[3] Not much is known about OHCA trends across the Asia-Pacific countries, although there are reports from specific countries.[4,5] In addition, it is difficult to benchmark and make comparisons across countries currently, due to differences in methods of data collection, data definitions and denominators used to estimate survival outcomes. Having baseline and benchmarking would be most useful moving forward to identify gaps in EMS and for service and quality improvement.

In 2010, Pan Asian Resuscitation Outcomes Study (PAROS) Clinical Research Network (CRN) was established in collaboration with EMS agencies and academic centers in Japan, Singapore, South Korea, Malaysia, Taiwan, Thailand, and UAE-Dubai. This CRN aims to report OHCA events using common data definitions and collection methods, thus providing a better understanding of OHCA trends in Asia.[6] More information about the PAROS network can be found at: http://www.scri.edu.sg/index.php/paros-clinical-research-network.

The mission of PAROS is to improve EMS systems and survival outcomes in the Asia-Pacific region, by establishing baseline information about OHCA prevalence, management and outcomes, describe variations among EMS systems in the region, and compare systemic and structural interventions to address OHCA. PAROS is a unique, low-cost, self-funded model of a collaborative research network. Each participating country administers its own data collection process, with data input via secured shared internet electronic data capture (EDC) hosted by the Study Coordination Centre (SCC) in Singapore.

1.2. Objectives

The objectives of this study are to provide a never before seen snapshot of the state of resuscitation across Asia. We describe the characteristics of OHCA and outcomes across the network sites.

2. Methods

2.1. Study design and setting

This was a prospective, international, multi-center cohort study of OHCA in the Asia-Pacific. Twelve sites from the seven PAROS countries participated in the study.

The socio-economic characteristics and EMS systems of the PAROS countries are diverse. The PAROS group has described the characteristics and EMS systems of participating countries in two previously published papers.[3,7] PAROS EMS systems were mostly single-tiered, public-funded and fire-based (except for Thailand and Malaysia which are hospital-based EMS). Ambulance personnel were mostly emergency medical technicians (EMT)-intermediate level except Thailand whose personnel include nurses and physicians. Personnel are trained to use automated external defibrillators and most have Basic Cardiac Life Support certification. The service capability of each EMS system varied greatly in terms of dispatch, response times, airway management and medications.

2.2. Data collection and management

A standardized taxonomy and case record form were adopted across the participating countries to collect common variables (categorized into core and non-core; non-core variables were optional). The PAROS data dictionary is attached as an online supplement to this paper. Data was extracted from emergency dispatch records, ambulance patient case notes, and emergency department (ED) and in-hospital records. Countries with existing national registries (Japan, South Korea, and Taiwan) contributed data via an export field entry process, which auto-populated the PAROS registry. This data is also used for their national cardiac arrest registries. Countries without existing registries entered data via the EDC system. Patient identifiers are not accepted in the database to protect patients' confidentiality. Data received from sites with existing registries were reconciled with those collected via EDC system. Time intervals or categorical variables which were not captured in the original databases were determined and then converted into the EDC format according to the reconciliation rules. Datasets from all sites were then merged together. Each country was asked to contribute between 1.5 and 2.5 years of data from January 2009 to December 2012.

A detailed description of the study's methodology had been previously published.[6]

2.3. Participants

All OHCA cases (including both children and adults) of presumed cardiac and non-cardiac etiology conveyed by EMS or presenting at EDs, were captured in the study. For Malaysia, Singapore, and Thailand, non-EMS OHCA cases that presented to the ED were also included in the study. We included patients presenting to ED in cardiac arrest as this reflects the reality on the ground, especially in Thailand and Malaysia, where large numbers of OHCA are brought to ED by their own transport, rather than by EMS. Out-of-hospital cardiac arrest was determined by these criteria: absence of pulse, unresponsiveness, and apnea. Patients for whom resuscitation was not attempted and were immediately pronounced dead (due to decapitation, rigor mortis, dependent lividity and "do not attempt resuscitation" orders) were excluded from the study. However, patients where resuscitation was attempted but were subsequently pronounced dead in the field, were also included in the study (for Malaysia and Thailand).

2.4. Variables

The primary outcome was survival to hospital discharge. Secondary outcomes included return of spontaneous circulation, survival to hospital admission, and neurological status on hospital. Neurological status was assessed using Glasgow–Pittsburgh Outcome Scores [Cerebral Performance Category (CPC) and Overall Performance Category (OPC)]. Neurologic status was evaluated

by abstraction from clinical records, telephone and face to face interviews.

2.5. Study size

The PAROS study is intended as a long-term OHCA registry. This paper reports the first 2.5 year's data collection from PAROS. We have also set an initial aim of identifying the factors (and thus the related interventional strategies) associated with better survival outcome among OHCA patients in the Asia-Pacific.

2.6. Ethical consideration

The study was approved by the local Institutional Review Boards. Each participating site was responsible for obtaining approval from their local ethics committee to conduct the study.

2.7. Statistical analysis

Patient demographics and OHCA characteristics for all cases were summarized by country and also for overall. For age and EMS timings, both mean (SD) and median (IQR) age were summarized. For categorical variables, frequencies and percentages were described. Cases with missing data for a particular variable were excluded from analysis. For cases that were brought in by EMS or private ambulance, incidence rates and outcomes of OHCA were also reported as frequencies and percentages stratified by country. These cases were summarized in a three-tier cascade manner: (1) cardiac etiology, witnessed arrest, ventricular fibrillation (2) cases where resuscitation was attempted and (3) cases where resuscitation was attempted and who experienced non-traumatic cardiac arrest (not due to blunt or penetrating trauma, includes presumed cardiac etiology, respiratory etiology, drowning and other causes). The following outcomes were compared by country: (1) EMS ROSC, (2) ED ROSC, (3) survival rate to admission, (4) survival rate to discharge, (5) post arrest CPC score 1 or 2, and (6) post arrest OPC score 1or 2. Analyses were performed using SAS 9.2 (SAS© Cary, NC, USA).

3. Results

Table 1 shows the characteristics of the 12 participating PAROS sites. A total of 808 receiving hospitals and 113 EMS agencies participated in the study.

All participating sites had single-tiered EMS systems with the exception of Singapore, which uses a combination of motorcycle first responders and ambulances. The majority were fire-based services, with the exception of Thailand and Malaysia with hospital-based ambulance services. In general, ambulance personnel in all countries were proficient in basic life support skills and could administer automated external defibrillators. The type of providers in the ambulances also differed between sites. Thailand has physicians on board some ambulances, who are usually residents based in the ED. Otherwise, they usually have nurses on board. The other countries have a mix of paramedics and emergency medical technicians (EMT) on ambulances; in Malaysia EMTs are known as Medical Assistants (Assistant Medical Officer).

Fig. 1 describes the overall patient flowchart for OHCA patients with cardiac etiology, witnessed, ventricular fibrillation.

A total of 66,780 OHCA cases were submitted to the PAROS CRN, of which 41,004 cases were presumed cardiac etiology. Table 2 shows the characteristics of the study population. The mean age of the study population was 69.9 years (SD = 18.9); 59.8% were males. Past medical history of heart disease was present in 27.1% of the study population. Most OHCA cases occurred at home (65.4%); 35.5% of cardiac arrests were witnessed by bystanders and 9.1% had ventricular fibrillation (VF), ventricular tachycardia, or unknown shockable rhythms as the first arrest rhythm. 2.6%–35.8% of OHCA cases received pre-hospital defibrillation.

Bystander cardiopulmonary resuscitation (CPR) rates varied from 10.5% to 40.9%; only less than 1.0% of arrests received bystander defibrillation. 11.1% of OHCA cases received pre-hospital adrenaline and laryngeal mask airway (12.7%) was most commonly used by EMS. Only 1% of OHCA cases received hypothermia therapy as part of post-resuscitation care. Overall survival to discharge rates ranged from 0.5% to 8.5%; overall survival to discharge rate was 5.4%. Survival with good neurological function (CPC score of 1 and 2) ranged from 1.6% to 3%; overall survival with good neurological function was 2.7%.

Table 3 shows the time intervals of cases that were treated by EMS. The mean EMS response time ranged from 5.9 min (SD = 3.0) to 19.8 min (SD = 12.3). Mean scene time ranged from 8.1 min (SD = 9.0) to 20.4 min (SD = 15.3).

Table 4 shows the outcomes for all OHCA cases conveyed by EMS.

66,395 OHCA cases were attended to by EMS. Fig. 2 compares survival to discharge rates in different cohorts between PAROS sites.

4. Discussion

This is the first large multi-country study describing the epidemiology of OHCA across Asia using standardized data definitions and data collection methods.

While there have been similar large population-based cardiac arrest registries such as the Resuscitation Outcomes Consortium (ROC) Epistry[8] and Cardiac Arrest Registry to Enhance Survival (CARES)[2,9] that have published data from North America, PAROS is unique in the breadth of countries involved and the mix of both developing and newly developed EMS systems they involve. It thus gives a never before seen snapshot of the state of resuscitation across Asia. This study shows that survival to hospital discharge for Asia varies widely and this variation may be related to patient and system differences.

In general, the EMS systems represented in this study have only developed fairly recently (over the last 10–15 years). They represent a mix of fire-department based (Japan, Korea, Singapore, Taiwan), hospital-based (Malaysia, Thailand) and independent (UAE-Dubai) EMS systems.[3] They also serve a mix of urban (Tokyo, Seoul, Singapore, Bangkok), rural (Kota Bahru, Songkla) and urban–rural populations (Klang Valley, Aichi, Penang, Dubai). The level of EMS resourcing also varies greatly, from 1 ambulance: 14,000 population (Songkla) to 1 ambulance: 218,000 population (Penang).

Some interesting findings from our study include that the average age OHCA occurs varies among the countries. Japan had the highest median age of OHCA patients (76 years), which is consistent with their advanced economic development, known long population life span and high proportion of elderly in their population.[10] In contrast, UAE-Dubai had the lowest median age (50 years), probably due to their high numbers of younger migrant workers.[11] The majority of OHCA patients were male, ranging from 57.9% (Japan) to 82.7% (UAE). Japan's relatively high proportion of females among their arrests may reflect the relatively older population, and the observation that heart disease prevalence in females increases with age.[12] Similarly, the high proportion of males seen in UAE may be a reflection of their high number of male migrant workers in the population.[11] We also note that overall, only 27.1% of OHCA patients had a previously known history of ischemic heart disease, which means that in the majority of cases, the first presentation of heart disease was a cardiac arrest.

Table 1
Characteristics of study sites.

Country	City	Service area population	Population density (per km^2)	No. of ambulances	No. of hospitals	No. of participating EMS agencies	Ambulance:population ratio	Type of providers[3]	Operation of ambulance[3,7]	Tiered response[3,7]	Data entry
Japan	Aichi	7,434,996	1439.5	249	155	36	1:30,000	First aid class one, standard first aid class, emergency life-saving technician	Fire-based	BLS single	Export
Japan	Osaka	8,860,280	4659.8	285	272	33	1:32,000	First aid class one, standard first aid class, emergency life-saving technician	Fire-based	BLS single	Export
Japan	Tokyo	13,286,735	6070.7	218	276	1	1:61,000	First aid class one, standard first aid class, emergency life-saving technician	Fire-based	BLS single	Export
Korea	Seoul	10,249,679	16,941.6	140	63	24	1:74,000	Emergency medical technician-basic (EMT-B)/emergency medical technician-intermediate (EMT-I)	Fire-based	BLS single	Export
Malaysia	Klang Valley	1,749,059	3869.6	12	2	2	1:146,000	EMT-B/medical assistant	Hospital-based and non-profit community	BLS/ALS single	Direct entry
Malaysia	Kota Bahru	491,237	1247.0	30	2	4	1:17,000	EMT-B/medical assistant	Hospital-based and non-profit community	BLS/ALS single	Direct entry
Malaysia	Penang	1,520,143	1500.0	7	1	5	1:218,000	EMT-B/medical assistant	Hospital-based and non-profit community	BLS/ALS single	Direct entry
Singapore	Singapore	5,076,700	7252.4	46	7	1	1:111,000	EMT-I	Fire-based	BLS single	Direct entry
Thailand	Bangkok	2,521,240	19,014.4	16	2	1	1:158,000	Doctor/nurse	Hospital-based	BLS and ALS	Direct entry
Thailand	Songkla	55,144	1326.5	4	1	4	1:14,000	Doctor/nurse	Hospital-based	BLS and ALS	Direct entry
Taiwan	Taipei	2,650,968	9753.4	50	22	1	1:54,000	Paramedic/EMT-B	Fire-based	BLS and ALS	Export
UAE	Dubai	2,003,170	474.8	68	5	1	1:30,000	Paramedic	Fire-based	ALS single	Direct entry

Table 2
Patient demographics, out-of-hospital cardiac arrest characteristics and outcomes for all cases.

Characteristics	Japan (*n* = 51,377)	Korea (*n* = 7990)	Malaysia (*n* = 389)	Singapore (*n* = 3023)	Thailand (*n* = 573)	Taiwan (*n* = 3023)	UAE (*n* = 405)
Age							
Mean (SD)	71.7 (18.4)	63.5 (19.0)	57.0 (17.0)	63.5 (18.2)	55.7 (22.1)	70.5 (18.6)	49.7 (18.3)
Median (IQR)	76.0 (63.0, 85.0)	66.5 (52.0, 78.0)	59.0 (47.0,70.0)	65.0 (53.0,77.0)	57.0 (40.0, 74.0)	75.0 (59.0, 85.0)	50.0 (38.0, 63.0)
Gender (%)							
Male	29,760 (57.9)	5243 (65.6)	276 (71.0)	1988 (65.7)	367 (64.0)	1936 (64.1)	335 (82.7)
Past medical history (%)							
Heart disease	2958 (28.1)[a]	837 (21.5)	88 (22.6)	1090 (36.0)	100 (17.5)	751 (26.5)	53 (13.1)
Location type (*n*, %)							
Home residence	8409 (63.0)	5057 (64.9)	278 (71.5)	2127 (70.4)	354 (61.8)	2201 (73.1)	220 (54.3)
Healthcare facility	50 (0.4)	137 (1.8)	11 (2.8)	110 (3.6)	11 (1.9)	Not available	7 (1.7)
Public/commercial building	964 (7.2)	449 (5.8)	44 (11.3)	236 (7.8)	30 (5.2)	70 (2.3)	52 (12.8)
Nursing home	1555 (11.7)	286 (3.7)	6 (1.5)	111 (3.7)	7 (1.2)	240 (8.0)	Not available
Street/highway	809 (6.1)	465 (6.0)	26 (6.7)	155 (5.1)	86 (15.0)	238 (7.9)	71 (17.5)
Industrial place	Not available	95 (1.2)	1 (0.3)	63 (2.1)	5 (0.9)	78 (2.6)	18 (4.4)
Transport center	Not available	101 (1.3)	3 (0.8)	37 (1.2)	2 (0.3)	4 (0.1)	Not available
Place of recreation	Not available	187 (2.4)	2 (0.5)	57 (1.9)	6 (1.0)	54 (1.8)	24 (5.9)
In EMS[b]/private ambulance	852 (6.4)	382 (4.9)	9 (2.3)	69 (2.3)	33 (5.8)	Not available	Not available
Other	700 (5.2)	629 (8.1)	9 (2.3)	58 (1.9)	39 (6.8)	125 (4.2)	13 (3.2)
Arrest witnessed by (*n*, %)							
Not witnessed	30,532 (59.4)	3158 (46.7)	176 (45.2)	1302 (43.1)	151 (26.4)	1939 (67.9)	205 (50.6)
Bystander	17,221 (33.5)	3144 (46.5)	183 (47.0)	1482 (49.0)	373 (65.1)	630 (22.1)	186 (45.9)
EMS	3624 (7.1)	459 (6.8)	30 (7.7)	239 (7.9)	49 (8.6)	288 (10.1)	14 (3.5)
First arrest rhythm (*n*, %)[c]							
VT[d]/VF[e]/unknown shockable	3831 (7.5)	1233 (15.4)	9 (4.1)	554 (18.7)	19 (7.1)	296 (9.8)	80 (19.8)
Unknown unshockable	13,889 (27.0)	251 (3.1)	82 (37.1)	24 (0.8)	2 (0.7)	23 (0.8)	6 (1.5)
Asystole	26,005 (50.6)	4487 (56.2)	54 (24.4)	1585 (53.3)	105 (39.2)	1716 (56.8)	282 (69.6)
Pulseless electrical activity	7601 (14.8)	1132 (14.2)	4 (1.8)	805 (27.1)	24 (9.0)	561 (18.6)	37 (9.1)
Unknown	51 (0.1)	887 (11.1)	72 (32.6)	5 (0.2)	118 (44.0)	427 (14.1)	0 (0)
Prehospital intervention (*n*, %)							
Bystander CPR[f,g]	19,176 (40.2)	2854 (40.9)	81(22.6)	677 (24.3)	83 (15.8)	845 (31.4)	41 (10.5)
Prehospital defibrillation[c]	5260 (10.2)	1833 (22.9)	9 (2.6)	697 (23.4)	32 (9.2)	357 (11.8)	145 (35.8)
Bystander defibrillation[c,g]	313 (0.6)	22 (0.3)	Not available	29 (1.1)	1 (0.3)	Not available	3 (0.8)
Prehospital adrenaline[c]	4346 (8.5)	Not available	44 (12.7)	1414 (47.4)	135 (23.6)	552 (18.3)	4 (1.0)
Prehospital advanced airway (*n*, %)[c]							
Oral/nasal endotracheal tube	4129 (8.0)	153 (1.9)	22 (6.4)	18 (0.6)	132 (38.0)	402 (13.2)	5 (1.2)
Combitube	0	2 (0.02)	0	0	0	0	0
Laryngeal mask airway	4004 (7.8)	470 (5.9)	36 (10.4)	2368 (79.3)	2 (0.6)	535 (17.7)	20 (4.9)
King airway	6478 (12.6)	183 (2.3)	0	0	0	0	0
Other	4450 (8.7)	381 (4.8)	20 (5.8)	1 (0.01)	2 (0.6)	0	5 (1.2)
Post-resuscitation care (*n*, %)							
Hypothermia therapy	Not available	617 (7.7)	1 (0.3)	29 (1.0)	2 (0.3)	Not available	1 (0.2)
Etiology of cardiac arrest (*n*, %)[h]							
Trauma	7495 (14.6)	718 (9.3)	20 (5.9)	99 (3.3)	77 (22.2)	228 (7.8)	13 (3.2)
Presumed cardiac etiology	29,928 (58.3)	5605 (72.7)	285 (84.1)	2251 (74.5)	189 (54.5)	2384 (81.1)	362 (89.4)
Respiratory	2293 (4.5)	65 (0.8)	15 (4.4)	240 (7.9)	47 (13.5)	192 (6.5)	4 (1.0)
Drowning	308 (0.6)	91 (1.2)	3 (0.9)	22 (0.7)	5 (1.4)	14 (0.5)	11 (2.7)
Other	11,352 (22.1)	1230 (16.0)	16 (4.7)	411 (13.6)	29 (8.4)	120 (4.1)	15 (3.7)
Outcomes (*n*, %)							
Survived to admission	3644/13,339 (27.3)[a]	1593 (20.4)	31 (8.0)	514 (17.0)	159 (27.7)	179 (5.9)	32 (7.9)
Survived to discharge	2677 (5.2)	681 (8.5)	2 (0.5)	76 (2.5)	24 (4.2)	139 (4.6)	12 (3.0)
Post arrest CPC[i] 1/2	1436 (2.8)	236 (3.0)	Not available	50 (1.7)	9 (1.6)	87 (2.9)	11 (2.7)

[a] Data not available from Tokyo and Aichi.
[b] Emergency medical services.
[c] Exclude brought in by own/private/public transport: Malaysia 43, Singapore 38, Thailand 226.
[d] Ventricular tachycardia.
[e] Ventricular fibrillation.
[f] Cardiopulmonary resuscitation.
[g] Exclude arrest witnessed by EMS/private ambulance: Japan 3624, Korea 459, Malaysia 30, Singapore 239, Taiwan 288, Thailand 49, UAE 14.
[h] For Malaysia, Thailand, if pronounced dead at scene, cause of arrest is the one evaluated at scene; if conveyed to ED, cause of arrest is the one evaluated in ED.
[i] Cerebral Performance Category.

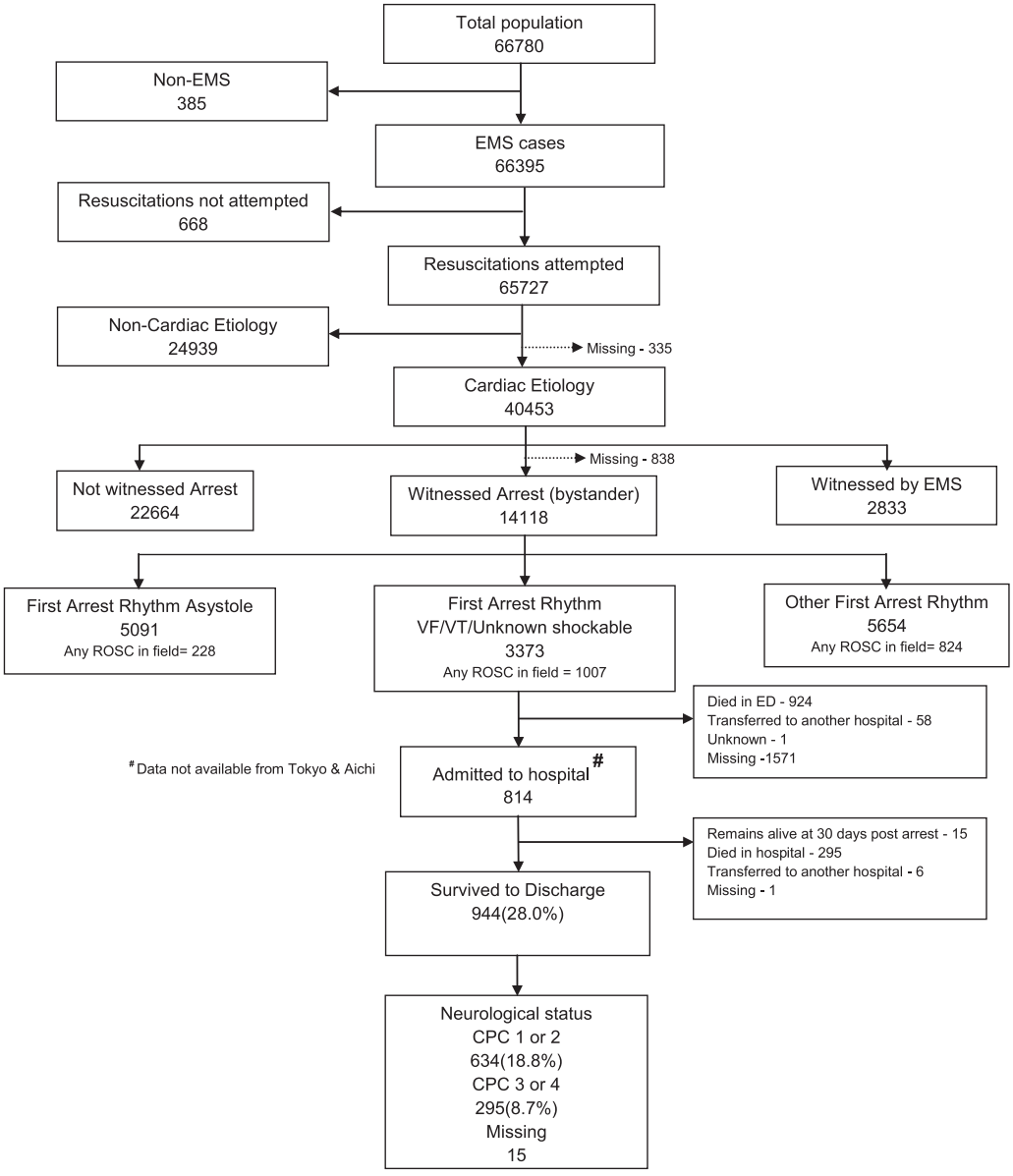

Fig. 1. Patient flow based on out-of-hospital cardiac arrests with cardiac etiology, witnessed arrest, and ventricular fibrillation (overall). EMS – emergency medical services; VF – ventricular fibrillation; VT – ventricular tachycardia; ED – emergency department; ROSC – Return of spontaneous circulation; CPC – Cerebral Performance Category.

Table 3
Emergency medical services (EMS) timings.

EMS timing (median, IQR) (min)		Japan (n = 51,377)	Korea (n = 7990)	Malaysia (n = 343)	Singapore (n = 2958)	Thailand (n = 299)	Taiwan (n = 3023)	UAE (n = 405)
Time of arrest to time of call	Call after arrest	n = 13,237 3.0 (1.0, 5.0)	n = 4955 4.0 (0.0, 14.0)	n = 143 19.0 (7.0, 46.0)	n = 2228 5.4 (2.0, 12.0)	n = 216 12.4 (4.4, 30.6)	Time of arrest not available	n = 162 7.0 (4.0, 14.0)
	Call before arrest	n = 7613 8.0 (16.0, 4.0)	n = 2795 2.0 (5.0, 1.0)	n = 40 14.3 (23.5, 6.7)	n = 719 6.3 (15.8, 1.8)	n = 36 12.5 (23.0, 5.0)		n = 22 17.0 (27.0, 9.0)
Time of call to time arrival at scene (Response time)		6.0 (5.0, 8.0)	6.0 (5.0, 7.0)	17.4 (12.0, 24.2)	7.9 (5.9, 10.3)	11.5 (7.0, 15.5)	5.2 (4.1, 7.0)	10.0 (7.0, 12.0)
Time arrival at scene to time leave scene (Scene time)		14.0 (11.0, 19.0)	7.0 (5.0, 10.0)	15.8 (9.0, 27.5)	14.1 (11.6, 17.2)	10.0 (5.0, 24.3)	13.0 (10.0, 16.4)	12.0 (8.0, 17.0)
Time leave location to time arrival at hospital (En-route time)		7.0 (4.0, 10.0)	6.0 (5.0, 9.0)	10.0 (6.0, 15.0)	10.0 (7.0, 13.9)	12.6 (8.0, 20.0)	4.0 (2.6, 5.2)	10.0 (7.0, 15.0)

Table 4
Outcomes of out-of-hospital cardiac arrests (EMS[a] cases only).

	Japan	Korea	Malaysia	Singapore	Thailand	Taiwan	UAE
Cases with cardiac etiology, witnessed arrest, ventricular fibrillation (VF) (*n*, %)							
Total number of cardiac etiology, witnessed arrest, VF EMS cases	2199	669	5	321	11	122	46
EMS ROSC[b]	772 (35.1)	154 (23.4)	0 (0)	36 (11.2)	1 (9.1)	38 (31.1)	6 (13.0)
ED[c] ROSC	Not available	294 (56.2)	1 (25.0)	98 (30.4)	1 (9.1)	62 (50.8)	9 (19.6)
Survived to admission	374/634 (59.0)[d]	290 (43.3)	0 (0)	84 (26.1)	1 (9.1)	55 (45.1)	10 (21.7)
Survived to discharge	686 (31.2)	198 (29.6)	Nil	31 (9.7)	Nil	23 (18.9)	6 (13.0)
Post arrest CPC[e] 1/2	463 (21.1)	122 (18.2)	Nil	23 (7.1)	Nil	20 (16.4)	6 (13.0)
Post arrest OPC[f] 1/2	458 (20.9)	Not available	Nil	23 (7.1)	Nil	Not available	6 (13.0)
All non-traumatic arrests (*n*, %)							
Total number of resuscitation attempted, non-traumatic arrest EMS cases	43,881	6613	204	2859	186	2774	392
EMS ROSC	3864 (8.8)	331 (5.0)	7 (3.4)	147 (5.1)	39 (21.0)	355 (12.8)	14 (3.6)
ED ROSC	Not available	2471 (37.4)	17 (8.3)	746 (26.1)	53 (28.5)	846 (30.5)	23 (5.9)
Survived to admission	3593/12,587 (28.5)[d]	1499 (22.7)	12 (5.9)	474 (16.6)	40 (21.5)	665 (24.0)	31 (7.9)
Survived to discharge	2441 (5.6)	653 (9.9)	2 (1.0)	71 (2.5)	5 (2.7)	132 (4.8)	11 (2.8)
Post arrest CPC 1/2	1354 (3.1)	243 (3.7)	Not available	47 (1.6)	4 (2.2)	81 (2.9)	10 (2.6)
Post arrest OPC 1/2	1322 (3.0)	Not available	Not available	47 (1.6)	4 (2.2)	Not available	10 (2.6)
All resuscitation attempted arrests (*n*, %)							
Total number of resuscitation attempted EMS cases	51,377	7537	217	2958	235	2998	405
EMS ROSC	4397 (8.6)	366 (4.9)	9 (4.1)	149 (5.0)	41 (17.4)	376 (12.5)	15 (3.7)
ED ROSC	Not available	2652 (35.2)	17 (7.8)	773 (26.1)	66 (28.1)	896 (29.9)	24 (5.9)
Survived to admission	3644/13,339 (27.3)[d]	1582 (21.0)	15 (6.9)	494 (16.7)	55 (23.4)	707 (23.6)	32 (7.9)
Survived to discharge	2677 (5.2)	676 (9.0)	2 (0.9)	71 (2.4)	6 (2.6)	138 (4.6)	12 (3.0)
Post arrest CPC 1/2	1436 (2.8)	233 (3.1)	Not available	47 (1.6)	4 (1.7)	86 (2.9)	11 (2.7)
Post arrest OPC 1/2	1401 (2.7)	Not available	Not available	47 (1.6)	4 (1.7)	Not available	11 (2.7)

[a] Emergency medical services.
[b] Return of spontaneous circulation.
[c] Emergency department.
[d] Data not available from Tokyo, Aichi.
[e] Cerebral Performance Category.
[f] Overall Performance Category.

The majority of arrests occurred at home, ranging from 73.1% (Taiwan) to 54.3% (UAE); we have also captured detailed information regarding the place of arrest for each country. Such information will be helpful in developing CPR awareness campaigns and the planning of automated external defibrillator (AED) deployment and CPR training in study sites.

The proportion of arrests that had an initial shockable rhythm ranged from 4.1% (Malaysia) to 19.8% (UAE). In general the rate of VF observed is lower than that reported in the USA[1,2] and Europe.[13] One possible explanation for this might be the relatively longer EMS response times in Asian countries. However we also believe that it possibly reflects a different etiology of cardiac arrest in Asian countries compared to USA[1,2] or Europe.[14,15] One hint is the relatively high 'non-cardiac' etiology reported in our study.

Bystander CPR rates varied from 10.5% (UAE) to 40.2% (Japan) and 40.9% (Korea). In particular, we want to highlight the

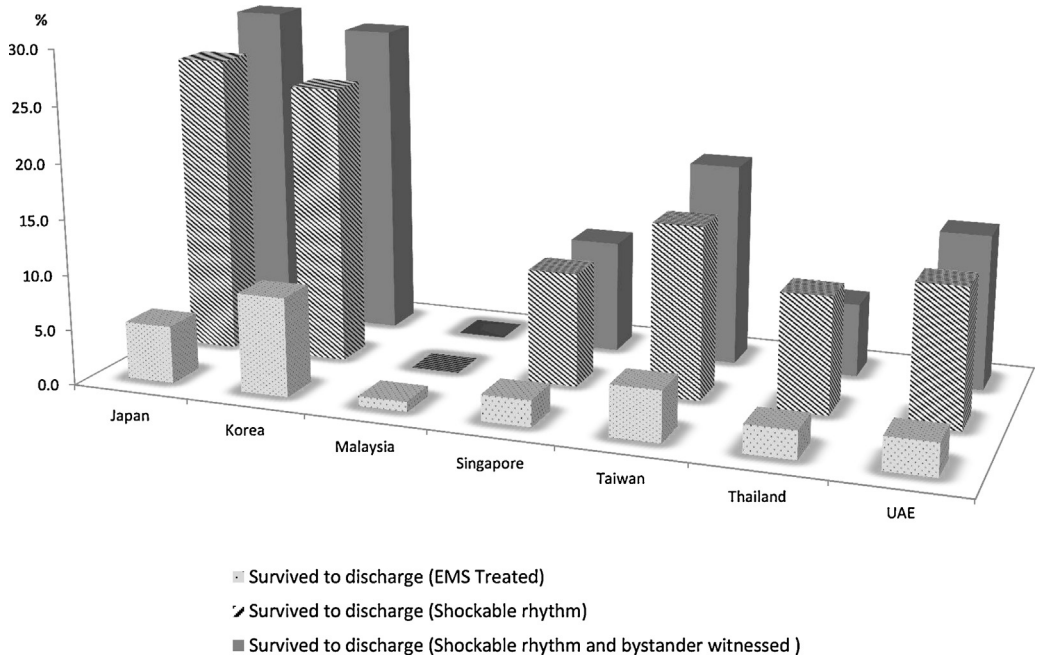

Fig. 2. Comparison of survival to discharge rates in different cohorts between Pan-Asian Resuscitation Outcomes Study sites. EMS – emergency medical services.

success of Korea[16] and Japan[17] in raising bystander CPR rates over the last decade. Seoul, Korea has been able to do this by adopting a nurse telephone-assisted CPR program.[18] In Japan, there have been comprehensive efforts on community CPR education starting in schools and extending to fire department and driver license CPR programs.[19–21] However, there is still work to be done in introducing PAD as only less than 1.0% of arrests received bystander defibrillation across all sites.

EMS response times were generally longer compared to USA[22] or Europe[23,24] and ranged from a median of 5.2 min (Taiwan) to 17.4 min (Malaysia). Taipei was noteworthy in being able to achieve good response times using a close quality monitoring program for ambulance responses. Scene times were also generally shorter due to a predominantly 'scoop and run', basic/intermediate life support model used in Asia.

For arrests with cardiac etiology, witnessed arrest and VF, the survival rate to hospital discharge varied from no reported survivors to 31.2%. Overall survival to hospital discharge varied from 0.5% to 8.5%. This data is consistent with previously published data from Japan,[25] Korea,[4] Taiwan,[26] and Singapore.[27] From Fig. 2, we also see that survival to discharge is highest amongst patients with witnessed arrest and initial shockable rhythm as compared to those who were EMS-treated or had only initial shockable rhythm. However, for Malaysia and Thailand, survival to discharge was highest amongst the EMS-treated group and the initial shockable rhythm group, respectively. We believe the unusual results could be due to the small number of cases involved. For some survivors at these sites, the initial rhythm is 'missing', which is why the number of 'shockable' survivors is low.

In this study we made much effort to align data definitions and report alternative denominators for computing survival rates (e.g. witnessed VF, non-trauma, all resuscitation attempted). One important observation from our study is that due to the low rates of witnessed VF cases, using cases with cardiac etiology, witnessed arrest, and ventricular fibrillation may not be the most appropriate for benchmarking survival in Asia; non-traumatic or all resuscitation attempted arrests would give a fuller picture of the state of resuscitation in Asia.

4.1. Limitations

Limitations of this study include that there was likely underreporting of OHCA cases in some PAROS sites, due to data loss and especially regarding outcomes. Also in the more developing EMS systems in Asia, a significant proportion of OHCA cases might still come to hospital by their own transport rather than by EMS. Some of these cases might also be attended to by primary health care providers, pronounced dead at home or not be conveyed to hospital at all. This possibly resulted in incomplete enrolment of patients into the registry, which may introduce selection bias,[28] i.e. patients who were enrolled into the study versus those not enrolled could have different profiles. In addition, we are unable to ascertain the extent of the study's data loss. These might account for some reporting differences with Western figures.

It is however, notable that all of our PAROS sites mandate transport of OHCA cases to hospital (unless obviously dead with rigor mortis, decapitation, dependant lividity), with the exception of Malaysia, which practices termination of resuscitation in the field. Thus for some of these countries (Malaysia, Thailand, UAE), the OHCA survival rates may not be representative of the true situation. Also, as Japan contributed a large majority of the cases, generalizations about Asia from the aggregated data may need to be interpreted accordingly.

Despite our best efforts to synchronize data definitions and data collection methods, important challenges remained. One such challenge is the consistency in reporting EMS timings – different EMS systems might use different standards for recording time of call (primary vs. secondary public service answering points, timestamps on first detection of an incoming call, etc.). Likewise, many EMS systems face challenges in synchronization of dispatch, ambulance and hospital clocks. Thus interpretation of response times should be with these limitations in mind.

4.2. Future plans

The wide variation in survival outcomes seen in this study is likely due to various patient, EMS and hospital system factors. This indicates that there is potential to improve survival rates in the various countries by addressing and improving some of these modifiable factors affecting OHCA. This includes public recognition of cardiac arrest, increasing bystander CPR and AED use, improving EMS systems and post-resuscitation care. In the next phases of PAROS, we intend to move into system-level interventional studies to improve OHCA survival in PAROS countries. We have already launched PAROS phase 2, which is a large implementation trial of a dispatcher-assisted CPR bundle across the PAROS sites.

5. Conclusion

Survival to hospital discharge for Asia varies widely and this may be related to patient and system differences. This implies that survival in many countries can be improved with interventions to improve EMS systems such as increasing bystander CPR, public access defibrillation, improving ambulance and post-resuscitation care in the region.

Conflict of interest statement

Authors have no conflict of interest.

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Appendix A.

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Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2015.07.026.

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