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Regional variation in functional outcome after out-of-hospital cardiac arrest across 47 prefectures in Japan☆

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ABSTRACT

Background: Although prior work reported regional variation in survival after out-of-hospital cardiac arrest (OHCA), mechanisms of the variation have not been fully investigated. We sought to evaluate regional variation in favourable functional outcome after OHCA across 47 prefectures in Japan as our primary aim. We also evaluated the associations between favourable functional outcome and the numbers of basic life support (BLS) providers and public access automated external defibrillators (AEDs) within each prefecture as our secondary aim.

Methods: Using the All-Japan Utstein Registry, a nationwide prospective, population-based OHCA database, we identified 97,408 patients with OHCA of medical origin across 47 prefectures in 2014. Primary outcome was 1-month survival with favourable functional outcome, defined as Cerebral Performance Category (CPC) scale 1 or 2. We fitted multivariable hierarchical logistic regression models (patients nested within prefectures) to adjust for potential confounding factors at patient- and prefecture-level and clustering of patients within prefectures. We calculated median odds ratios (ORs) from the hierarchical models to quantify the outcome variation at prefecture-level. We also evaluated the associations between OHCA outcome and the numbers of BLS providers and public access AEDs within each prefecture, using the hierarchical models.

Results: A total of 2246 patients (2.3%) had 1-month survival with favourable functional outcome. The unadjusted rates of 1-month survival with favourable functional outcome in each prefecture ranged from 1.1% to 4.1% (median OR = 1.29; 95% credible interval, 1.20–1.40) and the adjusted rates varied from 0.9% to 3.5% (median OR = 1.34; 95% credible interval, 1.24–1.48). We observed no associations between 1-month survival with favourable functional outcome and the numbers of BLS providers (correlation coefficient = −0.25; 95% confidence interval [CI], −0.50 to 0.04; p = 0.09) and public access AEDs (correlation coefficient = −0.27; 95% CI, −0.51 to 0.02; p = 0.07) within prefectures.

Conclusions: We found substantial regional variation in favourable functional outcome after OHCA of medical origin that was not explained by the numbers of BLS providers and public access AEDs within each prefecture.

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health problem worldwide, annually affecting more than 350,000 individuals in the United States and 123,000 in Japan [1,2]. Importantly, prior studies in North America and Japan reported large regional variations in survival and functional outcomes after OHCA [3–7].

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The extent of regional variation in OHCA outcome suggests underlying differences in rural and urban features, patient characteristics, and patient care [4,7]. However, mechanisms of this regional variation in OHCA outcome have not been fully investigated.

Bystander interventions such as bystander cardiopulmonary resuscitation (CPR) and early defibrillation with automated external defibrillators (AEDs) are part of the "chain of survival" and play crucial roles in OHCA care [8]. Intensive public health efforts (e.g., International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations) advocate bystander CPR and AEDs use [9], based on anticipated outcome benefits. Although prior work showed that bystander CPR and defibrillation using public access AEDs were associated with favourable outcomes after OHCA [10–14], few studies evaluated the contribution of the numbers of basic life support (BLS) providers and public access AEDs to the regional variation in OHCA outcome.

To address this knowledge gap, we analysed the All-Japan Utstein Registry, a population-based OHCA database that includes all prefectures in Japan [5,6,10–12]. We performed complementary analyses: (1) evaluated the regional variation in OHCA outcome between prefectures after adjustment for potential confounding factors at patient- and prefecture-level and clustering of patients within prefectures as our primary aim; and (2) evaluated the associations between favourable functional outcome after OHCA and the numbers of BLS providers and public access AEDs in each prefecture as our secondary aim.

Methods

Study design and participants

We conducted a retrospective analysis of All-Japan Utstein Registry of the Fire and Disaster Management Agent (FDMA), a prospective, nationwide, population-based registry system of OHCA that includes the entire population of Japan across 47 prefectures [5,6,10–12,15–17]. This study included all patients with OHCA of medical origin, including infants, children, and adults on whom EMS attempted resuscitation from 1st January to 31st December 2014, with subsequent transport to hospital. We defined cardiac arrest as lack of cardiac mechanical activity confirmed by lack of clinical evidence of a circulation [15–17]. We defined attempted resuscitation as attempts of external defibrillation (by laypersons or EMS personnel) or chest compression by EMS personnel [15–17]. Chest compression performed only by a lay person was not recognized as an attempted resuscitation. We excluded EMS-witnessed arrest, OHCA with unknown witness status, unknown first documented rhythm, unknown age, unknown interval from call to initiation of EMS CPR, unknown interval from initiation of EMS CPR to hospital arrival, unknown adrenaline [epinephrine] use, and OHCA of non-medical origin. The aetiology of arrest was presumed to be medical origin unless aetiology was trauma, drug overdose, drowning, electrocution, or asphyxia [17]. An attending physician clinically determined the aetiology of each arrest in collaboration with EMS personnel. The institutional review board of Kyoto University approved the secondary analysis of the All-Japan Utstein Registry with a waiver of informed consent.

Study settings in Japan

Japan has an area of 378,000 km^2 across 47 prefectures and the population was approximately 127 million in 2014 [18]. Prefectures are jurisdictional and administrative division levels in Japan. The EMS system in Japan has been previously described elsewhere [5,6,10–12]. Briefly, as of 2014, municipal governments provide an almost uniform EMS system through 752 fire departments that contain dispatch centres across Japan. All EMS personnel perform resuscitation according to the Japanese CPR guidelines, based on the International Liaison Committee on Resuscitation (ILCOR) consensus [19]. EMS personnel are not legally permitted to terminate resuscitation, except under particular conditions (e.g., decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis) [5,6,10–12]. The majority of EMS-treated OHCA victims are therefore transferred to hospitals and included in the registry.

Data collection and quality control

Data were prospectively collected using the Utstein Resuscitation Registry Templates for OHCA [15–17]. The form includes age, sex, date of cardiac arrest, aetiology of cardiac arrest, onset witnessed by bystander, first documented rhythm, presence and type of bystander CPR, presence of dispatcher CPR instruction, public-access AEDs shock delivery, presence and type of prehospital advanced airway management, prehospital administration of intravenous fluids and adrenaline, and resuscitation time-course, as well as outcome measures, including prehospital return of spontaneous circulation, 1-month survival, and functional status 1 month after the arrest [5,6,10–12]. When a bystander delivered a shock with a public-access AED, first documented rhythm was regarded as ventricular fibrillation (VF) [6,10,11]. The data were integrated into the registry system on the FDMA database server, and subsequently had logical checks by the computer-operated system. When the data form was not completed, the FDMA contacted the respective EMS and instructed to them to complete the form.

Outcome measures

To collect 1-month outcome data, EMS providers in charge followed up all survivors for 1 month after the arrest. Functional outcome was determined at a follow-up interview 1 month after successful resuscitation using the Cerebral Performance Category (CPC) scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death/brain death [15–17]. Outcome measure in this study was 1-month survival with favourable functional outcome, defined as CPC scale 1 or 2 [15–17].

Study variables

Patient-level variables that we considered for risk adjustment included (1) patient demographics: age (continuous) and sex (male/female), (2) cardiac arrest event characteristics: aetiology of arrest (cardiac/non-cardiac), witness status (bystander witness/no witness), and first documented rhythm (shockable: VF and pulseless ventricular tachycardia/non-shockable: pulseless electrical activity and asystole), (3) bystander interventions: bystander CPR (presence/absence) and public access AEDs shock delivery (presence/absence), and (4) EMS interventions: dispatcher CPR instruction (presence/absence), prehospital adrenaline administration (presence/absence), prehospital advanced airway placement (tracheal intubation or supraglottic device [presence/absence]), EMS shock delivery (presence/absence), interval from call to initiation of EMS CPR (continuous), and interval from initiation of EMS CPR to hospital arrival (continuous). Prefecture-level variables included the numbers of (5) BLS providers, (6) public access AEDs, and (7) EMS personnel per 100,000 population within each prefecture in 2014. We obtained the numbers of BLS providers and EMS personnel from the FDMA annual report, which represents the majority of BLS trainees in Japan [2,20]. We estimated the number of AEDs in each prefecture from cumulative AED sales in 2014