

## Original Article

# Basic life support by citizens in Kawasaki City, Japan – a descriptive epidemiological study of out-of-hospital cardiac arrest patients

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**Aim:** To better understand the current status and barriers to making basic life support a common practice among the citizens of Kawasaki City, Japan.

**Method:** We extracted data according to the Utstein-style guidelines specifically regarding out-of-hospital cardiac arrests (OHCAs) of cardiac etiology. The items were as follows: (i) OHCA witnessed by a citizen, (ii) the victim received bystander cardiopulmonary resuscitation (CPR), (iii) an automatic external defibrillator was used by the witness. We compared the rate of each item and the 1-month survival rates with the national average in Japan. We further divided Kawasaki City into three areas and compared each item. We also examined the rate of bystander CPR in each time period and location. Statistical analysis was carried out using the  $\chi^2$ -test and Fisher's test.

**Results:** The 1-month survival rates did not differ significantly from the national average for cases meeting conditions (i)–(iii): (i) 14.0% versus 13.3%, (ii) 19.1% versus 16.4%, (iii) 71.4% versus 53.3%, respectively. However, the rate of condition (i) was significantly lower (47.5% versus 55.8%,  $P = 0.01$ ). The rate of condition (ii) was higher in the northern area of Kawasaki City, as well as in a location other than the home in the daytime. The rate of condition (iii) was low in the home.

**Conclusions:** Although the 1-month survival rates of OHCAs witnessed by citizens in Kawasaki City did not differ significantly from the national average, the low rate of bystander CPR was notable, especially in the southern and middle areas of the city and when the location was in the home, which implies that basic life support knowledge should be spread to these areas.

**Key words:** Cardiopulmonary arrest, cardiopulmonary resuscitation, defibrillation, Kawasaki City, Utstein-style

## INTRODUCTION

CARDIOPULMONARY RESUSCITATION (CPR) requires the aid of general citizens, and in December 1990, the international standardized guidelines regarding out-of-hospital cardiac arrest (OHCA) were established.<sup>1</sup> Concerning the Utstein-style guidelines worldwide, several elements have been found to be associated with the prognosis of OHCAs, including a witnessed arrest by bystanders, bystander CPR, automatic external defibrillator (AED) use,

and an initial shockable rhythm.<sup>2,3</sup> In Japan, Osaka prefecture first introduced the guidelines in 1998. The guidelines were introduced to fire departments across the country, which began following the guidelines and summarizing and analyzing the data online in 2005. As a result, the evidence has revealed the utility of continuous chest compressions without rescue breathing<sup>4</sup> and an association between the prognosis and the time from calling an ambulance to resuscitation.<sup>5</sup>

From the data collected according to the Utstein-style guidelines, organizations such as the fire department and the Japanese Red Cross Society have attempted to spread knowledge regarding basic life support (BLS) and to increase the use of AEDs.<sup>6</sup> These efforts have led to a significant increase in bystander CPR and AED use for OHCAs.<sup>7</sup>

Kawasaki City is a small city with an area of 144 km<sup>2</sup> and a population of 1,500,000. Kawasaki City has one of the highest population densities among all cities in Japan. There

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are three emergency and critical care centers in Kawasaki City, located in the south, middle, and north of the city. The number of emergency physicians/100,000 population in Kawasaki City is 3.5, which is higher than that in Japan overall (3.1/100,000).<sup>8</sup> In Japan, the association between the number of emergency physicians/100,000 population and the 1-month survival rates of OHCAs was reported.<sup>9</sup> However, data from the Kawasaki Fire Department showed that 1-month survival rates of cardiogenic OHCAs witnessed by citizens were low in Kawasaki City compared to that in Japan overall in 2015 (Kawasaki City, 12.3%; Japan, 13.0%<sup>10</sup>). One main reason for the low 1-month survival rates was the low rate of bystander CPR by a witness (Kawasaki City, 44.9%; Japan, 58.9%<sup>10</sup>).

The aim of this study was to determine the current situation and problems concerning citizen participation in CPR in Kawasaki City. As shown above, despite the enrichment of emergency medicine in Kawasaki City, we hypothesized that the 1-month survival rate in Kawasaki City in 2016 also would not be higher than the national average in Japan because of low bystander CPR.

## METHODS

### Study design

**T**HIS WAS A retrospective observational study using data collected according to the Utstein-style guidelines. Each fire department collected and registered the data in accordance with the online entry form. In Kawasaki City, the Kawasaki Fire Department collected the data. Regarding ethical approval, the Department of Clinical Research in Kawasaki Municipal Hospital stated that, as this study was a descriptive epidemiological study and we did not handle personal data, our study was exempt from institutional review.

### Data collection

In Kawasaki City, 1,168 OHCAs were registered between 1 January, 2016, and 31 December, 2016. In this study, we received data regarding OHCAs in each administrative district through the Kawasaki Fire Department. The data examined were those identified in the Utstein-style guidelines.

### End-points

We analyzed the statistical data collected in Kawasaki City. We specifically focused on analyzing cardiogenic OHCAs because resuscitation by citizens before arriving at the hospital is crucial in cardiogenic cardiopulmonary arrest.

Data regarding cardiogenic OHCAs were compared with the national data posted on the website of the Ministry of Internal Affairs and the Communications Fire and Disaster Management Agency. The data received were as follows: (i) the number of cardiogenic OHCAs witnessed by bystanders and, of those witnessed by bystanders, the number who (ii) received bystander CPR or (iii) were subjected to AED use. We compared these proportions and the 1-month survival rates.

Kawasaki has administrative districts with different characteristics, and therefore, we divided Kawasaki City into three areas and compared the items by area. The southern area included Kawasaki-ku and Saiwai-ku, which are centered around Kawasaki station and contain many industrial zones and industrial roads. The middle area included Nakahara-ku, Takatsu-ku, and Miyamae-ku, which are centered around Musashi-Kosugi station and contains many high-rise apartments and large shopping malls. The northern area included Tama-ku and Asou-ku, which are residential areas.

### Statistical analysis

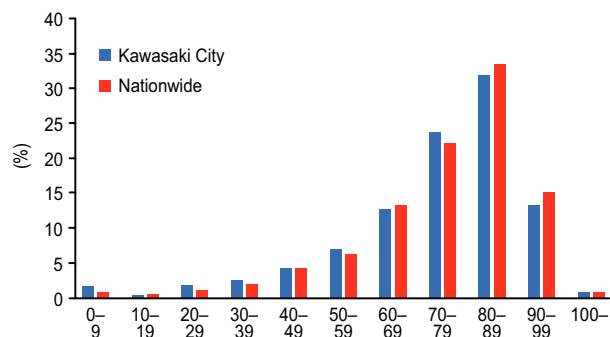
Statistical analysis of ratios was performed using the  $\chi^2$ -test, and if the sample size was small, Fisher's exact test was used. Two-sided *P*-values <0.05 were considered statistically significant. All statistical analyses were undertaken with R statistical software, version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

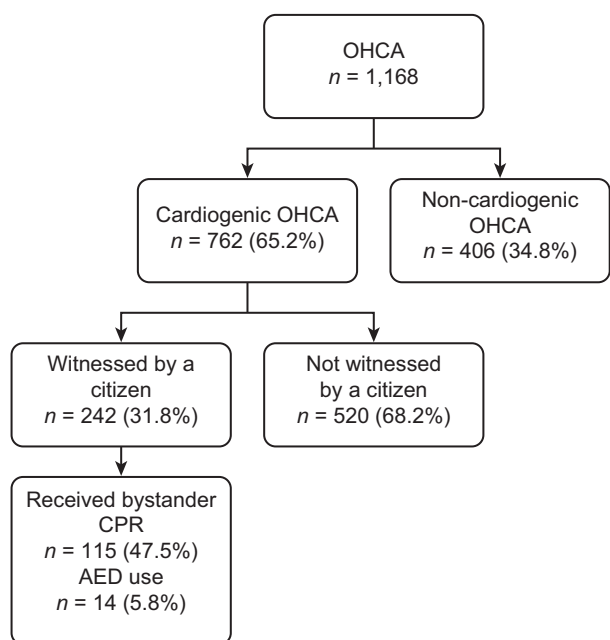
**I**N KAWASAKI CITY, 1,168 OHCAs were registered between 1 January, 2016, and 31 December, 2016. Figure 1 shows the age distribution, which did not differ between Kawasaki City and the overall Japanese data.

Of the 1,168 OHCAs in Kawasaki City, 762 were cardiogenic cardiac arrests. Of the cardiogenic cardiac arrests, 242 cases were witnessed by a citizen. Of these, 115 cases received bystander CPR, and 14 cases were subjected to AED use. In OHCAs witnessed by a citizen, 41 had an initial electrocardiogram (ECG) rhythm of ventricular fibrillation or ventricular tachycardia (Fig. 2).

We compared these rates with Japan's national data obtained from the Fire and Disaster Management Agency site (Table 1). The ratio of cardiogenic OHCAs was higher in Kawasaki City (*P* = 0.002). Among cardiogenic OHCAs, the ratio of OHCAs witnessed by a citizen and the 1-month survival rate did not differ significantly. However, among the OHCAs witnessed by a citizen, the rate of bystander CPR was significantly lower in Kawasaki City than in the



**Fig. 1.** Age distribution of out-of-hospital cardiac arrests in 2016 in Kawasaki City and nationwide in Japan. The age distribution of out-of-hospital cardiac arrests between Kawasaki City and nationwide did not apparently differ.



**Fig. 2.** Utstein-style statistics regarding cardiogenic out-of-hospital cardiac arrests (OHCAs) in Kawasaki City, Japan, between 1 January, 2016, and 31 December, 2016. A total of 1,168 OHCAs occurred in Kawasaki City, including 762 cases of cardiogenic cardiac arrest. Of these, 242 cases were witnessed by citizens. Among these cases, 115 received bystander cardiopulmonary resuscitation (CPR), and an automatic external defibrillator (AED) was used in 14 cases. The initial electrocardiogram rhythm was ventricular fibrillation or ventricular tachycardia in 41 cases.

Japanese national data ( $P = 0.007$ ). The 1-month survival rate did not differ. Similarly, the rate of OHCAs in Kawasaki City in which an AED was used and the 1-month survival rate did not differ from the Japanese national data.

**Table 1.** Data collected according to the Utstein-style guidelines and 1-month survival rates in Kawasaki City and nationwide, Japan, 2016

	Kawasaki City $n = 1,168$	Nationwide $n = 123,554$	$P$ -value
Number of cardiogenic OHCAs	762 (65.2%)	60.8%	0.002
1-month survival rate	7.5% (57/762)		
Witnessed by a citizen	242 (31.8%)	34.0%	0.186
1-month survival rate	14.0% (34/242)	13.3%	0.732
Received bystander CPR	115 (47.5%)	56.1%	0.007
1-month survival rate	19.1% (22/115)	16.4%	0.437
AED use	14 (5.8%)	4.7%	0.432
1-month survival rate	71.4% (10/14)	53.3%	0.177
Initial rhythm of VT/VF	41 (16.9%)	19.0%	0.526
1-month survival rate	39% (16/41)	36.4%	0.732

Nationwide data includes only the rate as a percentage. AED, automatic external defibrillator; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; VF, ventricular fibrillation; VT, ventricular tachycardia.

In Kawasaki City, the rate of cardiogenic OHCAs and the 1-month survival rate did not differ significantly among the three areas (Table 2).

Among cardiogenic OHCAs, the number witnessed by a citizen was slightly lower in the south. The 1-month survival rates of OHCAs witnessed by a citizen were 14.5% in the south, 11.6% in the middle, and 18.0% in the north, and these rates did not differ significantly.

Among cardiogenic OHCAs witnessed by a citizen, the rates of OHCAs that received bystander CPR were 44.9% in the southern area, 43.8% in the middle, and 57.4% in the northern area. The rates were not significantly different, but the rate in the northern area tended to be higher than those in other areas. The rate of OHCAs in which an AED was used in the north was higher than that of other areas.

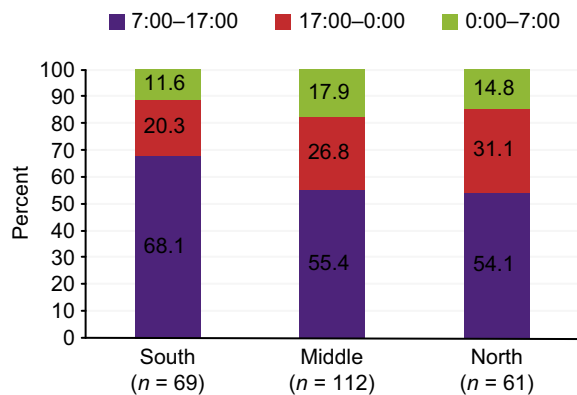
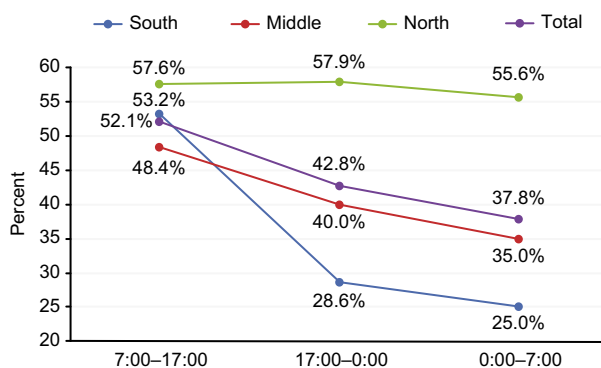
Figure 3 shows the percentage of cardiogenic OHCAs witnessed by a citizen according to the time of day. Each area showed a high percentage in the daytime (7:00–17:00). The results also showed high bystander CPR rates in the daytime, which decreased late in the day (Fig. 4). However, in the north, the rate of bystander CPR was constant over time.

Table 3 shows the discovery location and the rate of bystander CPR in each area by time period. Although some locations had a small number of cases, slight variations existed between locations. Overall, a tendency exists for low rates of bystander CPR at home and high rates of bystander CPR at indoor locations other than the home.

**Table 2.** Data collected according to the Utstein-style guidelines and 1-month survival rates in three areas of Kawasaki City, Japan, 2016

	South <i>n</i> = 374	Middle <i>n</i> = 510	North <i>n</i> = 284	<i>P</i> -value
Mean age, years	74.7	74.8	77.7	
Number of cardiogenic OHCA	240 (64.2%)	336 (65.9%)	186 (65.5%)	0.865
1-month survival rate	6.3% (15/240)	7.7% (26/336)	8.6% (16/186)	0.639
Witnessed by a citizen	69 (28.8%)	112 (33.3%)	61 (32.8%)	0.477
1-month survival rate	14.5% (10/69)	11.6% (13/112)	18.0% (11/61)	0.505
Received bystander CPR	31 (44.9%)	49 (43.8%)	35 (57.4%)	0.202
1-month survival rate	16.1% (5/31)	16.3% (8/49)	25.7% (9/35)	0.494
AED use	2 (2.9%)	5 (4.5%)	7 (11.5%)	0.088
1-month survival rate	50% (1/2)	80% (4/5)	71.4 (5/7)	1.000

AED, automatic external defibrillator; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest.

**Fig. 3.** Percentage of cardiogenic out-of-hospital cardiac arrests witnessed by a citizen in Kawasaki City, Japan, during each time period. A trend was observed toward high percentages during the daytime (7:00–17:00).**Fig. 4.** Rate of bystander cardiopulmonary resuscitation in cardiogenic out-of-hospital cardiac arrests witnessed by a citizen in Kawasaki City, Japan, during a time period. A tendency was observed toward high bystander cardiopulmonary resuscitation rates in the daytime, which decreased later in the day.

## DISCUSSION

AS DESCRIBED EARLIER, the 1-month survival rate of OHCA witnessed by a citizen in Kawasaki City was expected to be higher than the Japanese national rate; however, there was no significant difference between the two rates (Kawasaki, 14.0%; Japan, 13.3%). The rate of OHCA with an initial ECG rhythm of ventricular fibrillation or ventricular tachycardia did not differ between Kawasaki City (39.0%) and the overall Japanese data (36.4%). In Kawasaki City, a low rate of bystander CPR was identified; of the cardiogenic OHCA that were witnessed, the rate of bystander CPR was 47.5%, which is significantly lower than the overall rate for Japan (56.1%). We suggest that the low rate of bystander CPR was one of the major factors in the low 1-month survival rate of OHCA witnessed by a citizen in Kawasaki City.

Saga Prefecture, which is in northwestern Kyushu in the western part of Japan, has an area of 2,440 km<sup>2</sup> and a population of 850,000. A retrospective study divided the prefecture into five areas and found a difference in the rate of return of spontaneous circulation between these areas; this is because the rate differed according to the rate of bystander CPR (37.9–59.3%) even within the same prefecture.<sup>11</sup> Similar to Saga Prefecture, in Kawasaki City, there are differences in the rate of bystander CPR between each area, and the rates in the south (44.9%) and middle (43.8%) regions were low. This low rate is a major contributor to the low rate of bystander CPR in Kawasaki City.

In Kawasaki City, there were high bystander CPR rates in the daytime and lower rates late in the day in the south and middle areas. One reason for the low

**Table 3.** Discovery location and the rate of bystander cardiopulmonary resuscitation (CPR) in Kawasaki City, Japan, according to time period

7:00–17:00	South		Middle		North		Total	
	n = 47	BS CPR, %	n = 62	BS CPR, %	n = 33	BS CPR, %	n = 142	BS CPR, %
At home	22	54.5	27	29.6	13	46.2	62	41.9
Indoors outside of the home	17	47.1	28	64.3	16	75.0	61	62.3
Outdoors	8	62.5	7	57.1	4	25.0	19	52.6
17:00–0:00	n = 14	BS CPR, %	n = 30	BS CPR, %	n = 19	BS CPR, %	n = 63	BS CPR, %
At home	11	36.4	22	36.4	11	36.4	44	36.4
Indoors outside of the home	2	0.0	7	57.1	6	100.0	15	66.7
Outdoors	1	0.0	1	0.0	2	50.0	4	25.0
0:00–7:00	n = 8	BS CPR, %	n = 20	BS CPR, %	n = 9	BS CPR, %	n = 37	BS CPR, %
At home	6	16.7	13	23.1	6	66.7	25	32.0
Indoors outside of the home	2	50.0	6	66.7	3	33.3	11	54.0
Outdoors	0	0.0	1	0.0	0	0.0	1	0.0

BS, bystander.

rate of bystander CPR is that the patient was discovered at home in these areas. The rate of OHCAs discovered indoors at areas other than the home was high during the daytime, and the rate of bystander CPR was also high during the daytime; in contrast, the rate of OHCAs discovered at home was high and the rate of bystander CPR was low during the night-time in these areas.

Differences in the proportion of elderly people within the family structure are possible factors relating to the rate of bystander CPR. If the family is composed of only an elderly couple, the chance of receiving bystander CPR at home is low. However, according to data from the Japanese Government, the rate of elderly people is not particularly low in the north area (south, 21.7%; middle 16.8%; north, 20.1%) and the rate of families consisting only of elderly couples is higher in the north area than in other areas (south, 7.0%; middle, 6.7%; north, 8.8%). This means that the number of elderly people in the population or family might not be a major factor in the low rate of bystander CPR in the south and middle areas of Kawasaki City.

Based on the above data, to improve the overall rate of bystander CPR in Kawasaki City, the rate of bystander CPR at home should be improved. When a patient becomes unresponsive in the home, the key person who performs CPR is often a member of his/her family. Therefore, it could be said that the target population for

CPR training should be people who are often at home for longer periods of time, like students, housewives, or the elderly. However, in Kawasaki City, most of the CPR training is provided to corporations.

In Kawasaki City, a difference was found between the daytime and night-time population (day and night population ratio: south, 110%; middle, 80.3%; north, 80.7%). However, the rate of bystander CPR in OHCAs discovered at home was low in the south and middle, which implies that BLS knowledge should be spread to these areas.

According to a survey by Shibata *et al.*,<sup>12</sup> nearly 80% of participants answered that they might not perform CPR on an unresponsive stranger. This study shows a significant positive correlation between the number of times someone received CPR training and the likelihood of performing CPR on an unresponsive stranger.<sup>12</sup> These findings emphasize the importance of educating citizens to increase the rate of bystander CPR.

In addition to the need to increase knowledge regarding CPR, it is also important to spread knowledge regarding stroke. In Japan, surveys evaluating the knowledge of stroke have been actively undertaken.<sup>13–15</sup> Upper elementary or junior high school students are educated, and the students then teach the material to their parents. This strategy can increase both students' and their parents' knowledge of stroke. Similar methods can be used to spread knowledge regarding CPR to students and housewives to increase the rate of bystander CPR at home.

There are limitations to this study. The Utstein-style guidelines are only a record of the “situation.” If the rate of bystander CPR is low in some areas, the Utstein-style guidelines cannot reveal the reason for this observation. In Japan, nationwide or prefecture data exist, but municipal data are limited. To compare each area, it is important to study the data from many municipalities.

## DISCLOSURE

Information consent: N/A.

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

Animal study: N/A.

Conflict of interest: None.

Approval of the research protocol: N/A.

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