

## Clinical paper

# Does the number of rescuers affect the survival rate from out-of-hospital cardiac arrests? Two or more rescuers are not always better than one<sup>☆</sup>

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## ARTICLE INFO

## Article history:

Received 7 March 2012

Received in revised form 15 May 2012

Accepted 31 May 2012

## Keywords:

Out-of-hospital cardiac arrest

Home

Location

Telephone-CPR

Prospective cohort study

## ABSTRACT

**Review:** An increased number of rescuers may improve the survival rate from out-of-hospital cardiac arrests (OHCAs). The majority of OHCAs occur at home and are handled by family members.

**Materials and methods:** Data from 5078 OHCAs that were witnessed by citizens and unwitnessed by citizens or emergency medical technicians from January 2004 to March 2010 were prospectively collected. The number of rescuers was identified in 4338 OHCAs and was classified into two (single rescuer ( $N=2468$ ) and multiple rescuers ( $N=1870$ )) or three (single rescuer, two rescuers ( $N=887$ ) and three or more rescuers ( $N=983$ )) groups. The backgrounds, characteristics and outcomes of OHCAs were compared between the two groups and among the three groups.

**Results:** When all OHCAs were collectively analysed, an increased number of rescuers was associated with better outcomes (one-year survival and one-year survival with favourable neurological outcomes were 3.1% and 1.9% for single rescuers, 4.1% and 2.0% for two rescuers, and 6.0% and 4.6% for three or more rescuers, respectively ( $p=0.0006$  and  $p<0.0001$ )). A multiple logistic regression analysis showed that the presence of multiple rescuers is an independent factor that is associated with one-year survival (odds ratio (95% confidence interval): 1.539 (1.088–2.183)). When only OHCAs that occurred at home were analysed ( $N=2902$ ), the OHCAs that were handled by multiple rescuers were associated with higher incidences of bystander CPR but were not associated with better outcomes.

**Conclusions:** In summary, an increased number of rescuers improves the outcomes of OHCAs. However, this beneficial effect is absent in OHCAs that occur at home.

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## 1. Introduction

According to the ERC basic life support (BLS) guidelines 2010, a bystander should shout for help after he or she finds a victim who is unresponsive.<sup>1,2</sup> This recommendation may be based on the assumption that an increased number of rescuers may facilitate the BLS actions. The majority of out-of-hospital cardiac arrests (OHCAs) occur at home, where the response to OHCAs and the characteristics of OHCA patients and their rescuers may differ from those in other locations.<sup>3–6</sup> The ageing population accompanied with an increase in number of households with elderly residents<sup>7–9</sup> may influence not only the number of rescuers but also the performance of BLS.<sup>10–12</sup>

Nevertheless, it has not been investigated whether an increased number of rescuers may improve the survival rate from OHCAs. The aim of this study was to elucidate the effect of the number

of rescuers on the outcomes of OHCAs with an emphasis on the different characteristics of the OHCAs that occurred at home.

## 2. Materials and methods

The data were collected in accordance with the national guidelines of ethics for epidemiological surveys.<sup>13</sup> This study was approved by the review board of the Ishikawa Medical Control Council.

### 2.1. Populations and setting

The Ishikawa prefecture encompasses a snowfall area of 4186 km<sup>2</sup>, and has a resident population of 1,170,000. There are 11 fire departments. The prefecture is divided into four administrative regions: one central/urban region with five fire departments and three semi-rural/rural, regions with six departments. Sixty-two percent of the residents are located in the central region, which has an area of 1432 km<sup>2</sup>. The population age is older in semi-rural/rural regions (28.5% vs. 20.3% over the age of 65, respectively).

Since the beginning of 2004, telephone-assisted instruction of CPR (telephone-CPR) has been conducted by all fire

<sup>☆</sup> A Spanish translated version of the summary of this article appears as Appendix in the final online version at <http://dx.doi.org/10.1016/j.resuscitation.2012.05.026>.

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**Table 1**  
Differences in patient backgrounds and time factors between/among the groups.

Characteristics and backgrounds	Group (Number of rescuers), N				Statistics	
	Single N = 2468		Multiple N = 1870		p Value by univariate analysis between 2 groups <sup>a</sup> /among 3 groups	Odds ratio (95% C.I.) for multiple rescuers (single rescuer as reference)
	Two N = 887	Three or more N = 983	Two N = 887	Three or more N = 983		
Region – central, % (N)	55.2%(1361)	49.9%(443)	48.7%(910)	47.5%(467)	<b>&lt;0.0001</b>	<b>0.771</b>
Patient's age, median (25–75%)	77(64–84)	77(64–84)	76(62.75–85)	75(61–85)	0.7845	–
Patient's sex – male, % (N)	60.4%(1490)	60.2%(534)	60.8%(1136)	61.2%(602)	0.8019	1.016
Location – home, % (N)	79.1%(1952)	69.7%(618)	50.8%(950)	33.8%(332)	0.8721	(0.898–1.149)
Aetiology – presumed cardiac, % (N)	51.9%(1282)	48.6%(431)	47.4%(887)	46.4%(456)	<b>&lt;0.0001</b>	<b>0.273</b>
Arrest – witnessed, % (N)	39.7%(979)	41.5%(368)	44.1%(825)	46.5%(457)	<b>0.0032</b>	<b>(0.239–0.312)</b>
Call to arrival at patient, median (25–75%)	7(6–10)	7(6–10)	8(6–10)	8(6–10)	<b>0.0083</b>	<b>0.834</b>
Call to first CPR, <sup>b</sup> median (25–75%)	5(1–8)	3(0–7)	3(0–8)	3(0–8)	<b>0.0032</b>	1.201
Arrest recognition/witness to call, median (25–75%)	2(1–5)	2(1–5)	2(1–5)	2(1–5)	<b>0.0012</b>	(1.063–1.356)
					<b>0.0196</b>	–
					<b>0.0389</b>	–
					<b>&lt;0.0001</b>	–
					<b>&lt;0.0001</b>	–
					0.1381	–
					0.3054	–

<sup>a</sup> 2 groups: single or multiple.

<sup>b</sup> First CPR: whoever performed CPR first, between citizens and EMTs.

departments. All fire departments have a one-tiered ambulance dispatch system. Nine fire departments have a centralised dispatch system. EMTs resuscitate patients experiencing OHCA according to the protocol developed by the Ishikawa Medical Control Council. This protocol is based on the guidelines of the American Heart Association and the Japan Resuscitation Council. The paramedics are authorised to perform the following procedures during the resuscitation: (1) the use of supra-pharyngeal airways, (2) infusion of Ringer's lactate and (3) the use of semi-automated external defibrillators. Since July 2004, specially trained paramedics have been permitted to insert tracheal tubes under a limited indication criteria,<sup>14</sup> and since April 2006, they have been permitted to administer intravenous adrenaline. In all fire departments, each ambulance is usually boarded with three or more EMTs including at least one paramedic. The EMTs are not permitted to terminate resuscitation in the field.

## 2.2. Patient data and identification of the number of rescuers

Data from 5078 OHCA that were witnessed by citizens and were not witnessed by citizens or EMTs from January 2004 to March 2010 were prospectively collected by fire departments in the Ishikawa prefecture. The EMTs made an every effort to identify the number of rescuers defined as lay people who were close to the scene at arrest recognition or witness, responded to the first rescuer's cry for help and participated in any part of basic life support (BLS) and other related supports provided to the victim. The counting did not include either spectators at the scene, curious citizens who arrived at the scene after a time lapse or "responders" who arrived at the scene shortly before EMT arrival. The number of rescuers was identified in 85.4% (4338) of 5078 OHCA and was classified into two (single rescuer (N = 2468) and multiple rescuers (N = 1870)) or three (single rescuer, two rescuers (N = 887) and three or more rescuers (N = 983)) groups.

The collected data were based on the Utstein template<sup>15,16</sup> and included the region, place, patient's age, patient's sex, arrest

witness, causes of arrest (presumed cardiac or not), bystander CPR, initial cardiac rhythm, estimated time of collapse, times of the initiation of CPR by bystanders and EMTs, interval between the emergency call and arrival at the patient, sustained return of spontaneous circulation (SROSC), one-month (1-M) survival, one-year (1-Y) survival and 1-Y survival with a favourable neurological outcome, determined based on the Pittsburgh cerebral performance category (CPC).<sup>17,18</sup> The times of collapse and the initiation of CPR by bystanders were estimated by an interview, as reported previously.<sup>4</sup> The SROSC is defined as the continuous presence of palpable pulses for more than 20 min.<sup>15,16</sup> The survival rate at 1-Y was defined as the patient being alive in a hospital at 1-Y or as the patient being alive and discharged from the hospital to home or to a care or rehabilitation facility within 1-Y. One-year survival with favourable neurological outcome was defined as a CPC of one (good recovery) or two (moderate disability) in patients without any neurological disturbance before the arrest event and when the best CPC was equal to the pre-arrest category in patients with neurological disturbance. The primary end point was 1-Y survival.

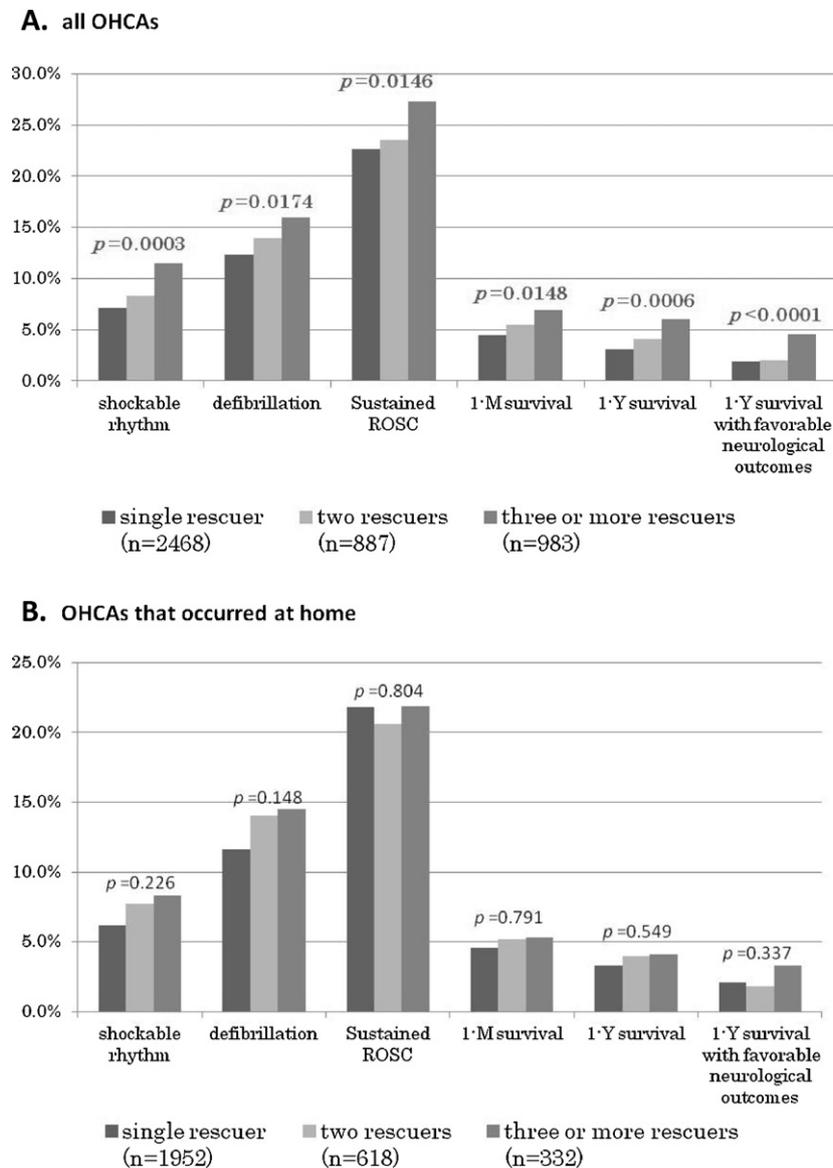
The quality of bystander CPR was rarely evaluated at EMT arrival and excluded from analysis. There were no data on how many cases having continuous CPR with a high quality.

The backgrounds, characteristics and outcomes of OHCA were compared between the two groups and among the three groups with reference to arrest location (home and others). The comparisons included BLS performance.

## 2.3. Statistical analysis

We analysed the data using JMP ver.7 for Windows (SAS institute, Cary, NC). The chi-squared test, with and without Pearson's correction, was applied for univariate analyses. The Kruskal–Wallis test was used for non-parametric comparisons. We used a multiple logistic regression analysis to identify the factors associated with 1-Y survival. In all analyses,  $p < 0.05$  was considered significant. Odds ratio (OR) and 95% confidence interval (95% C.I.) were shown when





**Fig. 1.** Effects of the number of rescuers on incidences of shockable initial rhythm and EMT-performed defibrillation, as well as the outcomes of all categories of OHCA.

The effects of the number of rescuers on some of the outcomes remained significant when the analysis was made based on bystander-witnessed OHCA of presumed cardiac aetiology (Fig. 2A). The increased number of rescuers was associated with higher incidences of shockable rhythm ( $p=0.0002$ ), EMT-performed defibrillation ( $p=0.0001$ ), 1-Y survival ( $p=0.0049$ ) and 1-Y survival with favourable neurological outcome ( $p=0.0049$ ).

### 3.5. Factors associated with 1-Y survival in all OHCA (Table 3)

A univariate analysis revealed that the presence of multiple rescuers (OR: 95% C.I. = 1.685: 1.238–2.292), central region (1.766: 1.281–2.434), patient's age ( $p<0.0001$ ), male patients (1.473: 1.059–2.048), arrest location ( $p<0.0001$ ), presumed cardiac aetiology (1.947: 1.412–2.684), witnessed arrest (4.424: 3.115–6.284), CPR before EMT arrival (1.417: 1.040–1.931), interval between call and EMT arrival at patient ( $p<0.0001$ ), interval between call and first CPR ( $p=0.0004$ ) and interval between arrest witness/recognition and call ( $p<0.0001$ ) were factors that were associated with 1-Y survival. A multiple logistic regression analysis ( $R^2=0.1665$ ) confirmed that the presence of multiple rescuers

is an independent factor that is associated with 1-Y survival (OR: 95% C.I. = 1.539: 1.088–2.183). Presumed cardiac aetiology and witnessed arrest were also independent factors that were associated with 1-Y survival. An increase in the patient's age, care facilities as arrest location, increased interval between call and arrival at patient and increased duration between arrest witness/recognition and call were other independent factors related to a low 1-Y survival.

### 3.6. Effects of the number of rescuers on OHCA that occurred at home

When the backgrounds and characteristics of OHCA were compared among the groups (Table 4), there were significant differences in the region and aetiology of arrest among the groups. The interval between the call and arrival at the patient significantly differed between single rescuer and multiple rescuer groups. The interval between the call and first CPR was significantly shortened when multiple rescuers were present. These differences were almost similar to those observed in all OHCA.

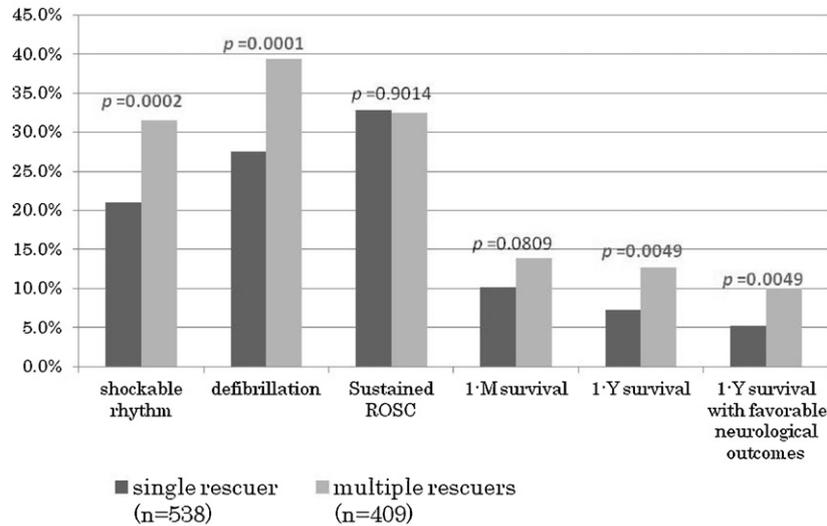
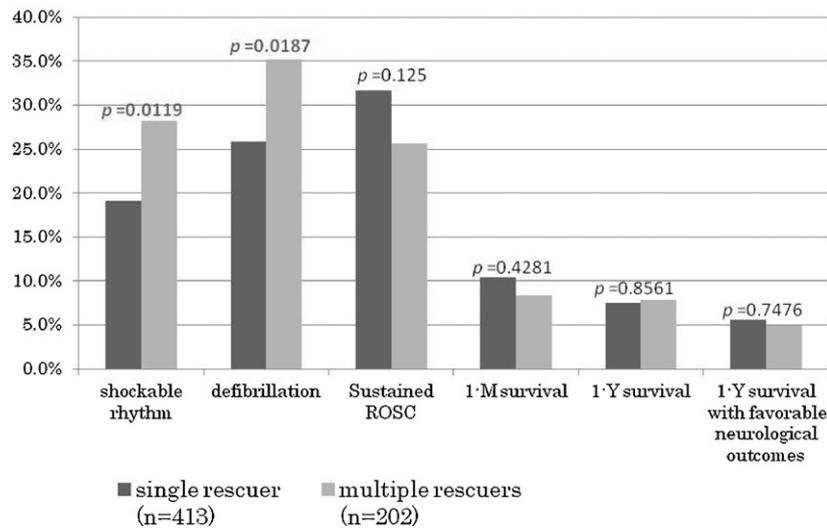
**Table 3**  
Independent factors associated with survival at 1-year.

Factors analysed		1-year survival % (number) or values	Statistics	
			Odds ratio (95% C.I.) or p value by univariate analysis	Adjusted Odds ratio (95% C.I.) by multiple logistic regression analysis <sup>b</sup> for survival
Number of rescuers, % (N)	Single	3.1% (76/2468)	Reference	Reference
	2 or more	5.1% (95/1870)	<b>1.685(1.238–2.292)</b>	<b>1.539(1.088–2.183)</b>
Region, % (N)	Central	4.9% (112/2271)	<b>1.766(1.281–2.434)</b>	1.265(0.806–1.988)
	Non-central	2.9% (59/2067)	Reference	Reference
Patient's age, median (25–75%)	Survivor	63 (52–76)	<b>&lt;0.0001</b>	<b>0.974(0.966–0.982)</b>
	Non-survivor	77 (64–84)		
Patient's gender, % (N)	Male	4.5% (118/2626)	<b>1.473(1.059–2.048)</b>	1.064(0.744–1.540)
	Female	3.1% (53/1712)	Reference	Reference
Location, % (N)	Home	3.5% (100/2902)	<b>&lt;0.0001</b>	0.735(0.506–1.075)
	Care facilities	1.5% (8/548)		<b>0.238(0.093–0.549)</b>
	Others	7.1% (63/888)		Reference
Aetiology, % (N)	Presumed cardiac	5.2% (112/2169)	<b>1.947(1.412–2.684)</b>	<b>2.170(1.532–3.110)</b>
	Non-cardiac	2.7% (59/2169)	Reference	Reference
Arrest – witnessed, % (N)	Witnessed	7.1% (128/1804)	<b>4.424(3.115–6.284)</b>	<b>4.169(2.885–6.146)</b>
	Unwitnessed	1.7% (43/2534)	Reference	Reference
CPR before EMT arrival to patient, % (N)	CPR	4.6% (99/2151)	<b>1.417(1.040–1.931)</b>	1.188(0.739–1.947)
	No CPR	3.3% (72/2187)	Reference	Reference
CPR performer, % (N)	HCP	3.1% (14/448)	0.725(0.415–1.265)	1.167(0.560–2.302)
	No CPR/others	4.3% (149/3498)	Reference	Reference
Tracheal intubation, % (N)	Perform	3.1% (14/455)	0.753(0.432–1.313)	0.997(0.527–1.755)
	Not performed	4.0% (157/3883)	Reference	Reference
Adrenaline, % (N)	Perform	2.1% (3/145)	0.506(0.160–1.604)	0.385(0.065–1.318)
	Not performed	4.0% (168/4192)	Reference	Reference
Type of hospital, % (N)	High level	5.1% (102/2000)	<b>0.0013</b>	1.057(0.678–1.660)
	Others	3.0% (69/2338)		Reference
Call to arrival at patient, median (25–75%)	Survivor	6.0 (5.0–8.0)	<b>&lt;0.0001</b>	<b>0.906(0.865–0.945)</b>
	Non-survivor	8.0 (6.0–10.0)		
Call to first CPR, <sup>a</sup> median (25–75%)	Survivor	2.5 (0–6.0)	<b>0.0004</b>	0.959(0.915–1.007)
	Non-survivor	4.0 (0–8.0)		
Arrest witness/recognition – call, median (25–75%)	Survivor	2.0 (1.0–3.0)	<b>&lt;0.0001</b>	<b>0.945(0.912–0.977)</b>
	Non-survivor	2.0 (1.0–5.0)		

<sup>a</sup> First CPR: whoever performed CPR first, between citizens and EMTs.<sup>b</sup> R<sup>2</sup> = 0.1665.**Table 4**  
Differences in patient backgrounds and time factors among the groups in in-home OHCA (univariate analysis).

Characteristics and backgrounds	Group (number of rescuers), N				Statistics	
	Single N = 1952	Multiple N = 950		p Value by univariate analysis between 2 groups <sup>a</sup> /among 3 groups	Odds ratio (95% C.I.) for multiple rescuers (single rescuer as reference)	
		Two N = 618	Three or more N = 332			
Region – central, % (N)	54.2%(1057)	52.3%(323)	47.0%(446)	37.1%(123)	<b>0.0003</b> <b>&lt;0.0001</b>	<b>0.749</b> <b>(0.641–0.875)</b>
Patient's age, median (25–75%)	76(64.3–83)	76(64–84)	77(66–84)	78(68–85)	0.3049 0.0972	–
Patient's sex – male, % (N)	60.7%(1184)	62.0%(383)	61.0%(579)	59.0%(196)	0.88 0.669	1.012 (0.864–1.187)
Aetiology – presumed cardiac, % (N)	52.8%(1031)	50.2%(310)	48.3%(459)	44.9%(149)	<b>0.0228</b> <b>0.0224</b>	<b>0.835</b> <b>(0.715–0.975)</b>
Arrest – witnessed, % (N)	38.6%(753)	39.0%(241)	39.8%(378)	41.3%(137)	0.5296 0.6511 0.0768	1.052 (0.898–1.233)
Call to arrival at patient, median (25–75%)	7(6–9)	7(6–10)	7(6–10)	8(6–10)	<b>0.0301</b>	–
Call to first CPR, <sup>b</sup> median (25–75%)	5(1–8)	3(0–7)	3(0–8)	4(1–8)	<b>&lt;0.0001</b> <b>&lt;0.0001</b>	–
Arrest recognition/witness to call, median (25–75%)	2(1–6)	2(1–5)	2(1–5)	2(1–5)	0.4189 0.5904	–

<sup>a</sup> 2 groups: single or multiple.<sup>b</sup> First CPR: whoever performed CPR first, between citizens and EMTs.

**A. All bystander-witnessed OHCA of presumed cardiac aetiology****B. Bystander-witnessed OHCA of presumed cardiac aetiology at home**

**Fig. 2.** Effects of the number of rescuers on incidences of shockable initial rhythm and EMT-performed defibrillation, as well as the outcomes of bystander-witnessed OHCA of presumed cardiac aetiology.

As shown in Table 2, the presence of multiple rescuers significantly increased the incidence of bystander CPR ( $p < 0.0001$ ) but did not significantly reduce the interval between the call and bystander CPR ( $p = 0.0862$ ). Healthcare providers performed bystander CPR more frequently when multiple rescuers were present ( $p < 0.0001$ ), as observed in all OHCA, but healthcare providers very rarely performed CPR at home (4.8% at home and 47.1% at other locations,  $p < 0.0001$ ). It should also be noted that most (84%) bystander CPR was initiated following telephone-CPR. Bystanders applied the PAD in one case.

Despite these beneficial effects on CPR performance before EMT arrival at the patients, we failed to detect any significant effects on the incidences of shockable initial rhythm, EMT-performed defibrillation and patient outcomes in all OHCA that occurred at home (Fig. 1B). When analysed based on bystander-witnessed OHCA of presumed cardiac aetiology that occurred at home (Fig. 2B), the presence of multiple rescuers had no significant influences on patient outcomes but was associated with higher incidences of

shockable initial rhythm ( $p = 0.0119$ ) and EMT-performed defibrillation ( $p = 0.0187$ ).

Univariate analysis followed by multiple logistic regression analysis (for 1-Y survival ( $R^2 = 0.1451$ )) confirmed that the number of rescuers is not an independent factor associated with 1-Y survival (OR: 95% C.I. = 1.282: 0.820–1.985). The analysis demonstrated that the patient's age, witnessed cardiac arrest, interval between the call and arrival at patient and interval between arrest witness/recognition and the call are other independent factors associated with 1-Y survival.

#### 4. Discussion

To the best of our knowledge, this study is the first to investigate the effect of the number of rescuers on BLS performance and outcomes of OHCA patients. When all OHCA were analysed collectively, an increased number of rescuers, as expected by ERC BLS Guidelines, was associated with higher incidences of

CPR before EMT arrival, healthcare provider as a CPR performer, shockable initial rhythm and better outcomes. Furthermore, the PAD was more frequently applied and defibrillation was more frequently attempted by bystanders when multiple rescuers were present. However, these beneficial effects of an increased number of rescuers on patient outcomes were absent in OHCA that occurred at home. Of note, the presence of multiple rescuers significantly increased the incidences of shockable initial rhythm and EMT-performed defibrillation in bystander-witnessed OHCA of presumed cardiac aetiology that occurred at home. The presence of multiple rescuers in OHCA that occurred at home significantly increased the incidence of CPR before EMT arrival at the patient but did not reduce the interval between the call and CPR prior to EMT arrival. Furthermore, in most (67%) OHCA cases that occurred at home, bystander-CPR was initiated following telephone-CPR, and more than half (55%) of the cases were managed by a single rescuer. The presence of multiple rescuers in public places may be one reason why survival is less for the in-home OHCA than the public OHCA.

Japan has a rapidly ageing population,<sup>7,8</sup> which has led to an increase in the number of households with elderly residents (42% in 2010).<sup>9</sup> Furthermore, the number of household members was 2.5 members/household in 2010. Approximately 20% of all households are “elderly households” (defined as households consisting of individuals aged 65 years or over, with or without unmarried dependents below the age of 18), and nearly half of them are composed of elderly couples.<sup>9</sup> These characteristics of Japanese households may contribute to our observations.

In Japan, fire departments,<sup>19</sup> the Japanese Red Cross Society<sup>20</sup> and qualified drivers license schools<sup>21,22</sup> provide the BLS training programme for citizens. Annual participants in these qualified programmes are reported to be approximately 2,600,000 in total. Assuming that participants in the BLS course maintain fundamental BLS skills and sufficient willingness to perform BLS for two years,<sup>10,23,24</sup> approximately 4.4% ( $2 \times 2.6/127 \times 100$ ) of the population in Japan is estimated to have an ability to perform BLS with the fundamental skills. The sum of healthcare providers represents 1.4% of the population in Japan.<sup>25,26</sup> Thus, the incidence of a well-trained rescuer performing BLS for victims is 5.8% when estimated approximately in an ideal situation. This incidence increases in proportion to the number of rescuers for OHCA that occur in most public locations because these high-potential bystanders are consistently distributed. In this study, we showed that multiple rescuers were less frequently present and healthcare providers less frequently performed CPR in OHCA that occurred at home. The willingness to attend a BLS course<sup>11</sup> and to perform BLS<sup>10,12</sup> has been reported to be low in elderly citizens. The home environment is a relatively confined location where high-potential bystanders are rarely present. Presumably, the low quality of bystander CPR due to the rescuers’ educational backgrounds and unwillingness to performing BLS (including AED use) on bystander’s own initiative may also explain the lack of beneficial effects of multiple rescuers on outcomes.

Finally, the diffusion of responsibility among family members<sup>27</sup> and bureaucracy and/or patriarchal system in Japanese families<sup>28</sup> may be a reason for the lack of beneficial effects of multiple rescuers. Male has a shorter life than female. A male patriarch (or a husband) is frequently the first victim of OHCA that is witnessed or detected by a family member (occasionally by a housewife). This situation may cause a chaos at home. These behavioural properties of Japanese families may cause the delay in the initiation of bystander CPR and the delay in emergency calls.<sup>4</sup>

The results of the present study suggest that different strategies will be needed to improve BLS performance for OHCA that occur at home. Because the incidence of a single rescuer is higher in OHCA that occur at home than those that occur at other

locations, BLS instruction for families should be arranged in case help from other rescuers is unavailable. BLS instruction should be targeted to the “elderly household.” The implementation of a community first responder system<sup>29</sup> or recruitment of well-trained citizens to perform BLS on OHCA victims at home<sup>30</sup> may be necessary.

#### 4.1. Limitations

There are some limitations in our study. Apparently ineffective bystander CPR, including ventilation-only CPR, was characterised as “no CPR,” but the quality of bystander CPR was not evaluated or quantified. Furthermore, backgrounds for BLS training were not obtained. Rescuers defined in this study may include some laypersons that just help without doing any CPR. This may be the reason why multiple rescuers did not show any benefit on survival of in-home OHCA. Exclusion of OHCA patients without an identified number of rescuers might modify the results although the number was identified in 85.4% of OHCA during the study period.

However, this study contains a considerably large prospective cohort. The results of the present study are interpreted with reference to the current BLS guidelines and BLS education that was designed for a small household where multiple rescuers are present.

#### 5. Conclusions

As a whole, an increased number of rescuers improved the outcomes of OHCA that were not witnessed by EMTs. However, this beneficial effect was absent in OHCA that occurred at home. Different strategies, including BLS instruction focused on a single rescuer in a small family or household and the recruitment of well-trained citizens to perform BLS on OHCA victims at home, may be necessary to improve the outcome of OHCA that occur at home.

#### Conflict of interest statement

We have no conflicts of interest to disclose.

#### Acknowledgements

We would like to thank all of the fire departments in Ishikawa Prefecture for help with data collection.

#### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.resuscitation.2012.05.026>.

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