


## Original Article

# Patient outcomes of school-age, out-of-hospital cardiac arrest in Japan: A nationwide study of schoolchildren as witnesses

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**Aim:** Using the data from the All-Japan Utstein Registry, this study evaluates the neurologically favourable patient outcomes and associated factors of out-of-hospital cardiac arrest (OHCA) with Japanese schoolchildren as witnesses.

**Methods:** We analysed 1,068 school-age children (6–18 years old) who underwent OHCA from 2011 to 2016. Among the 1,068 cases, 179 were witnessed by schoolchildren and 889 were witnessed by other bystanders. Propensity score-matched and logistic regression analyses were used to evaluate the outcomes and associated factors.

**Results:** The crude neurologically favourable outcome in the schoolchildren-witnessed group was considerably higher than that in the other-bystander-witnessed group (19.6% versus 12.3%;  $P < 0.010$ ). However, the difference was not significant in the propensity score-matched analysis (19.6% versus 21.8%;  $P = 0.602$ ). The multivariable logistic regression analyses of school-age OHCA with schoolchildren as witnesses demonstrated that bystander cardiopulmonary resuscitation (CPR) provision (odds ratio [OR] 4.12, 95% confidence interval [CI] 1.44–11.75), shockable initial rhythm (OR 3.39, 95% CI 1.43–8.04), and defibrillation (OR 4.58, 95% CI 1.65–12.71) provided by any bystander were positively associated with favourable outcomes. By contrast, dispatcher-assisted CPR provision (OR 0.28, 95% CI 0.11–0.70), exogenous cause (OR 0.16, 95% CI 0.03–0.86), adrenaline administration (0.25; 95% CI 0.07–0.92), and prolonged response time (OR 0.86; 95% CI 0.75–0.98) were negatively associated with favourable outcomes.

**Conclusions:** Patient outcomes did not differ significantly between schoolchildren- and other-bystander-witnessed cases of school-age OHCA. Although schoolchildren as witnesses might not be inferior to other bystanders in school-age OHCA, further studies are needed to examine the effect of bystander CPR by schoolchildren and basic life support education in schools.

**Key words:** Emergency medical service, out-of-hospital cardiac arrest, school-age children

## INTRODUCTION

THE INTERNATIONAL LIAISON Committee on Resuscitation recommends practising cardiopulmonary resuscitation (CPR) as a standard aspect of school curricula.<sup>1</sup> In Japan, basic life support (BLS) education became

compulsory in 1994 and is included in the curricula at primary, junior, and senior high-school levels.<sup>2</sup>

Because BLS education is conducted in schools throughout Japan, schoolchildren could contribute to the improvement of clinical outcomes when they encounter out-of-hospital cardiac arrest (OHCA). School-age children are more likely to witness a school-age child undergoing OHCA than other types of OHCA cases because they spend much of their time at school or in other public places with friends.<sup>3</sup> Nevertheless, whether school-age children as witnesses affects patient outcomes in school-age OHCA remains unknown. Furthermore, although previous studies have explored factors associated with outcomes in paediatric OHCA,<sup>4–6</sup> related factors in school-age OHCA with schoolchildren as witnesses were given little attention. BLS

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Received 27 Aug, 2020; accepted 1 Nov, 2020

**Funding information**

No funding information provided.

education would be enhanced further by identifying factors associated with outcomes in cases with schoolchildren as witnesses, which leads to achieving better outcomes in school-age OHCA.

This study included two major aims: one was to investigate whether outcomes differ between school-age OHCA cases witnessed by schoolchildren and those witnessed by other bystanders, and the other one was to identify factors associated with the outcomes in school-age OHCA with schoolchildren as witnesses.

## METHODS

### Study design

**T**HIS IS A population-based, observational study using the data from All-Japan Utstein Registry, a prospective, nationwide, population-based registry of OHCA patients in Japan. The anonymous data collection method complied with the national guidelines for ethics in epidemiological surveys.<sup>7</sup> Permission from the Fire and Disaster Management Agency (FDMA) was received to analyse the data. This study was approved by the Institutional Review Board of the Ishikawa Medical Control Council (review number: 2011-2).

### Setting

The Japanese school system comprises 6 years of elementary school, 3 years of junior high school, and 3 years of senior high school. Attending elementary and junior high schools is compulsory, and the rate of continuous education throughout the study period exceeded 97%. In 2016, the population of Japan was 127 million including 13.3 million school-age children (6–18 years old), constituting 10.5% of the total population.<sup>8</sup> In 2016, the number of students in elementary, junior high, and senior high schools was 20,313, 10,404, and 4,925, respectively.<sup>9</sup> School holidays, including summer, spring, and winter holidays, were determined by the Board of Education in each prefecture, which was responsible for school rules and regulations.

The emergency medical service (EMS) system in Japan has been previously described in detail.<sup>4</sup> In 2016, 733 fire stations with dispatch centres in Japan existed.<sup>10</sup> All ambulance teams operate according to the protocols established by a local medical control council based on the Japan Resuscitation Council guidelines.<sup>11</sup> According to FDMA guidelines,<sup>12</sup> dispatcher-assisted CPR (DA-CPR) is commonly provided.

### Participants

School-age children (6–18 years old) who had OHCA, for whom resuscitation was attempted by EMS personnel, with

subsequent transport to hospitals, from 1 January 2011 to 31 December 2016, were eligible for analysis.

### Data sources

The All-Japan Utstein Registry included patient background, clinical characteristics, and critical time factors, based on the Utstein recommendations for reporting OHCA cases.<sup>13</sup> A data form was filled out by EMS personnel along with the physician in charge and transferred to the registration system on the FDMA database server. Then, the data were assessed by the FDMA. All OHCA survivors were followed up with an interview 1 month after successful CPR provided by fire department personnel to assess their outcomes. A neurologically favourable outcome was defined using the Cerebral Performance Category (CPC) score,<sup>14</sup> where 1 is classified as good recovery and 2 as moderate disability. The CPC score was determined by a physician in collaboration with EMS personnel.

Although the registry covers OHCA cases that have occurred in Japan, it does not include information about the bystanders' age. In the registry, eight items focused on bystander–patient relationship, such as family, friends, colleagues, passer-by, fire department personnel, EMS personnel, paramedics, and others. Because the data in this study were about school-age OHCA, we selected friends and colleagues in the registry items on bystander–patient relationship and defined them as schoolchildren. Likewise, we selected family, passer-by, and others and defined them as other bystanders.

### Study endpoints

The primary endpoint of this study was the neurologically favourable outcome defined as a CPC score of 1 or 2. The secondary endpoint was 1-month survival.

### Statistical methods

We used the JMP Pro 15 software (SAS Institute, Cary, NC, USA) for all statistical analyses. To assess the univariate differences in background, clinical characteristics, time factors, and outcomes between schoolchildren and other bystanders, we used the chi-square test for nominal variables and the Mann–Whitney *U* test for continuous variables. To adjust the differences in these variables between the groups, we performed a propensity score-matched analysis. We conducted a logistic regression analysis to estimate the propensity score for schoolchildren in the bystander–patient relationship. Matching was performed using a 1:1 protocol with a calliper value of 0.2 with schoolchildren or other bystanders based

on the average propensity score. We used *C*-statistics (concordance index) to confirm the fit of this model.

Furthermore, a multivariable logistic regression analysis was performed after matching to identify factors associated with the outcomes in school-age OHCA with schoolchildren as witnesses. All tests were two-tailed, and *P* values of <0.05 were considered significant.

## Variables

For the propensity score matching, we included the following variables: age (elementary schoolchildren or not), gender, bystander CPR provision, DA-CPR provision, presumed cardiac aetiology, exogenous cause (e.g., trauma, poisoning, submersion, and suicide attempt), shockable initial rhythm, defibrillation provided by any bystander, and school hours on school days. We confirmed the school days in each prefecture by excluding weekends, national and school holidays, and vacations. School hours were defined as 08:00–18:00, considering the extracurricular after-school activities and commuting to school.

For the multivariable logistic regression analysis, clinically important confounders selected according to previous studies<sup>4,5,15,16</sup> were included. The variables include age (elementary schoolchildren or not), gender, bystander CPR provision, DA-CPR provision, presumed cardiac aetiology, exogenous cause (e.g., trauma, poisoning, submersion, and suicide attempt), shockable initial rhythm, defibrillation provided by any bystander, adrenaline administration, school hours on school days, and response time (time intervals between emergency call and EMS contact with the patient).

## RESULTS

### Selection criteria

**F**IGURE 1 shows the selection criteria of the patients for this study. Among all OHCA cases from 2011 to 2016, we extracted 1,068 bystander-witnessed, school-age (6–18 years old) OHCA cases without prehospital physician involvement with a complete data set for analysis. We divided the cases into two groups: 179 cases witnessed by schoolchildren (friends: 90.5%, colleagues: 9.5%) and 889 cases witnessed by other bystanders (family: 44.0%, passer-by: 22.8%, others: 33.2%).

### Background and clinical characteristics of the two groups before and after propensity score matching

The ratio of elementary schoolchildren and female among the schoolchildren-witnessed cases were lower than for

those among the other-bystander-witnessed cases (13.4% versus 35.3% for elementary schoolchildren; 21.8% versus 33.0% for female, respectively). The percentages of exogenous causes (58.1% versus 49.3%), shockable initial rhythm (24.0% versus 14.9%), and defibrillation provided by any bystander (14.5% versus 5.7%) in the schoolchildren-witnessed cases were higher than those in the other-bystander-witnessed cases.

In the propensity score matching, 179 patients were matched in each case (schoolchildren-witnessed cases—friends: 90.5%, colleagues: 9.5%; other-bystander-witnessed cases—family: 27.9%, passer-by: 29.1%, others: 43.0%). No significant differences in the background and clinical characteristics were found between the groups, except for the response time. The response time in the schoolchildren-witnessed cases was longer than that in the other-bystander-witnessed cases (median 9.0 min versus 8.0 min; Table 1). The concordance index was 0.70, showing a fair fit of this model.

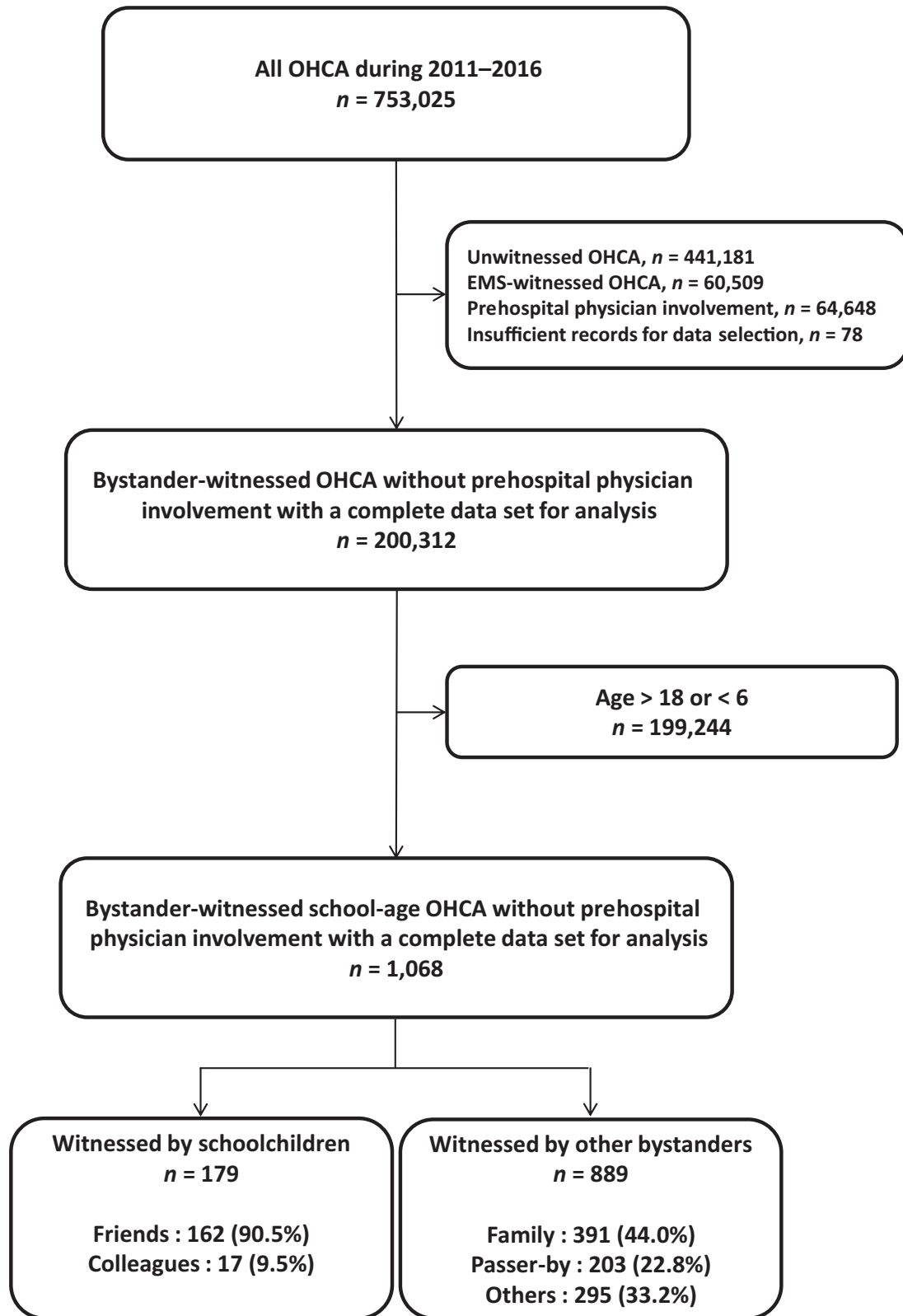
### Outcomes of the two groups

The crude neurologically favourable outcome in the schoolchildren-witnessed group was considerably higher than that in the other-bystander-witnessed group (19.6% versus 12.3%; *P* < 0.010). No significant differences in crude 1-month survival were found between the two groups (25.1% versus 21.5%; *P* = 0.282). The crude neurologically favourable outcome and 1-month survival for school hours on school days in the schoolchildren-witnessed group were significantly higher than those in the other-bystander-witnessed group (40.0% versus 16.4%; *P* < 0.001 and 50.0% versus 27.1%; *P* < 0.010, respectively).

After case matching the two groups, we found no significant differences between the schoolchildren-witnessed group and the other-bystander-witnessed group in (i) overall cases (19.6% versus 21.8% and *P* = 0.602 for neurologically favourable outcome; 25.1% versus 25.7% and *P* = 0.903 for 1-month survival, respectively) and (ii) school hours on school days (40.0% versus 30.6% and *P* = 0.390 for neurologically favourable outcome; 50.0% versus 36.1% and *P* = 0.223 for 1-month survival, respectively; Table 2).

### Factors associated with outcomes in school-age OHCA with schoolchildren as witnesses

Multivariable logistic regression analysis of school-age OHCA with schoolchildren as witnesses revealed various factors associated with outcomes. Bystander CPR provision (adjusted odds ratio [OR] 4.12; 95% confidence interval [CI] 1.44–11.75), shockable initial rhythm (OR 3.39; 95%



**Fig. 1.** Selection criteria. EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest.

**Table 1.** Background and clinical characteristics of the two groups before and after propensity score matching

	Before matching			After matching		
	Bystander–patient relationship		P-value	Bystander–patient relationship		P-value
	Schoolchildren (n = 179)	Other bystanders (n = 889)		Schoolchildren (n = 179)	Other bystanders (n = 179)	
Elementary schoolchildren, % (n)	13.4 (24)	35.3 (314)	<0.001	13.4 (24)	13.4 (24)	1.000
Female, % (n)	21.8 (39)	33.0 (293)	<0.010	21.8 (39)	20.7 (37)	0.769
Bystander CPR provision, % (n)	48.0 (86)	50.6 (450)	0.530	48.0 (86)	47.5 (85)	0.916
DA-CPR provision, % (n)	37.4 (67)	38.3 (340)	0.838	37.4 (67)	39.1 (70)	0.744
Presumed cardiac aetiology, % (n)	36.3 (65)	29.6 (263)	0.075	36.3 (65)	33.0 (59)	0.505
Exogenous cause <sup>†</sup> , % (n)	58.1 (104)	49.3 (438)	0.031	58.1 (104)	62.0 (111)	0.450
Shockable initial rhythm, % (n)	24.0 (43)	14.9 (132)	<0.010	24.0 (43)	20.1 (36)	0.372
Defibrillation by any bystander, % (n)	14.5 (26)	5.7 (51)	<0.001	14.5 (26)	13.4 (24)	0.760
Adrenaline administration, % (n)	11.7 (21)	9.6 (85)	0.376	11.7 (21)	12.9 (23)	0.748
School hours on school days <sup>‡</sup> , % (n)	22.4 (40)	23.3 (207)	0.786	22.4 (40)	20.1 (36)	0.605
Time intervals, median (IQR) (min)						
Response time <sup>§</sup>	9.0 (7.0–13.0)	8.0 (6.0–10.0)	<0.001	9.0 (7.0–13.0)	8.0 (6.0–10.0)	<0.010

CPR, cardiopulmonary resuscitation; DA-CPR, dispatcher-assisted cardiopulmonary resuscitation; IQR, interquartile range.

<sup>†</sup>Trauma, poisoning, submersion and suicide attempt.

<sup>‡</sup>08:00 to 18:00 on school days.

<sup>§</sup>Time intervals between emergency call and emergency medical service contact with the patient.

**Table 2.** Outcomes of the two groups

	Bystander–patient relationship		P-value
	Schoolchildren	Other bystanders	
Overall cases	n = 179	n = 889	
One-month survival, % (n)	25.1 (45)	21.5 (191)	0.282
Neurologically favourable outcome, % (n)	19.6 (35)	12.3 (109)	<0.010
School hours on school days <sup>†</sup>	n = 40	n = 207	
One-month survival, % (n)	50.0 (20)	27.1 (56)	<0.010
Neurologically favourable outcome, % (n)	40.0 (16)	16.4 (34)	<0.001
Propensity score-matched patients			
Overall cases	n = 179	n = 179	
One-month survival, % (n)	25.1 (45)	25.7 (46)	0.903
Neurologically favourable outcome, % (n)	19.6 (35)	21.8 (39)	0.602
School hours on school days <sup>†</sup>	n = 40	n = 36	
One-month survival, % (n)	50.0 (20)	36.1 (13)	0.223
Neurologically favourable outcome, % (n)	40.0 (16)	30.6 (11)	0.390

<sup>†</sup>08:00 to 18:00 on school days.

CI 1.43–8.04), and defibrillation by any bystander (OR 4.58; 95% CI 1.65–12.71) were associated with a higher rate of neurologically favourable outcomes. Alternatively, DA-CPR provision (OR 0.28; 95% CI 0.11–0.70), exogenous cause (OR 0.16; 95% CI 0.03–0.86), adrenaline

administration (OR 0.25; 95% CI 0.07–0.92), and response time (OR 0.86; 95% CI 0.75–0.98/1 min increase) were associated with a lower rate of neurologically favourable outcomes. Furthermore, bystander CPR provision (OR 3.02; 95% CI 1.31–6.96), shockable initial rhythm (OR 2.89; 95%

CI 1.35–6.16), and defibrillation provided by any bystander (OR 4.77; 95% CI 1.82–12.52) were associated with higher 1-month survival. DA-CPR provision (OR 0.42; 95% CI 0.19–0.89) and response time (OR 0.88; 95% CI 0.79–0.98/1 min increase) were negatively associated with 1-month survival (Table 3).

## DISCUSSION

### Key observation

**I**N THIS STUDY, although schoolchildren-witnessed cases had better outcomes than other-bystander-witnessed cases on crude analysis, no statistically significant differences were found between the two groups on propensity score-matched analysis. In addition, bystander CPR provision, shockable initial rhythm, and defibrillation provided by any bystander were associated with better outcomes in school-age OHCA with schoolchildren as witnesses. By contrast, DA-CPR and prolonged response time were negatively associated with outcomes.

### Strength

Although studies have investigated the incidence and patient outcomes of school-age OHCA,<sup>3–5,15,17</sup> little attention has been paid to the effects of schoolchildren as witnesses. To our best knowledge, this is the first study to examine patient outcomes of school-age OHCA with Japanese schoolchildren as witnesses using a nationwide registry. Furthermore, to adjust the differences in variables between the groups, we used propensity score-matched analysis. Therefore, we believe that we could minimize the potential bias with this method.

### Interpretation

In this study, the differences in outcomes were not significant after adjusting the background and clinical characteristics between the schoolchildren- and other-bystander-witnessed cases on the propensity score-matched analysis. However, although no significant differences in outcomes were found, schoolchildren as witnesses have not negatively affected the outcomes. Therefore, we believe that most schoolchildren could contribute to improving the clinical outcomes by calling for help or using automated external defibrillators (AEDs) appropriately when they witness school-age OHCA.

Studies have reported that bystander CPR provision, shockable initial rhythm, and defibrillation provided by any bystander were associated with better outcomes in paediatric OHCA.<sup>4–6</sup> The present study revealed that those factors

**Table 3.** Factors associated with outcomes in school-age OHCA with schoolchildren as witnesses

Factors	Adjusted OR (95% CI)	
	Neurologically favourable outcome	One-month survival outcome
Elementary schoolchildren	1.31 (0.46–3.78)	1.19 (0.49–2.88)
Female	1.26 (0.50–3.21)	0.84 (0.38–1.88)
Bystander CPR provision	4.12 (1.44–11.75)	3.02 (1.31–6.96)
DA-CPR provision	0.28 (0.11–0.70)	0.42 (0.19–0.89)
Presumed cardiac aetiology	2.57 (0.58–11.37)	1.71 (0.48–6.12)
Exogenous cause <sup>†</sup>	0.16 (0.03–0.86)	0.32 (0.09–1.15)
Shockable initial rhythm	3.39 (1.43–8.04)	2.89 (1.35–6.16)
Defibrillation by any bystander	4.58 (1.65–12.71)	4.77 (1.82–12.52)
Adrenaline administration	0.25 (0.07–0.92)	0.85 (0.33–2.18)
School hours on school days <sup>‡</sup>	0.68 (0.27–1.68)	0.99 (0.46–2.15)
Time intervals (/1 min increase)		
Response time <sup>§</sup>	0.86 (0.75–0.98)	0.88 (0.79–0.98)

CI, confidence interval; CPR, cardiopulmonary resuscitation; DA-CPR, dispatcher-assisted cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; OR, odds ratio.

<sup>†</sup>Trauma, poisoning, submersion, and suicide attempt.

<sup>‡</sup>08:00 to 18:00 on school days.

<sup>§</sup>Time intervals between emergency call and emergency medical service contact with the patient.

were equally associated with better outcomes in school-age OHCA with schoolchildren as witnesses. Unfortunately, our data could not address the first action a bystander takes after witnessing OHCA. Some children might use an AED themselves, and others might call for help from an adult and the adult might conduct CPR. Further study needs to be conducted to investigate how schoolchildren act when they encounter OHCA.

Furthermore, this study revealed that DA-CPR provision was negatively associated with patient outcomes. In Japan, Akahane *et al.* reported that DA-CPR was not associated with a neurologically favourable outcome in paediatric OHCA as the witness collapsed.<sup>16</sup> One possible reason for these results would be that individuals who needed instruction had few or no CPR skills. Furthermore, OHCA in children might result in bystanders panicking. DA-CPR is commonly provided by EMS dispatchers and could be

incrementally beneficial in bystander CPR.<sup>18</sup> However, further improvements in the dispatcher instruction would be necessary to improve outcomes in school-age OHCA.

### Clinical implication

A study in Denmark has reported that educating schoolchildren on CPR is associated with an increase in lay CPR rates and survival following OHCA; the survival rate of OHCA has increased significantly since BLS education became mandatory for schoolchildren.<sup>19</sup> In 2015, the Japan Circulation Society published the statement “Aiming for Zero Deaths: Prevention of Sudden Cardiac Death in Schools and Sport Locations.”<sup>20</sup> As a result, CPR education and widespread AED installation have occurred, resulting in a higher proportion of bystander interventions.<sup>21</sup> The present study suggests that schoolchildren could contribute to improving outcomes in OHCA. Therefore, adding BLS training in school curricula is beneficial and should be valued in school education. Furthermore, basic procedures in BLS, especially calling for help, should continue to be emphasized in BLS education for schoolchildren.

### Limitations

This study has several limitations. First, although we utilized propensity score-matched analysis, many important unmeasured factors exist, such as the location of the event, the first action by the bystanders, access to AED, patient medical history, and activities at the time of arrest. Furthermore, information regarding bystander background was lacking; therefore, knowing whether bystanders were trained in BLS and the quality of the BLS provided were impossible to know. Those factors could have affected the outcomes regardless of the witnesses (either schoolchildren or other bystanders), making it challenging to interpret the results of this study. Second, this study included the quite large number of patients with external causes (e.g., trauma, poisoning, submersion, and suicide attempt). Generally, bystander CPR is more effective for patients with cardiac arrest due to cardiac origin. Thus, the different types of bystanders might have little effects on the outcomes in this study population. Third, the definition of the bystander was a critical concern in interpreting the study results. Although we defined friends or colleagues listed in the bystander–patient relationship items in the registry as schoolchildren, schoolchildren might be included in the other-bystander-witnessed group and vice versa. Furthermore, we defined family, passer-by, and others as other bystanders. However, because there was no detailed information regarding their backgrounds because of the limited data of the All-Japan Utstein Registry, the definition of

other bystanders might be quite vague, all of which would cause the results to be less reliable. Fourth, the small sample size might have affected the results of this study because the power to detect differences is lacking. Therefore, we might have obtained different results if the sample size was larger. Finally, this study did not include the quality of EMS intervention or hospital management (e.g., therapeutic hypothermia and extracorporeal CPR), which might have affected the patient outcomes.

### CONCLUSIONS

THERE WERE NO statistically significant differences in patient outcomes between schoolchildren- and other-bystander-witnessed cases of school-age OHCA. Furthermore, bystander CPR provision and defibrillation provided by any bystander were factors associated with improved outcomes in school-age OHCA with schoolchildren as witnesses. It might support the hypothesis that schoolchildren could contribute to the improvement of clinical outcomes by acting appropriately when they witness a school-age OHCA; however, this study should be interpreted carefully because of some critical limitations. Further studies are needed to examine the effect of bystander CPR by schoolchildren and BLS education in schools.

### ACKNOWLEDGEMENTS

HK AND KT equally contributed to this manuscript as the first author. We thank all EMS members in Japan for their data collection. The authors thank Enago ([www.enago.jp](http://www.enago.jp)) for the English language review.

### DISCLOSURE

Approval of the research protocol: This study was approved by the Institutional Review Board of the Ishikawa Medical Control Council (2011-2).

Informed Consent: The requirement for informed consent of patients was waived.

Registry and the Registration No. of the study/Trial: This study was not registered.

Animal Studies: N/A.

Conflict of Interest: None declared.

### REFERENCES

- 1 Chamberlain DA, Hazinski MF. Education in resuscitation: an ILCOR symposium: Utstein Abbey: Stavanger, Norway: June 22–24, 2001. *Circulation* 2003; 108: 2575–94.

- 2 Japan Resuscitation Council. EIT; Education, Implementation, and Teams. Available from URL: <https://www.japanresuscitationcouncil.org/wpcontent/uploads/2016/04/b7b5b647189bc07f38f6fecf014cf5d9.pdf>
- 3 Nitta M, Iwami T, Kitamura T, *et al.* Age-specific differences in outcomes after out-of-hospital cardiac arrests. *Pediatrics* 2011; 128: e812–20.
- 4 Yamashita A, Kurosaki H, Takada K, *et al.* Association of school hours with outcomes of out-of-hospital cardiac arrest in schoolchildren. *Heart Asia*. 2019; 11: e011236.
- 5 Goto Y, Funada A, Goto Y. Duration of prehospital cardiopulmonary resuscitation and favorable neurological outcomes for pediatric out-of-hospital cardiac arrests: a Nationwide. Population-Based Cohort Study. *Circulation*. 2016; 134: 2046–59.
- 6 Kiyohara K, Nitta M, Sato Y, *et al.* Ten-year trends of public-access defibrillation in Japanese school-aged patients having neurologically favorable survival after out-of-hospital cardiac arrest. *Am. J. Cardiol*. 2018; 122: 890–7.
- 7 Ministry of Education, Culture, Sports, Science and Technology, Ministry of Health, Labour and Welfare (Japan). Ethical guidelines for epidemiological research, 2002. Available from URL: <http://www.niph.go.jp/wadai/ekigakurinri/guidelines.pdf>
- 8 Ministry of Internal Affairs and Communications (Japan). Population transition as of October 1, 2016. Available from URL: [https://www.soumu.go.jp/menu\\_news/s-news/01toukei03\\_01000058.html](https://www.soumu.go.jp/menu_news/s-news/01toukei03_01000058.html)
- 9 Ministry of Education, Culture, Science and Technology (Japan). School basic survey in Sports, 2016. Available from URL: [https://www.mext.go.jp/component/b\\_menu/other/\\_icsFiles/afiedfile/2016/12/22/1375035\\_1.pdf](https://www.mext.go.jp/component/b_menu/other/_icsFiles/afiedfile/2016/12/22/1375035_1.pdf)
- 10 Fire and Disaster Management Agency (Japan). The number of fire stations. Available from URL: <https://www.fdma.go.jp/publication/hakusho/h29/data/2180.html>
- 11 Japan Resuscitation Council. ALS; Advanced Life Support. Available from URL: <https://www.japanresuscitationcouncil.org/wp-content/uploads/2016/04/0e5445d84c8c2a31aaa17db0a9c67b76.pdf>
- 12 Fire and Disaster Management Agency (Japan). Dispatcher-assisted CPR. Available from URL: [http://www.fdma.go.jp/neuter/topics/kouto\\_shido.html](http://www.fdma.go.jp/neuter/topics/kouto_shido.html)
- 13 Perkins GD, Jacobs IG, Nadkarni VM, *et al.* Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest. *Circulation* 2015; 132: 1286–300.
- 14 Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet* 1976; 1: 480–4.
- 15 Matsuyama T, Kitamura T, Kiyohara K, *et al.* Impact of cardiopulmonary resuscitation duration on neurologically favourable outcome after out-of-hospital cardiac arrest: A population-based study in Japan. *Resuscitation*. 2017; 113: 1–7.
- 16 Akahane M, Ogawa T, Tanabe S, *et al.* Impact of telephone dispatcher assistance on the outcomes of pediatric out-of-hospital cardiac arrest. *Crit. Care Med*. 2012; 40: 1410–6.
- 17 Kiyohara K, Sado J, Kitamura T, *et al.* Epidemiology of pediatric out-of-hospital cardiac arrest at school - an investigation of a Nationwide Registry in Japan. *Circ. J*. 2018; 82: 1026–32.
- 18 Fukushima H, Imanishi M, Iwami T, *et al.* Abnormal breathing of sudden cardiac arrest victims described by laypersons and its association with emergency medical service dispatcher-assisted cardiopulmonary resuscitation instruction. *Emerg. Med. J*. 2015; 32: 314–7.
- 19 Wissenberg M, Lippert FK, Folke F, *et al.* Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *JAMA* 2013; 310: 1377–84.
- 20 Mitamura H, Iwami T, Mitani Y, Takeda S, Takatsuki S. Aiming for zero deaths: prevention of sudden cardiac death in schools-statement from the AED Committee of the Japanese Circulation Society. *Circ. J*. 2015; 79: 1398–401.
- 21 Shida H, Matsuyama T, Kiyohara K, *et al.* Prehospital cardiopulmonary resuscitation duration and neurological outcome after out-of-hospital cardiac arrest among children by location of arrest: a Nationwide cohort study. *Scand. J. Trauma Resusc. Emerg. Med*. 2019; 27: 79.