Circulation Journal
Circ J 2025; **89:** 394–418
doi:10.1253/circj.CJ-24-0599

JCS STATEMENT

Strategies for Reducing Sudden Cardiac Death by Raising Public Awareness

— A Statement From the Education and Implementation for Cardiac Emergency Committee of the Japanese Circulation Society —

Chika Nishiyama, RN, DrPH; Satoshi Yoshimura, MD, MPH; Takuya Taniguchi, MD, MPH, PhD; Tetsuya Amano, MD, PhD, FJCS; Hirohiko Ando, MD, PhD, FJCS; Yosuke Homma, MD, MPH; Tomohiko Imamura, MD; Tomonori Itoh, MD, FJCS; Takeyuki Kiguchi, MD, PhD; Kosuke Kiyohara, DrPH; Satomi Konno, MD, PhD; Hisaki Makimoto, MD, PhD; Tomohiro Manabe, MD, PhD; Yasushi Matsuzawa, MD, PhD; Hideo Mitamura, MD, PhD; Nogiku Niwamae, MD, PhD; Masashi Sakuma, MD, PhD; Kayoko Sato, MD, PhD, FJCS; Yasuhiro Satoh, MD, PhD, FJCS; Yoshio Tahara, MD, PhD, FJCS; Kenichi Tsujita, MD, PhD, FJCS; Yayoi Tetsuou Tsukada, MD, PhD, FJCS; Masato Uchida, MD, MPH; Yasunori Ueda, MD, PhD, FJCS; Taku Iwami, MD, PhD

Abbreviations

ACS	Acute coronary syndrome
AED	Automated external defibrillator
AMI	Acute myocardial infarction
ARVC	Arrhythmogenic right ventricular cardiomyopathy
BLS	Basic life support
CAD	Coronary artery disease
COR	Classification of recommendation
CPR	Cardiopulmonary resuscitation
CPVT	Catecholaminergic polymorphic ventricular tachycardia
EAP	Emergency action plans
ECG	Electrocardiography
EMS	Emergency medical services
ESC	European Society of Cardiology
ICD	Implantable cardioverter defibrillator
ICD-10	International Classification of Diseases, Tenth Revision
ILCOR	International Liaison Committee on Resuscitation
JCS	Japanese Circulation Society
JRC	Japan Resuscitation Council
LOE	Level of evidence
LVEF	Left ventricular ejection fraction
MI	Myocardial infarction
OHCA	Out-of-hospital cardiac arrest
PAD	Public-access defibrillation
PCI	Percutaneous coronary intervention
PDCA	Plan-do-check-act
PDSA	Plan-do-study-act
ROSC	Return of spontaneous circulation
SCA	Sudden cardiac arrest
SCD	Sudden cardiac death
SMR	Standardized mortality ratio
STE	ST-segment elevation
T-LOC	Transient loss of consciousness
VF	Ventricular fibrillation
VT	Ventricular tachycardia
WCD	Wearable cardioverter defibrillator

J-STAGE Advance Publication released online December 26, 2024
Department of Critical Care Nursing, Graduate School of Human Health Sciences, Kyoto University, Kyoto (C.N.); Department of Preventive Services, Graduate School of Medicine, Kyoto University, Kyoto (S.Y., T. Imamura, T.K., T. Iwami); Department of Cardiovascular Medicine, Otsu City Hospital, Shiga (T.T.); Department of Cardiology, Aichi Medical University, Aichi (T.A., H.A.); Department of Emergency Medicine, Chiba Kaihin Municipal Hospital, Chiba (Y.H.); Division of Cardiology, Department of Internal Medicine, Division of Community Medicine, Department of Medical Education, Iwate Medical University, Iwate (T. Itoh); Department of Emergency and Critical Care, Osaka General Medical Center, Osaka (T.K.); Department of Food Science, Faculty of Home Economics, Otsuma Women's University, Tokyo (K.K.); Konno Hospital, Fukuoka (S.K.); Data Science Center/Cardiovascular Center, Jichi Medical University, Tochigi (H. Makimoto); Sports Medicine Research Center, Keio University, Yokohama (T.M.); Department of Cardiovascular Medicine, Graduate School of Medical Sciences, Kumamoto University, Kumamoto (Y.M., K.T.); Department of Cardiology, Tachikawa Hospital, Tokyo (H. Mitamura); Department of Cardiovascular Medicine, Japanese Red Cross Maebashi Hospital, Gunma (N.N.); Department of Cardiovascular Medicine, Dokkyo Medical University, Tochigi (M.S.); Department of Cardiology, Tokyo Women's Medical University, Tokyo (K.S.); Clinical Pathology Laboratory, Department of Food Science and Nutrition, Faculty of Nutrition, Tokyo Kasei University, Tokyo (K.S.); Chigasaki Chuo Hospital, Kanagawa (Y.S.); Department of Cardiovascular Emergency, National Cerebral and Cardiovascular Center, Osaka (Y.T.); Department of General Medicine and Health Science, Nippon Medical School, Tokyo (Y.T.T.); Hashimoto Municipal Hospital, Wakayama (M.U.); and Cardiovascular Division, National Hospital Organization Osaka National Hospital, Osaka (Y.U.), Japan
Mailing address: Taku Iwami, MD, PhD, Department of Preventive Services, School of Public Health/Graduate School of Medicine, Kyoto University, Yoshida Konoe-cho, Sakyo-ku, Kyoto, 606-8501, Japan. email: iwami.taku.8w@kyoto-u.ac.jp

ISSN-1346-9843

I. Introduction

Despite many developments in cardiovascular medicine, emergency medicine, critical care medicine, and community emergency medical service (EMS) systems, including lay responder activities, sudden cardiac death (SCD) continues to be a significant medical and societal issue worldwide, with over 80,000 people dying annually in Japan.[1]

As a collective of cardiovascular medicine specialists, the Japanese Circulation Society (JCS) has been at the forefront of advocating for the implementation of automated external defibrillators (AEDs) in Japan.[2] In addition to promoting the need for AED deployment, the JCS has been dedicated to disseminating education related to chest compression-only cardiopulmonary resuscitation (CPR) and the proper use and strategic placement of AEDs to improve survival without neurological impairment following sudden cardiac arrest (SCA).[2,3] More recently, initiatives such as the STOP MI (myocardial infarction) campaign have been launched, with a focus on preventing SCA to curb cases of SCD.[4] In addition, Healthy Heart Week occurs each year around August 10. During this time, the Japan Heart Foundation, JCS, Japanese Circulation Association, and Japan AED Foundation collaborate on various events aimed at advertising the importance of public education and actions to prevent SCD for both the general public and healthcare professionals.

This statement addresses the current landscape and provides recommendations to prevent SCA and improve survival without neurological impairment following SCA by reinforcing public awareness as a strategy to prevent SCD. Through these community awareness efforts, our goal is to reduce the number of individuals affected by SCD, and consequently the number of individuals who grieve their loss.

II. Prevention of SCA

1. Prevention of SCA Caused by Acute Coronary Syndrome

1.1 Current Evidence and Status in Japan

1.1.1 Current Status of SCD Caused by Acute Coronary Syndrome

Most SCDs due to acute coronary syndrome (ACS) occur in out-of-hospital settings. Estimates of the incidence of out-of-hospital cardiac death due to ACS vary widely depending on the database used for case ascertainment, the definitions used for both SCD and ACS, and regional characteristics. Analysis of data in the Takashima acute myocardial infarction (AMI) registry,[5] the Northern Iwate Heart Disease registry,[6] and these 2 registries combined, has led to inventory surveys of cardiac conditions, including SCD, being almost complete.[7] To assess the number of out-of-hospital deaths in the study area,[6] physician-signed death certificates issued for all deaths resulting from possible cardiac causes, as defined by International Classification of Disease, 10th Revision (ICD-10) codes (i.e., I20–I25, ischemic heart disease; I46, cardiac arrest; I49.0, ventricular fibrillation; I50, heart failure; I71, aortic aneurysm and aortic dissection; R96, sudden unexpected death; R98, death without witness), were collected via the Ministry of Health and Welfare in Japan. Subsequently, using World Health Organization MONICA diagnostic criteria,[8] if the death certificates indicated evidence of a history of coronary artery disease (CAD) or cardiac symptoms, such as chest pain and syncope, the cases were designated as "possible fatal MI". Using these methods gave us confidence that we had identified virtually all cases of death caused by MI among patients admitted to referral hospitals in the study area, as well as out-of-hospital deaths. Of the 814 patients with definite or possible MI, 461 experienced a non-fatal definite MI, and 353 experienced a fatal MI, of which 250 (70.8%) were out-of-hospital deaths and 103 (29.2%) were in-hospital deaths.[6] This study demonstrated a decreasing trend in both the age-adjusted incidence of MI and the proportion of out-of-hospital cardiac deaths among cases of fatal MI during the period 2006–2014 in a Japanese rural population; however, there is still an urgent need to improve the high mortality of MI and the high proportion of out-of-hospital cardiac deaths among cases of fatal MI.

Toshima et al.[9] investigated the prevalence of out-of-hospital death using data from the Yamagata AMI registry and death certificates issued across all Yamagata Prefecture in Japan between 2010 and 2015. AMI was identified using the ICD-10 code I21. Prehospital death was defined as acute death due to out-of-hospital cardiac arrest (OHCA). Of the 7,085 patients identified (3,432 in the Yamagata AMI registry and 3,653 based on death certificate data), 6,984 were included in the analysis. Among the 6,984 patients with AMI, prehospital death occurred in 3,771.[9] Out-of-hospital cardiac death occurred in >50% of the total cases of AMI,[9] which is consistent with previously reported data from Western studies.[10]

Furthermore, Ogata et al.[11] conducted an observational study based on a city-wide comprehensive registry of data collected between 2015 and 2017 in Nobeoka City (population 125,000 persons), Japan, from 2 databases. Ogata et al.[11] included all patients with cardiogenic OHCA in Nobeoka City and all patients hospitalized for ACS in the Miyazaki Prefectural Nobeoka Hospital, where all ACS patients in Nobeoka City were hospitalized (although possible, it is highly unlikely that patients would be hospitalized elsewhere). The authors identified 260 eligible patients hospitalized with first-onset ACS; 75.4% had AMI and 24.6% had unstable angina pectoris.[11] Cardiogenic out-of-hospital cardiac death occurred in 126 patients who were transported by ambulance in Nobeoka City.[11] Incidence rates were evaluated in 107 eligible SCD patients. The crude incidence rate of SCD among hospitalized ACS patients was 130.2 per 100,000 (183.3 and 85.6 per 100,000 in men and women, respectively), and the crude incidence rate of hospitalization for ACS was 92.3 per 100,000 (132.8

Table 1. Summary of Recommendations on Angiography and PCI for Resuscitated Patients With OHCA

Guideline	Resuscitated cardiac arrest with persistent STE on ECG	Resuscitated cardiac arrest without persistent STE on ECG
2018 JCS guideline on diagnosis and treatment of ACS[24]	**COR 1, LOE B-NR** Emergency angiography (and PCI if indicated) should be performed in patients with resuscitated cardiac arrest with STE or new onset of complete LBBB	**COR 2a, LOE C** Emergency angiography (and PCI if indicated) should be considered in patients with resuscitated cardiac arrest without diagnostic STE but with a high suspicion of ongoing myocardial ischemia
2020 AHA guidelines for cardiopulmonary resuscitation and emergency cardiovascular care[23]	**COR 1, LOE B-NR** Emergency coronary angiography should be performed in all cardiac arrest patients with a suspected cardiac cause of arrest and STE on ECG	**COR 2a, LOE B-NR** Emergency coronary angiography is reasonable for select (e.g., electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without STE on ECG
2023 ESC guidelines for the management of ACS[22]	**Class 1, Level B** A primary PCI strategy is recommended in patients with resuscitated cardiac arrest and an ECG with persistent STE (or equivalents)	**Class 3, Level A** Routine immediate angiography after resuscitated cardiac arrest is not recommended in hemodynamically stable patients without persistent STE (or equivalents)

ACS, acute coronary syndrome; AHA, American Heart Association; COR, classification of recommendation; ECG, electrocardiography; ESC, European Society of Cardiology; JCS, Japanese Circulation Society; LBBB, left bundle branch block; LOE, level of evidence; NR, non-randomized; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; STE, ST-segment elevation.

and 58.1 per 100,000 in men and women, respectively).[11]

1.2 Cases of OHCA Caused by ACS

1.2.1 Current Status of OHCA Caused by ACS

CAD has emerged as the primary reversible cause among OHCA patients with shockable rhythms, such as ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT).[12,13] Acute coronary occlusion accounts for >85% of cases with ST-segment elevation (STE) on electrocardiography (ECG), regardless of shockable rhythms.[13] Approximately 60–65% of OHCA patients with an initial shockable rhythm who do not achieve a return of spontaneous circulation (ROSC) have acute coronary lesions. In contrast, patients without STE exhibit a markedly lower incidence of acute coronary occlusion, regardless of shockability.[13]

Approximately 6–9% of patients treated with primary percutaneous coronary intervention (PCI) are reported to have concomitant OHCA.[14–16] Several studies have identified risk factors for OHCA in patients with AMI, including younger age, male sex, the absence of calcium channel blocker therapy, larger infarct size, left main trunk lesion, chronic total occlusion, and a history of heart failure.[17–19] Another cause of OHCA due to ACS is vasospastic angina. A questionnaire survey conducted in Japan reported that vasospastic angina was responsible for 14% of sudden deaths.[20] Possible mechanisms of cardiac arrest include repolarization abnormalities caused by ischemia due to coronary spasm and the formation of myocardial scar as a result of ischemia.[21]

1.2.2 Diagnosis and Treatment Strategies for Resuscitated Patients With OHCA

Current guidelines strongly support emergency coronary angiography (CAG) for all successfully resuscitated OHCA patients with STE on pre- or postarrest ECG and an expected reasonable neurological prognosis (**Table 1**).[22–24] However, the benefit of immediate CAG in patients without STE on post-ROSC ECG is less clear owing to heterogeneity in study designs and findings. Although early observational studies[24a,24b] suggested a possible benefit, recent randomized trials[25–27] comparing immediate and delayed angiography in patients with cardiac arrest without STE found no significant differences in survival outcomes.[25–27] Collectively, these randomized trials[25–27] suggest that routine early CAG is not beneficial in patients with cardiac arrest without STE. Consequently, the latest European Society of Cardiology (ESC) guidelines published in 2023 downgraded the recommendation for early CAG from Class 2A to Class 3 for patients with resuscitated cardiac arrest without persistent STE.[22]

1.2.3 Outcomes of Resuscitated Patients With OHCA

It has been reported that approximately one-third of patients with OHCA and AMI die within 30 days of admission.[15,28,29] The outcome after OHCA is highly variable and depends on several factors, including initial rhythm (shockable or non-shockable) or time to effective resuscitation measures, including PCI. A previous Japanese study indicated that prodrome-induced earlier activation of EMS systems yielded better neurological outcomes (adjusted odds ratio per 1-min increase for neurologically better outcome 0.90; 95% confidence interval 0.82–0.99).[30] Early recognition of prodromal symptoms, early activation of the EMS system, early access to hospitals, and early treatment are crucial for improving outcomes after OHCA.[30–32]

1.3 Prodromal Symptoms of AMI and the Importance of Public Education to Prevent AMI

Approximately 40–50% of patients who have experienced AMI recognize its prodromal symptoms.[33] In addition to manifesting as chest pain, pressure, and tightness, these symptoms may also manifest occasionally as heartburn, and rarely as pain in the arm, shoulder, teeth, or jaw. These symptoms can sometimes be perceived as being unrelated to the heart. Moreover, because these symptoms can be mild and often subside within a few minutes, they are frequently overlooked and not considered serious. In particular, prodromal symptoms are frequently overlooked in the elderly and in women.[33,34] Timely medical intervention and appropriate treatment for patients with prodromal symptoms may be an avenue to prevent the onset of AMI.

It is essential to educate the general public about the existence of prodromal signs preceding AMI and the

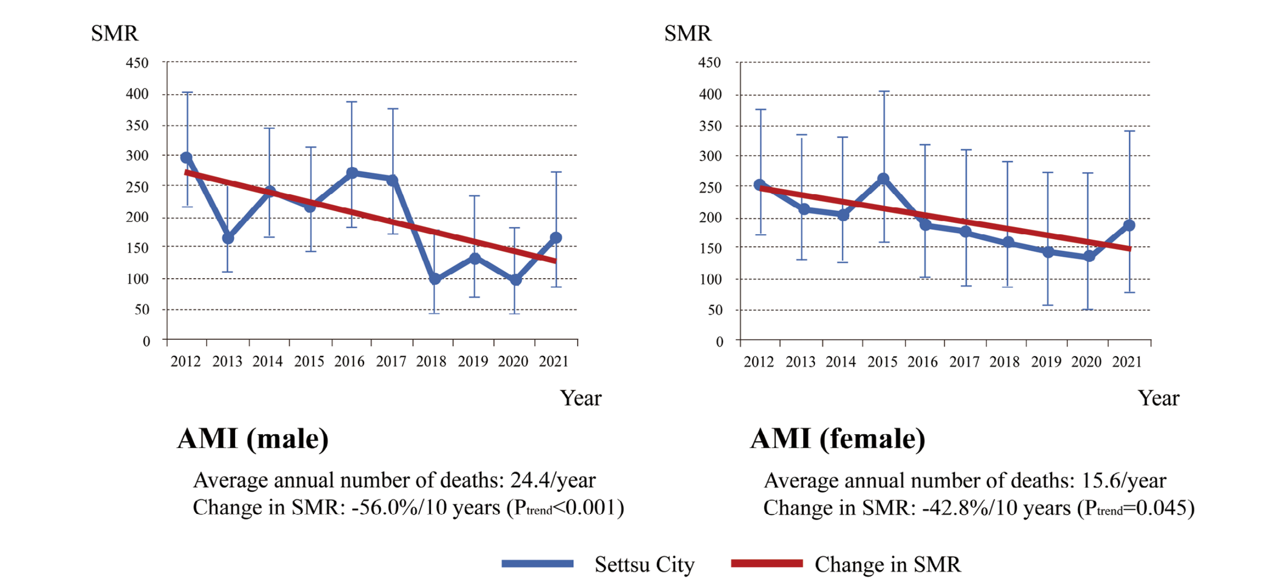

Figure 1. Standardized mortality ratio (SMR) in Settsu City 2012–2021 for men and women separately. The SMR expresses how high (or low) the age-adjusted mortality rate (likelihood of death) is in a given area, with the national rate used as a reference (=100). For example, SMR=120 implies that the likelihood of death in the region is 1.2-fold higher than that in the nation as a whole, whereas SMR=80 means that the likelihood of death is 0.8-fold higher (i.e., lower). The figure shows the likelihood of death in Settsu City in each year, assuming that the 2015 national rate was 100. We focus on the "absolute change in the likelihood of death" after adjusting for age. SMR of AMI in Settsu City are graphed as the upper and lower 95% confidence limits. AMI, acute myocardial infarction.

characteristic features of the prodromal symptoms outlined above, as well as to encourage prompt hospital visits for individuals who experience prodromal symptoms of AMI. There is a risk of sudden death immediately after onset in patients with AMI, so this proactive approach would contribute significantly to improving prognosis.

Apart from managing traditional coronary risk factors such as diabetes, hypertension, dyslipidemia, obesity, and smoking as primary and secondary prevention measures, lifestyle modifications and the adoption of regular exercise habits are crucial for preventing the onset of MI. Therefore, it is essential to enhance the awareness of primary and secondary prevention among the general healthy population and patients and their families, as well as within the primary care system. To this end, thorough implementation of community education is crucial. Implementing primary and secondary measures to prevent AMI, seeking hospital care at the onset of prodromal symptoms, and promptly requesting EMS at the onset of AMI are essential strategies to mitigate the risk of MI.

1.4 Case Examples

1.4.1 Public Education in Settsu City, Osaka

On April 2, 2015, the city of Settsu, in Osaka Prefecture, entered into a Basic Agreement on Mutual Collaboration and Cooperation with the National Cerebral and Cardiovascular Center. A key area of this collaboration was "efforts to develop a model for the prevention and control of acute coronary heart diseases".[4] Because the standardized mortality ratio (SMR) associated with MI among Settsu citizens is the second highest in Osaka Prefecture, the city aimed to reduce MI-related deaths among citizens by working on the STOP MI campaign[4,35] in collaboration with the National Cerebral and Cardiovascular Center.

A kick-off meeting for the STOP MI campaign was held in 2017 with the Medical Association, Dental Association, Pharmacists Association, Nurses Association, Dietitians Association, Settsu City Fire Department, and other related parties. The Health and Welfare Division of Settsu City prepared flyers and posters for the STOP MI campaign that were: distributed at community associations, citizen health classes, health festivals, and other events; posted at pharmacies, city halls, health centers, and other public facilities in the city; published in public relations magazines, community welfare newsletters, and hospital newsletters; broadcast on local television; broadcast via medical examination DVDs shown on medical checkup sites; and shared on YouTube. In addition, public lectures were held to raise awareness of the signs of MI and to encourage early medical checkups. According to the national SMR trends for the major causes of death assessed by the municipality between 2012 and 2021,[36] the SMR trend of AMI in Settsu City has improved over time (**Figure 1**). It is necessary to periodically confirm and publicize the effectiveness over time in the region.

1.4.2 Public Education in Iwate Prefecture

In Iwate Prefecture, efforts towards implementing the STOP MI campaign[4,35] were initiated in 2016. Owing to the excellent relationship between the administration, the Iwate Medical Association, and Iwate Medical University, the JCS partnered with Iwate Prefecture's Health Insurance Division, Iwate Medical University, and the Iwate Medical Association to implement the campaign. In collaboration with the Iwate Medical Association, health promotion

Table 2. Challenges Associated With Present Public Education Initiatives and Future Developments in the Iwate Region

	Benefit	Disadvantage	References
Lectures open to the public	Active platforms with a sense of immediacy in conveying information	The number of people exposed to information disseminated through these forums is limited	37
Television	The number of people exposed to information disseminated through this forum is huge	Unclear response to the activity	38, 39
Newspaper articles and newsletters from medical association	The number of people exposed to information disseminated through these forums is huge	Unclear response to the activity	40, 41
Pocket tissues with flyers	Publicity to unspecified targets is possible	The number of people exposed to information disseminated through this forum is limited	
Internet (promotional video)	The number of people exposed to information disseminated through this forum is huge	Unclear response to the activity	42
The Iwate Prefecture Regional Heart Disease Registry	Possible to verify whether there has been a decrease in ACS cases after the campaign	Accuracy in medical history taking at the ground level	43

ACS, acute coronary syndrome.

advertisements are published annually in local newspapers to disseminate information related to the STOP MI campaign (**Table 2**).[37–43] Furthermore, the campaign is promoted annually through the prefecture's local television programs and is featured in the health segments of television news programs to advance its cause. In 2019 and 2023, Iwate Prefecture distributed pocket tissues with STOP MI flyers and conducted lectures in public forums cohosted by the Iwate Medical Association and various newspapers to raise awareness of the STOP MI campaign.

Lectures that are open to the public serve as active platforms and involve a sense of immediacy in conveying information. However, given the vastness of Iwate Prefecture, information dissemination via these forums is to a limited number of people only. Therefore, mass media was used to complement these activities. Nevertheless, measuring the penetration of information disseminated through mass media among residents remains a one-way approach, and assessing its effectiveness poses a challenge.

Iwate Prefecture operates a regional heart disease registration system focusing on ACS in all catheter facilities across the entire prefecture.[43] This registry includes the presence of angina pectoris before MI, allowing for continuous monitoring. By using this registry, Iwate Prefecture can verify whether there has been a decrease in the number of ACS cases since the campaign was initiated. Single-facility data show that approximately 50% of patients exhibit angina pectoris before infarction.[4] Confirmation of a decrease in the number of cases involving this condition signifies the campaign's effectiveness. Maintaining accuracy in medical history taking at ground level is crucial in this system; however, accuracy of history taking stands at approximately 35% in multicenter registration programs. Establishing better history taking is another challenge that needs to be addressed in the future.

1.5 Policy Suggestions

1.5.1 Prevention of AMI Through Public Education (STOP MI Campaign)

As described above, once AMI occurs, approximately 40% of patients die in out-of-hospital settings.[35,44] However, it is difficult to adequately prevent AMI via risk-reduction therapies for atherosclerosis (as evidenced by a high residual risk) even if very low levels of low-density lipoprotein cholesterol are achieved through the use of proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors or hypertension and diabetes are well controlled. In contrast, it is well known that most patients with AMI experience pre-infarction angina before MI onset or various warning symptoms preceding cardiac arrest. It is of note that approximately half of AMI patients experience pre-infarction angina within 1 month before MI onset.[45]

Because approximately half of AMI patients develop pre-infarction angina before MI onset, it should be able to prevent MI occurrence in these patients if they can be treated appropriately. The reasons why patients with pre-infarction angina do not attend hospital are that they do not know that the symptoms originate from the heart; the disease may become life threatening; and/or death/AMI can be prevented by presenting to hospital at the time the symptoms manifest. This situation should be improved by educating the general public. Therefore, we proposed a new strategy for preventing AMI through public education, and this strategy is now being implemented by the JCS through the STOP MI campaign.[4] The details of the STOP MI campaign have been described elsewhere.[35] Although public education currently primarily relies on websites, posters, and town hall meetings, additional methods, as implemented in some advanced areas (Settsu City, Osaka or Iwate Prefecture), is required for its success, as described above.

1.5.2 Education Regarding the Prevention of AMI/SCA in School Settings

The Japanese National Plan for Promotion of Measures Against Cerebrovascular and Cardiovascular Disease (the National Plan) proposes the dissemination of accurate knowledge regarding cardiovascular diseases from childhood.[46] To convey accurate knowledge of cardiovascular disease to all citizens, it must be incorporated into the educational curriculum at schools. Thorough preventive education in schools will not only encourage younger generations (e.g., elementary school, junior high school, high school, and university students) to receive early medical examinations themselves, but will also encourage their parents, grandparents, and other older relatives to do so. Therefore, providing this education in the school curriculum would be effective, with most patients at risk of developing pre-infarction angina in the future being educated about it at school.

1.6 Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- What proportion of patients with unstable angina experience MI?
- What is the appropriate strategy to prevent patients with unstable angina experiencing MI?

2. Prevention of SCA Caused by Fatal Arrhythmia

2.1 Current Evidence and Status in Japan

2.1.1 Current Status of SCA Caused by Fatal Arrhythmia in Japan

Arrhythmias, including bradycardia and tachycardia, are known to cause SCA, with VF recognized as one of the main causes of OHCA.[47] In this context, survival following a fatal arrhythmic event depends significantly on prompt resuscitation efforts, particularly involving the use of AEDs. Factors such as the presence of witnesses during the cardiac arrest, the time until EMS arrival, CPR quality, and AED utilization rates have substantial effects on survival rates. In 2021, the 1-month survival rate among patients whose initial ECG showed VT or VF at the scene of a witnessed cardiac arrest was 35.4%, compared with 8.1% for those with rhythms other than VT or VF, indicating that an appropriate early response could potentially save >30% of patients with VT/VF.[1] Furthermore, 1-month survival rates in the case of witnessed cardiac arrests have ranged from 10% to 14% over the past decade, with social reintegration rates of between 7% and 9%.[1] Approximately 60–70% of those who survive a cardiac arrest could return to society within 1 month. This underscores the view that swift and appropriate early responses are crucial not only for survival but also for subsequent social reintegration. However, the use of AEDs in cases of cardiopulmonary arrest remains low at approximately 4%.[1] Therefore, there is a pressing need for continued awareness and educational efforts to increase the availability and use of AEDs.

2.1.2 Risk Stratification for SCA/SCD Caused by Fatal Arrhythmias

SCA is a precipitating event that culminates in SCD in the absence of swift and efficacious medical intervention. Consequently, a unified approach towards risk stratification is imperative for preventing both conditions. Risk assessment for arrhythmia-induced SCA/SCD is complex and requires consideration of a broad range of factors that extend beyond the disease state and include the patient's conditions. For instance, according to data from other countries, the risk factors for SCA/SCD vary between adolescents and the elderly.[48,49] Therefore, different risk-stratification strategies are used based on the underlying diseases that potentially lead to SCA/SCD.[47,50] In Japan, the health checkup system, including school cardiac screening, is well developed, and most people undergo health screening that includes an ECG at various milestones in their lives; however, follow-up examinations after the screening are not systematized, and the effectiveness of screening in preventing SCA/SCD has not been proven.

In the case of cardiomyopathies, which are among the underlying conditions leading to SCA/SCD, common predictors of SCA/SCD include a history of VT/VF and reduced left ventricular ejection fraction (LVEF). An LVEF of ≤35–40% is considered a high-risk factor, and the inducibility of VT during electrophysiological testing or the presence of non-sustained VT serves as a supplementary criterion for decision making. The Japanese guidelines recommend using the MADIT-ICD benefit score and the Seattle Proportional Risk Model, both of which integrate various clinical characteristics, for the assessment of arrhythmic and non-arrhythmic death in heart failure patients as a Class IIa indication.[51] In the case of hypertrophic cardiomyopathy, risk calculations endorsed by guidelines in Western countries are used to estimate the annual risk of SCA/SCD.[52,53] Moreover, risk stratification in hereditary arrhythmias/cardiomyopathies, such as long QT syndrome, catecholaminergic polymorphic VT (CPVT), Brugada syndrome, and arrhythmogenic right ventricular cardiomyopathy (ARVC), is based on factors such as a history of syncope, a family history of sudden death at a young age, or the results of genetic testing.[50] In addition, reflecting advances in genetic diagnostics, the Japanese guidelines recommend incorporating the presence of gene mutations, such as lamin A/C (*LMNA*), phospholamban (*PLN*), filamin C (*FLNC*), and RNA binding motif protein 20 (*RBM20*), into the risk assessment of patients with LVEF <50%.[51]

Treatment strategies are determined based on this risk stratification, with the primary intervention being the implantation of an implantable cardioverter defibrillator (ICD). Currently, ICDs are the only devices that can forcibly and physically terminate arrhythmias and reliably intervene in case of the occurrence of unpredictable fatal arrhythmias and SCA/SCD. Patients who have experienced SCA are typically prohibited from driving; however, they may be permitted to resume driving after a certain period of observation if an ICD is implanted. Nevertheless, long-term complications associated with ICD implantation are unavoidable. Furthermore, in a significant number of cases of SCD with preserved left ventricular function, the patients were not deemed to be at high risk according to the current risk stratification criteria.[53] Limitations in the accuracy of risk stratification based on clinical factors and concerns regarding long-term complications after ICD implantation represent challenges to be addressed in future research.[54]

In scenarios where immediate ICD implantation is not warranted, such as during the acute phase after MI, which is characterized by an elevated risk of ventricular arrhythmias and SCD, the use of a wearable cardioverter defibrillator (WCD) presents a viable alternative. The WCD has been reported to be useful for certain patients during specific high-risk periods, such as those with post-myocarditis, Takotsubo, postpartum, and idiopathic dilated cardiomyopathies.[50] In Japan, WCD use can be prescribed for up to 3 months, a period within which the need and suitability for ICD implantation are rigorously evaluated.

In Western countries, CAD is the primary underlying condition in approximately 70% of cases of SCD.[47] However, in Japan, the prevalence of CAD is comparatively low, ranging from 50% to 60%, with a corresponding higher incidence of non-ischemic cardiomyopathy (30–35%).[55] This variation in the distribution of underlying diseases across different races, cultures, and regions underscores the need for a Japan-specific risk-stratification approach.

Table 3. Risk Indicators for Cardiogenic Syncope

- Presence of severe structural heart disease or coronary artery disease, heart failure, reduced LVEF, or history of MI
- Indicators of arrhythmic syncope based on clinical presentation or ECG characteristics:
  1. Syncope during exertion or while supine
  2. Palpitations associated with syncope
  3. Family history of unexplained sudden death at young age
  4. Presence of structural heart disease or coronary artery disease
  5. Non-sustained ventricular tachycardia
  6. Bifascicular block or QRS duration ≥120 ms
  7. Inappropriate sinus bradycardia (<5 beats/min) or sinoatrial block without negative chronotropic medications or physical training
  8. Mobitz I AV block or first-degree AV block with markedly prolonged PR interval
  9. Pre-excitation QRS complexes
  10. Prolonged or shortened QT interval
  11. Early repolarization
  12. Brugada ECG pattern
  13. Negative T waves in right precordial leads, epsilon waves, or ventricular late potentials suggestive of ARVC
  14. Left ventricular hypertrophy suggesting hypertrophic cardiomyopathy
- Other factors such as severe anemia and electrolyte imbalances

Based on Brignole et al. (2018).[58] ARVC, arrhythmogenic right ventricular cardiomyopathy; AV, atrioventricular; ECG, electrocardiography; LVEF, left ventricular ejection fraction; MI, myocardial infarction.

2.1.3 Risk Assessment for Cardiogenic Syncope to Prevent Fatal Arrhythmias/SCA/SCD

The causes of transient loss of consciousness (T-LOC) are diverse but can be broadly classified into 3 categories: orthostatic hypotension, reflexes, and cardiogenic syncope. Of these, cardiogenic syncope has the worst prognosis: compared with those who have not experienced syncope, the hazard ratio in those who have had cardiogenic syncope is approximately double for death and more than double for cardiovascular events.[56,57] Because the 5-year survival rate in cases of cardiogenic syncope is quite poor (<60%),[56] it is extremely important to identify the cause of the disease as early as possible. Despite this, a complete improvement of symptoms is often observed immediately after syncope, without signs of sequelae. Therefore, patients themselves may not visit a medical institution and, even if they do, in many cases the cause is not explored because the symptoms have already disappeared and no abnormality is found on simple examination.

Cardiogenic syncope, a precursor to fatal arrhythmias, often results from sudden loss of consciousness due to arrhythmias. Patients who experience cardiogenic or unexplained syncope have a higher risk of subsequent fatal events and cardiac incidents.[56] In such cases, attention to high-risk findings (**Table 3**) is essential for appropriate clinical management.[58] In particular, the use of ICDs is recommended for patients at a high risk of ventricular arrhythmias.[50]

To prevent the onset of fatal arrhythmias, initiatives such as risk assessment and screening methods, educational and awareness campaigns, lifestyle modifications, the development of medical infrastructure, and pharmacological treatments are being implemented. Efforts to improve lifestyle habits, including smoking cessation programs, are examples of such initiatives. Beyond preventing the onset of fatal arrhythmias, efforts are also being directed towards educating the general public on early response measures in case of an event, with the aim of improving survival rates. Efficient prevention requires not only the involvement of healthcare professionals, but also the awareness and cooperation of the general public.

2.2 Case Examples

2.2.1 In-House Awareness-Raising Efforts at the Japanese Red Cross Maebashi Hospital

The Japanese Red Cross Maebashi Hospital established a syncope center in 2018 to ensure that cardiogenic syncope was not missed in the community or throughout the hospital. Patients with T-LOC may be referred to the neurology, neurosurgery, or pediatrics departments on suspicion of epilepsy, or to the emergency, orthopedics, or plastic surgery departments if the patient was injured due to syncope. Physicians in each department use a common hospital-wide T-LOC checklist to check for prodromal symptoms, circumstances, triggers, duration, the presence of trauma, history, recurrence, the presence of abnormal ECG or echocardiographic findings, medications, and a family history of sudden death. Items suspected to be related to cardiogenic syncope are marked in red letters in advance so that by checking certain boxes, it can be automatically determined whether cardiogenicity is suspected. If cardiogenic syncope is suspected, the system is designed to refer the patient to a cardiologist.

EMS personnel and local medical institutions are also educated to transport or refer patients to a syncope center when cardiogenic syncope is suspected, or the cause of syncope is unclear. After patients are evaluated at the syncope center, a pacemaker or ICD is implanted, depending on the underlying cardiac disease, in accordance with the guidelines.[47,50] Patients in whom the cause of syncope is unclear after various tests are implanted with an implantable cardiac monitor. Thus, the hospital is working to prevent fatal arrhythmias by not overlooking syncope, which appears to be a precursor to fatal arrhythmias.

2.3 Policy Suggestions

2.3.1 Prevention of Fatal Arrhythmias in High-Risk Asymptomatic Patients by Promoting Systematic Medical Examinations

2.3.1.1 Early Consultation When an Abnormal ECG Is Detected During a Health Checkup

In addition to tachycardia and bradycardia, ECG abnormalities that can be detected during a health checkup include bundle branch blocks, ST-T changes, T wave abnormalities, prolonged or shortened QT duration, and QRS abnormalities. These findings are characteristic not only of atrial fibrillation, sick sinus syndrome, and atrioventricular block but also of inherited conditions, such as long QT syndrome, short QT syndrome, Brugada syndrome, early repolarization syndrome, ARVC, CPVT, and hypertrophic cardiomyopathy, which can cause fatal arrhythmias even in young patients. In particular, early consultation is recommended in cases of sustained or non-sustained VT, frequent ventricular extrasystoles, corrected QT duration <330 or >480 ms, coved STE in the right precordial leads, slurred or notched J waves in the inferolateral leads, a family history of sudden juvenile death, or negative T waves (without complete right bundle branch block) or epsilon waves in leads V1–V3.[47] The use of a checklist, such as the previously described T-LOC checklist, for systematic evaluation to reduce oversights is recommended when evaluating individuals with a history of syncope. Even in cases of atrial fibrillation, the presence of delta waves should prompt immediate medical consultation.

2.3.1.2 Early Consultation and Genetic Counseling in Case of a Family History of Juvenile SCA/SCD

CAD is the leading cause of SCD, but inherited arrhythmias/cardiomyopathies account for the majority of SCDs in individuals aged <40 years. Therefore, inherited cardiac diseases should be considered when SCA/SCD occurs at a young age. More than 95% of inherited cardiac diseases involve autosomal dominant traits, and first-degree family members have a 50% probability of inheriting the same pathological variant.[59] Hence, a family history of sudden juvenile death should be considered to prompt early consultation and clinical evaluation even in asymptomatic individuals. More attention should be paid when the cause of the sudden death was not clear at pathological autopsy because it has been reported that half of first-degree relatives of individuals with sudden arrhythmic death were diagnosed with inherited heart disease.[60] Therefore, physicians screening individuals with a history of syncope or a family history of sudden death should consider referring them to a facility that performs genetic testing.

When genetic testing is performed in asymptomatic family members, appropriate genetic counseling should be provided, and informed consent should be obtained prior to testing.[61] This is because it is necessary to understand the medical and psychological impacts of inherited heart disease on the family and to help them adapt and make autonomous decisions. However, the number of genetic counselors providing this service is insufficient, and their training needs to be improved.

2.3.2 Prevention of Fatal Arrhythmias by Promoting Medical Examination at the Onset of Associated Signs

In 2023, insurance coverage for genetic testing was limited to congenital long QT syndrome and hypertrophic cardiomyopathy. However, the test for hypertrophic cardiomyopathy is covered by health insurance only when it is performed at an authorized medical institution that meets the institutional criteria specified by the Ministry of Health, Labour, and Welfare, and the Director of the Regional Bureau of Health and Welfare. Genetic testing for other inherited cardiac diseases, such as Brugada syndrome, ARVC, and CPVT, is currently performed by research institutions using their own research funds or is initiated by patients at their own expense. In addition, genetic counseling is only covered by insurance once genetic testing also covered by insurance has been performed. It should be noted that multiple counseling sessions are conducted at the patients' expense.

The first sign of fatal arrhythmia is a sudden loss of consciousness caused by the arrhythmia, so-called cardiogenic syncope. Nocturnal agonal breathing and fainting during exertion, with palpitations starting suddenly or a family history of sudden unexplained death at a young age, are suspected precursors of fatal arrhythmia.[47] It is important to educate the public so that they seek medical attention when these signs appear.

Compared with cardiac arrest due to ischemic heart disease, inherited arrhythmic diseases can cause fatal arrhythmias, even at a young age. In public CPR education, it is desirable to raise awareness about the risk of sudden death and its precursor symptoms in case of arrhythmia and to promote the fact that sudden death can be prevented by early consultation with healthcare professionals. It is also important to educate emergency services, clinical physicians, and non-specialists about the importance of referral to a specialist when they encounter a patient with syncope suspected of having fatal arrhythmias.

2.3.3 Awareness-Raising Activities Using Mass Media and Social Media

It is necessary to prevent fatal arrhythmias by encouraging asymptomatic patients with fatal arrhythmic diseases or those with associated signs to visit specialists. For this purpose, it is important to raise public awareness by actively using various mass media, such as television, newspapers, magazines, radio, and social media.

2.4 Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- What findings increase the risk of mortality in inherited arrhythmias?
- Is ECG screening useful in newborns and infants?
- Is advanced testing in asymptomatic patients with abnormal ECGs useful?
- Is genetic testing cost-effective? What diseases should be covered by health insurance?

III. CPR and AED Education for the General Public

1. Current Evidence and Status in Japan

1.1 Effectiveness of CPR and AED Use by Bystanders on Survival After SCA

Bystander CPR was associated with a 2-fold increase in survival in OHCA compared with no bystander CPR.[62,63] Early CPR and defibrillation using an AED initiated by the general public are key to saving lives after SCA.[64]

1.2 Current Situation of CPR and AED Shock Delivery by Bystanders in Japan

There have been considerable efforts to train the general public on how to perform CPR and use AEDs; however, the proportion of bystander CPR delivery varies significantly from 4.1% to 80.3% across different regions and areas worldwide.[65,66] In Japan, CPR training is provided mainly by municipal fire departments, which provide training to approximately 2 million people per year,[1] and the Japan Red Cross Society. In addition, hands-on CPR training, including AED use, is mandatory in junior high school[67] and high school,[68] and all drivers are taught CPR.[69] Despite the considerable efforts being made in Japan to train the general public in CPR to increase the proportion of bystander CPR, currently only approximately 54% of patients with OHCA receive bystander CPR,[66] and only 4% of cases of OHCA witnessed by bystanders receive bystander AED shock delivery.[1] Compared with other developed countries, the proportion of bystander CPR in Japan remains low.[66]

1.3 Barriers to Lay Rescues Providing CPR and Using an AED

Previous research has indicated that female patients are less likely to receive bystander CPR and AED shock delivery.[70,71] Another study indicated that female respondents feared inappropriate contact, whereas male respondents feared accusations of sexual assault or harassment, both of which were barriers to the administration of CPR to women.[72] Many studies have assessed the barriers faced by the general public when encountering cases of OHCA, such as panic, fear of infection, fear of causing injury to victims, and fear of litigation. Shimamoto et al.[73] reported that bystanders faced recurring conflicts between the perceived burden and sense of encouragement to perform CPR, influenced by many external factors, such as the emergency setting and their own knowledge and experience. In addition, Shida et al.[74] found that bystanders are fearful of approaching a collapsed person and experience difficulty in deciding to initiate rescue actions.

One report suggested that people who have received CPR training are approximately 3-times more likely to perform CPR in actual cardiac arrest situations than those who have not been trained.[75] Another study indicated that training significantly reduces the reported likelihood of all barriers and increases confidence in performing CPR.[76] Given these findings, hands-on CPR training is an effective way to address the barriers related to CPR and AED use and to help improve bystander CPR rates, thereby improving survival rates.

2. Case Examples for Raising Public Awareness Towards CPR and AED Use

2.1 CPR Awareness Campaigns

An important strategy for increasing survival rates in patients with SCA is to educate as many people as possible. Many countries have launched national CPR awareness campaigns, such as World Restart a Heart Day,[77] Resuscitation Week in Europe,[78] and AED Awareness Week in the US. The JCS and collaborating institutions, such as the Japan AED Foundation and Japan Heart Foundation, work diligently to increase public awareness of CPR and AED use through various campaigns, lectures, and events.[79] As a strategy to encourage widespread participation, the JCS led a simplification of CPR procedures and launched the Call & Push campaign. The JCS not only held CPR training with experts but also asked celebrities to cooperate and participate in CPR training. Typically, those who join the JCS's event training program are already interested in SCD. However, involving celebrities allowed the JCS to reach a different demographic that may not normally engage in SCD or CPR training.[80]

2.2 Innovative Technology-Based Basic Life Support Education

Traditional face-to-face training is important but difficult to disseminate more because of its significant time and cost burdens. Online platforms that garnered attention during the COVID-19 pandemic must be leveraged. Under these circumstances, the Team ASUKA app was developed by the Japan AED Foundation and features an AED map to locate the nearest AEDs, along with e-learning and game functionalities that allow everyone to learn basic life support (BLS).[81] The technology-driven online training Liv app offers practical training in just 15 min, enabling trainees to experience simulations of emergency calls and interactions with dispatchers.[82]

2.3 Need to Support Bystanders

Bystanders witnessing a cardiac arrest experience emotional, stressful, and traumatic challenges; however, many do not receive adequate support to deal with their feelings after an event.[83,84] To advocate for the need to support bystanders, the Japanese Society for Emergency Medicine issued Recommendations for the Establishment of a System to Support the Psychological Stress Responses of Bystanders in 2020.[85] Since 2017, the Komaki City Fire Department has been distributing thank-you cards to express gratitude for the actions of bystanders to alleviate their emotional burden.[86]

3. Policy Suggestions

3.1 CPR/AED Education Using Digital Technologies

By incorporating technology-driven methods, such as apps and virtual skills practice, along with traditional face-to-face instruction, BLS training opportunities can be offered more conveniently and effectively. Moreover, because acquired CPR skills and knowledge deteriorate within 3–12 months of training,[64] it is crucial to increase opportunities for repeated refresher training sessions in schools, universities, companies, and communities to ensure continuous learning. By using innovative training methods with digital technologies, BLS education can become more accessible to citizens, which would help us move closer to the goal of educating the entire population.

3.2 BLS Training Including Reality-Informed Contextual Information

Current BLS training, focusing on teaching technical skills such as chest compressions, rescue breathing, and AED use, is insufficient to encourage people to perform CPR and use an AED in actual emergencies. The 2020 Japan Resuscitation Council (JRC) resuscitation guideline states that BLS training should include information to help the public overcome potential barriers to administering CPR.[64] There is an urgent need to develop BLS training programs that consider psychological factors. For example, it may be effective to introduce the concept of the bystander effect, which suggests that when people are around others, they think someone else will perform some resuscitation actions; therefore, training scenarios are often conducted with an "unknown person" without clearly identifying the person who collapsed. In addition, considering that approximately 70% of cardiac arrests occur at home, it may be effective to prepare a training scenario in which a family member collapses while only the trainee and their family are at home.

3.3 Creating a Positive Culture for Performing BLS

One reason for the hesitation in performing bystander CPR is legal liability. It is essential to emphasize to the public through BLS training and advertisements that performing BLS with goodwill does not constitute a crime, in addition to considering legal protections.[64] Furthermore, nurturing a society that appreciates acts of goodwill is crucial.

3.4 Establishing and Strengthening Support Systems for Bystanders Involved in Resuscitation Actions

Bystanders often experience various feelings, such as concerns about the patient's outcome, guilt related to a patient's poor outcome, and the need for recognition for attempting CPR. Previous reports indicated that it is beneficial for bystanders to share their experiences or receive positive feedback from healthcare professionals, friends, and relatives after an event.[87] However, there is currently no official support system for bystanders in Japan. In Canada, the Bystander Support Network,[88] established in 2017, is a virtual space that provides information and communication opportunities to members of the general public who witnessed an OHCA. In Japan, we need to enhance the support system for the general public to receive organized professional follow-up.

4. Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- Does technology-based BLS education lead to an increment in bystander CPR, AED use, and better outcomes after SCA?
- Does training including elements to overcome psychological barriers increase the likelihood of bystanders performing CPR and using AEDs?
- Does a good understanding of bystander psychology and a system of bystander support lead to increasing bystander CPR and AED use?

IV. Aim of Achieving Zero Cases of SCD in Schools

1. Current Evidence and Status in Japan

1.1 OHCA Cases and Bystander CPR and AED Use in Schools

In Japan, approximately 50 OHCA cases occur annually among students in elementary, junior high, and high schools. Of these, 70.8% involve male students, 71.2% are of cardiac origin, and 65.4% occur during physical activity. In addition, 70.2% of these incidents are witnessed by bystanders.[89] In the case of non-traumatic OHCAs occurring in schools, the use of AEDs by bystanders increased from 61.9% in 2008 to 87.0% in 2015.[90] The survival rate when both AED shock and CPR were administered by bystanders was 50.9%, which is significantly higher than the 20.0% survival rate when neither was administered.[90]

Furthermore, among all OHCAs occurring in educational facilities throughout Japan (including universities, nurseries, and kindergartens), approximately three-quarters involved adult patients aged ≥18 years, such as school staff or visitors.[91] The proportion of these adult patients receiving bystander CPR was as high as that of pediatric patients. Therefore, CPR education in schools may greatly benefit both schoolchildren and adults (e.g., school staff or visitors).

1.2 BLS Training for Teachers and Students in Schools

The Japan Society of School Health reported on BLS training for teachers and staff in Japanese schools in 2018 across public elementary, junior high, and high schools nationwide. Among the schools, 73.8% held CPR and AED training sessions for all staff members annually, and 2.1% held them more than twice a year.[92] Although many schools conducted training sessions for some or all staff members, 5.4% did not implement any training.[92]

CPR and AED training for students has been provided during health and physical education classes, as stipulated by curriculum guidelines for junior high[67] and high schools.[68] The latest revisions of these guidelines emphasize instruction in practical skills during training sessions. However, curriculum guidelines for elementary schools do not include CPR or AED training. The proportion of schools providing hands-on training in health and physical education classes was 11.4% for elementary schools, 58.9% for junior high schools, and 66.0% for high schools.[92] The proportion of elementary, junior high, and high schools conducting hands-on training during special activities was 7.6%, 17.1%, and 15.4%, respectively.[92] Thus, even in junior high and high schools, where such training is mandated by curriculum guidelines, not all schools offer training.

1.3 Placement of AEDs in Schools

According to the Japan Society of School Health survey described above,[92] almost all public elementary, junior high, and high schools in Japan have at least 1 AED installed (77.1% of schools had 1 AED, and 18.4% had 2). The most common locations for AED placement were at staff and visitor entrances, followed by gymnasiums. However, the number of AEDs in schools is not enough to cover the entire school area, and many schools have AEDs placed in locations that are not accessible when the facility is locked, resulting in fewer than 30% of schools having AEDs available at all times, including early mornings, at night, and during holidays.

1.4 Current Status of School Heart Screening for the Prevention of SCD

In Japan, school heart screening is mandatory and conducted in the first grade of elementary, junior high, and high school following the *School Health and Safety Act*.[93] The primary examination includes ECGs, physical examination, and a review of medical history, family history, and subjective symptoms using a self-administered questionnaire.[94] ECG findings are essential for the detection of fatal arrhythmias and cardiomyopathies. However, abbreviated 4-lead ECGs conducted in some regions make the diagnosis difficult.

Follow-up examinations after the screening are not systematized. It was found that a secondary examination was required in 3.4% of children after the primary examination.[95] Pediatric cardiologists conduct detailed examinations, including chest radiography, 12-lead ECG, and echocardiography. If heart disease is suspected, exercise ECG, Holter ECG, cardiac catheterization, computed tomography, or magnetic resonance imaging may be performed. Once the final diagnosis is made, the doctor provides school-life guidance on physical activity tolerance. Based on doctors' advice, schools should implement safety measures, including education on BLS and AEDs.

2. Case Examples

2.1 "ASUKA Model", Based on a School AED Not Being Used, and a Student's Life Being Lost

A fifth-grade elementary school child, Asuka, collapsed during physical activity and was subsequently taken to the infirmary. Despite an AED being available in the school, nobody confirmed that she had had a cardiac arrest despite BLS training experience, and neither CPR nor an AED shock was administered. Based on this experience, and collaborating with Asuka's parents, Saitama City thoroughly re-evaluated and developed the school's emergency action plan (EAP) for cases of sudden collapse. A key revision was that even in cases where it was difficult to determine whether the victim was breathing normally, they should be considered to be in cardiac arrest, and immediate chest compressions and AED use should be initiated. This protocol was named the "ASUKA model",[96] symbolizing a commitment to preventing the recurrence of such a grievous oversight and prioritizing swift, decisive action in emergencies.

2.2 A Case in Which Scenario-Based Training and EAP Saved a Student's Life

A child at an elementary school experienced an SCA but was saved by the swift actions of 6 teachers. This successful outcome can be attributed to the school's commitment to conducting a scenario-based annual BLS training program specifically tailored to teachers. In contrast with conventional repetitive and unvaried training that lacks practical application, this training is distinctive in its focus on practical, scenario-based exercises that simulate real-life emergencies, such as a fifth-grade female student collapsing in the school corridor just before lunchtime. This training, along with a well-disseminated EAP, enabled teachers to efficiently coordinate their responses.[97]

This case of successful resuscitation emphasizes the importance of educational institutions adopting targeted emergency protocols and training programs. These initiatives equip staff with necessary skills to effectively manage school emergencies, thereby highlighting the vital role of preparedness and teamwork in ensuring student safety in critical situations.[97]

2.3 Identification of a High-Risk Child and Prevention of SCD by a School Heart Screening Program

A regularly conducted school heart screening program revealed supraventricular/ventricular extrasystoles and ST-T abnormalities in a 7-year-old asymptomatic girl. A subsequent examination revealed that she had dilated cardiomyopathy. The girl was treated for heart failure, underwent ventricular assist device implantation, successfully received a heart transplant, and remained alive.

It is important to note that children may not exhibit symptoms of severe cardiac disease in their daily lives and may be at risk of SCD if left untreated. School heart screening is vital for identifying high-risk children and initiating preventive treatments in the early stages.

2.4 Mass Training in CPR and AED Use for All Incoming New University Students

Since 2015, Kyoto University has conducted a mass CPR training program called PUSH training, which includes chest compression-only CPR and AED use, for approximately 3,000 new undergraduate students every year as part of the orientation course for new students.[98] As of 2024, over 20,000 students have participated in the training.[99] According to a study that followed up with students who received this training, the incidence rate of encountering a collapsed person was 2.5 per 100 person-years, and half of those who encountered a collapsed person performed at least one resuscitation action in the emergency setting.[100] In 2023, 2 students who had attended this training happened to encounter a man who had collapsed on the street and worked together to perform chest compressions until the ambulance arrived, ensuring the man survived with a good neurological status.[101] As the final educational institution before students enter society, universities play a crucial role in producing individuals equipped with BLS skills, which are essential for saving lives in the community.

3. Policy Suggestions

The JCS proposes that by implementing the measures described below, zero SCD in schools can be achieved.

3.1 BLS Training as a Mandatory Curriculum Item Starting From Elementary School

Previous studies demonstrated that BLS education can be effectively initiated in schoolchildren with adaptations based on their developmental stage,[102] and the International Liaison Committee on Resuscitation (ILCOR) suggests that children as young as 4 years of age can understand the initial steps of the chain of survival, and that by the ages of 10–12 years they are capable of performing effective chest compressions and ventilations, as well as using an AED.[102] Starting BLS education in elementary school and repeating age-appropriate education enables schoolchildren to gradually develop the skills necessary to perform CPR and use an AED, and this has been strongly recommended worldwide.[102]

Cardiac arrests can occur in elementary schools, and it is entirely possible for children to encounter situations where someone collapses in front of them without any adults being present. Moreover, considering that AEDs are available in all public elementary schools, it is necessary to teach children how to use them according to their developmental stage.

3.2 BLS Training as a Mandatory Subject in Teacher Training

At present, only those becoming school nurses or health and physical education teachers at the junior high or high school level take classes on school safety and emergency medical procedures as a mandatory subject.[103] However, to protect the lives of children in schools, it is highly desirable that all those training to become teachers acquire BLS skills before they start working in schools. The Third Plan for the Promotion of School Safety announced by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) in 2022 recommends that all those training to become teachers undergo education related to school safety, but it has not progressed to recommending the inclusion of BLS as a compulsory subject as part of teacher training.[104] Moreover, the Guidelines for School Accident Response (Revised Edition) published by MEXT in 2024 state that all teaching staff should conduct simulated training to be able to respond to emergencies and to establish a system whereby all teaching staff are prepared to handle such situations.[105] To ensure a safe school environment, it is crucial that BLS training is made a mandatory subject as part of teacher training.

3.3 Creating an EAP in Schools

An EAP, which is a written document that establishes specific steps for emergency situations and preparation for preventing SCD in school settings, should be implemented in all schools.[105] A carefully orchestrated response to emergencies will prevent unexpected deaths and ensure that chaos does not lead to an improper or no response. An EAP not only includes emergency action plans but also encompasses BLS training for staff and students during non-emergency times, the management of AEDs, and the identification of high-risk students.[106,107] Approximately two-thirds of SCAs in schools occur in relation to sports, and the JCS recommends installing AEDs at the locations presented in **Table 4** based on data on SCAs in schools.[106,108]

Table 4. Recommended Locations for Installation of AEDs in Schools

- AEDs should be placed in well-marked locations that students can readily see every day,[108] such as an entrance lobby or on a wall near nurses' or teachers' offices
- AEDs should be placed in locations that can be reached within a 1-min run from anywhere in the school
  If it takes more than 1 min for a single person to get to the AED and another 1 min to bring it back to where it is needed, somebody else should be called to bring it, or more than 1 AED should be installed in the school so that it will not take more than 2 min to get ready for defibrillation
- AEDs should be placed in locations with good access from sporting facilities, such as the playground, swimming pool, or gymnasium
  Sites where the AED may be exposed to rain or extreme heat or cold should be avoided
- AEDs should be positioned unlocked, with 24-h availability year-round
- AEDs should be able to be moved to prepare for emergencies at different sites during special events, such as sports days or interschool matches
  Rented AEDs should also be available for special events
  Multiple AED placements, as well as a bike squad carrying AEDs, may be helpful during marathon races
- Extra AEDs should be available at training camps or matches played away from school
- AEDs should preferably be ready to be made available to citizens in the neighborhood in case of an emergency

Based on Mitamura et al. (2015).[106] AED, automated external defibrillator.

3.4 Developing a Preventive Approach to SCD by Improving School Heart Screening

School heart screenings are conducted by local boards of education of public schools or by the founders of private schools, and the methods of implementation and evaluation vary considerably. As described above, in Japan, school heart screening is well developed, mandatory, and conducted in the first grade of elementary, junior high, and high school following the *School Health and Safety Act*.[93] However, neither follow-up examinations nor diagnostic processes after the screening are standardized. Standardization of school heart screening processes (e.g., changing from an abbreviated 4-lead to a 12-lead ECG or storing raw ECG data rather than a printed version to make it possible to accumulate life-course data and to use artificial intelligence technologies) will not only improve the accuracy of diagnosis but also identify the risk of sudden arrests to enable the development of EAPs in advance and reduce SCD in schools.

4. Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- Is school cardiac screening effective in preventing SCD in children?
- Are there appropriate strategies for the placement of AEDs according to school size or type?
- Is CPR education for students in schools effective in the long term?

V. Aim of Achieving Zero Cases of SCD During Sports

1. Current Evidence and Status in Japan

1.1 OHCA in the Sport Setting

OHCAs related to sports, although accounting for a small proportion of all OHCAs, are significant among the younger population, necessitating prevention and improved outcomes.[109] However, due to the vague definition and varying intensities of sports, accurate research is challenging, and clear incidence rates remain unknown. One review reported that the incidence of SCD in athletes varies significantly based on factors such as age, sex, ethnicity, and type of sport, with rates ranging from 0.24 per 100,000 athlete-years among Minnesota high school athletes aged 12–19 years to as high as 6.8 per 100,000 athlete-years among young European football players and to even higher rates of 1 per 2,087 athlete-years among specific groups, such as African American male National Collegiate Athletic Association Division I basketball players.[110] Another study estimated that the relative risk of sudden death during and up to 30 min after vigorous exertion was 16.9.[111]

In Japan, no studies have prospectively examined the risk of OHCA related to sports activities, but previous reports showed that the frequency of sports-related SCD varied widely, from 1 in 16.36 million in physical education facilities to 1 in 200,000 among university students.[112] A study on OHCAs among the general population in Osaka Prefecture found that 0.7% of all OHCA cases were sports-related, with 45% occurring in sports facilities.[113] The incidence rate of OHCAs in that study was 3.1 per million people per year, with a mean patient age of 63 years and males accounting for 86% of cases.[113] A questionnaire survey conducted in Japanese elementary and middle schools showed that 66% of OHCAs among students were sports-related, with the most common locations being playgrounds, followed by pools and gymnasiums.[114] Between 2008 and 2015, there were 188 cases of OHCA among schoolchildren during sports activities under school supervision, with an incidence rate of 0.172 per 100,000 children per year.[115] The majority of these students (~80%) were male.[115]

1.2 Risk of SCA by Type of Sport

The frequency of SCA varies according to sport type, region, and age.[116–119] This variation is thought to be influenced by the population participating in each sport and the duration of the activity. However, the specific risk of cardiac arrest per sport is unclear owing to limited research.

In Osaka City, 52 sports-related OHCAs were reported between 2009 and 2015, with long-distance running accounting for 28% of cases, followed by swimming and dancing (11% each).[120] Among schoolchildren who experienced an OHCA during sports activities under school supervision, long-distance running (21.8%), soccer/futsal (13.3%), basketball (12.2%), and baseball (11.2%) were the most common sports during which cardiac arrests occurred.[115] Marathons are associated with a relatively high incidence of OHCA. According to a report from Japan, there were 1.53 OHCAs per 100,000 runners in citizen marathons between 2005 and 2017.[121] Children are particularly susceptible to commotio cordis because of their softer chest wall; in Japan, 34 of 44 cases of commotio cordis between 1997 and 2013 occurred during sports, with baseball being the most common cause.[122]

1.3 CPR and AED Use for OHCA in Sports Settings

Sports-related OHCAs are more likely to be witnessed by bystanders and have a higher proportion of CPR administration and AED use. In Osaka Prefecture, the proportion of AED use was the highest in sports facilities, with 45% of OHCA patients receiving shocks and 52% achieving 1-month survival.[123] The proportion of bystander CPR for sports-related OHCA in Osaka Prefecture increased from 50% in 2005 to 86% in 2012, whereas AED use increased from 7% to 62%.[113] Accordingly, the 1-month survival rate improved from 29% to 62%.[113] Among schoolchildren, the proportion of bystander CPR in OHCAs occurring in school settings increased from 83% in 2008–2010 to 90% in 2017–2020, with the proportion of AED use increasing from 71% to 93% over the same period. In citizen marathons between 2005 and 2017, all 30 individuals experiencing an OHCA received bystander CPR, with 23 receiving AED shocks.[121] The median times to CPR initiation and AED shock were 0.8 min and 131 s, respectively. Of these 30 individuals experiencing an OHCA, 28 (93%) achieved ROSC at the scene and were reintegrated into the community.[121] This suggests that the 3 requirements for saving lives, namely the OHCA being witnessed, having a bystander nearby, and having an AED available, can be satisfied by preparing for SCA at sports events, where it is easy to meet these 3 requirements.[124] This scenario is important as a model for SCA countermeasures.

2. Case Examples

2.1 Cases of Resuscitation During Sports Activities

Based on the personal experience, two illustrative examples detailed below highlight the critical role of immediate responses in sports facilities.

- A 22-year-old man with no notable medical history experienced an SCA after being struck in the chest by a ball during a futsal game. Immediate bystander response involving CPR administration and the application of an AED by a student trainer was crucial. The patient was resuscitated prior to the arrival of EMS personnel. Subsequent evaluations revealed a life-threatening arrhythmia triggered by commotio cordis. Fortunately, the patient was discharged with an excellent neurological prognosis and resumed regular activities.

- A 55-year-old man with no significant medical history developed chest discomfort and collapsed while exercising. Immediate action by the gymnasium staff, including the administration of bystander CPR and defibrillation by an AED, resulted in ROSC before the EMS arrived. The patient was diagnosed with AMI, was later discharged, maintained good neurological function, and has since returned to work.

In both these cases, the availability of AEDs and the presence of individuals trained in BLS were crucial to the patients' good outcomes.

2.2 Strategic AED Implementation and EAPs Saving the Lives of Most Individuals Experiencing SCA During Marathons

As part of an initiative to enhance medical support during marathon events in Japan, a comprehensive first-aid system including a mobile AED team was implemented in 2007. This approach involved strategically positioning first-aid personnel equipped with AEDs along the length of the course. Between 2007 and 2020, across 334 events with a total of 3,214,701 participants, there were 42 instances of cardiopulmonary arrest. Thirty-nine of these individuals were successfully resuscitated, which was attributed to the prompt and efficient response facilitated by the mobile AED team.[121,125]

2.3 Initiatives for Facilitating Strategic CPR Training in Athletic Organizations and Sports Teams

The Japan Football Association, in collaboration with the AED Foundation and the NPO Osaka Life Association, proactively conducts regular lifesaving training sessions targeting a wide array of participants, including doctors, trainers, players, instructors, referees, and parents. Those who successfully complete the training are awarded a certificate, underscoring their competency in providing immediate medical assistance. Furthermore, this training is recognized as a part of the mandatory curriculum for athlete trainers seeking to renew their licenses with the Japan Sports Association, highlighting the emphasis on preparedness and safety in sports.[126]

In addition, several professional sports teams in Japan are actively involved in promoting lifesaving skills. For example, a professional rugby team, in collaboration with a local organization dedicated to promoting lifesaving education, hosts an annual event on game day. At this event, a booth is set up to provide training to spectators and participants in AED use and chest compression. Such initiatives are instrumental in enhancing public knowledge of BLS skills and in fostering greater community participation in safety practices.

2.4 Cases of Resuscitation While Watching Sports

Studies have indicated that the incidence of spectator cardiac arrest in stadiums ranges from 0.25 to 0.73 per 100,000 spectators,[127–129] and an increase in the occurrence of cardiac arrest during sporting events has been documented.[127,130] This is likely attributable to the emotional stress associated with intense spectatorship, which can precipitate acute cardiovascular incidents.[131–133] During the kickoff of the Rugby World Cup final match in Japan, the quick action of surrounding spectators, along with the stadium's resident medical team, including doctors and nurses, led to the successful administration of CPR and defibrillation with an AED, effectively saving a man's life.[134]

These cases underscore the need to ensure that medical equipment is readily available and that there are trained bystanders at major sporting events because they are crucial for providing immediate and effective responses in emergency medical situations.

3. Policy Suggestions

The JCS proposes that by implementing the following measures, zero SCD can be achieved during sport activities.

3.1 Creating an EAP and Conducting Related Simulations

Incidents such as serious injuries and SCA occur suddenly during sporting activities. If a response is initiated only after an accident occurs, it will not be quick. Therefore, it is necessary to create a plan that anticipates possible accidents in advance, including how to respond quickly, provide CPR, use an AED, and transport patients to a medical institution after an accident occurs. An EAP is an effective strategy applicable to all sports, disciplines, competitions, and locations.[135] Whether an EAP has been formulated in advance would be a legal issue in the event of an accident.

The EAP must include the following information:

- Emergency response personnel and role sharing
- Emergency contacts and communication
- Location of medical resources, including an AED and equipment used in an emergency
- Information on the destination medical institution
- Map of the venue.[136]

For large-scale events with many athletes and spectators, including professional sports events, it is desirable to prepare an EAP that includes the deployment of medical personnel who will be present throughout the event.

It is recommended that the EAP created is posted in easily viewable locations such as medical rooms, competition headquarters, and that it is shared with teams participating in the game, as necessary. Although the EAP describes the process up to the point of handing injured and sick people over to emergency services, it is also important to consider how to prevent the recurrence of accidents.

For the content described in the EAP to be implemented smoothly, it is necessary for those involved to undergo BLS training and participate in simulations in advance. By running a simulation, it becomes clear where in the process improvements can be made, such as discovering deficiencies in the EAP, defects in the medical supplies and equipment planned for use, and an inability to use the planned transport route. In addition, by conducting a simulation, the people involved can see each other face to face, making communication easier.

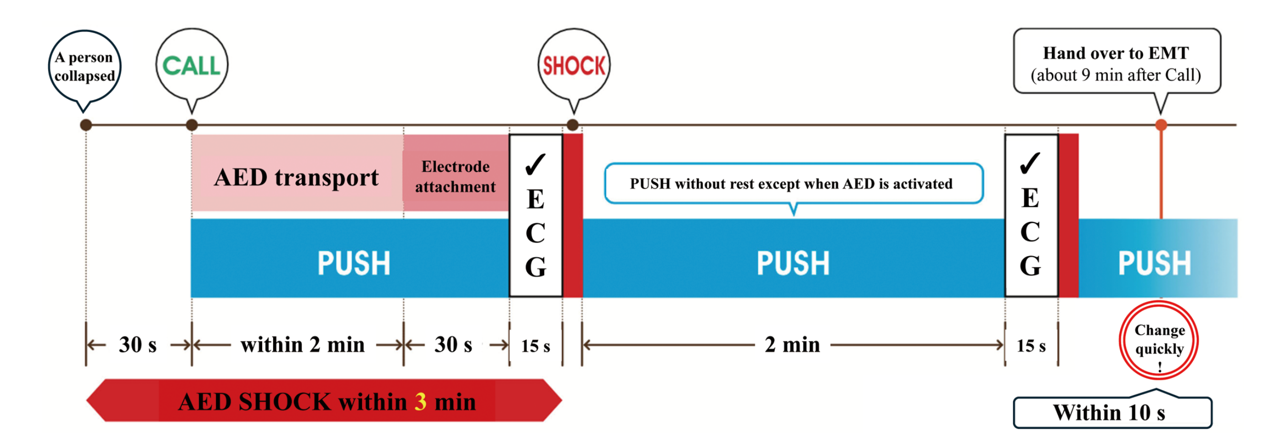

Figure 2. Second-by-second flow of lifesaving treatment in the event of a cardiac arrest. The figure shows a timeline of actions required from the time person collapses to automated external defibrillator (AED) shock within 3 min and the handover to emergency medical personnel. ECG, electrocardiogram; EMT, emergency medical technician; PUSH, chest compression. Adapted from Suggestion "Zero Sudden Cardiac Death During Sports".[124]

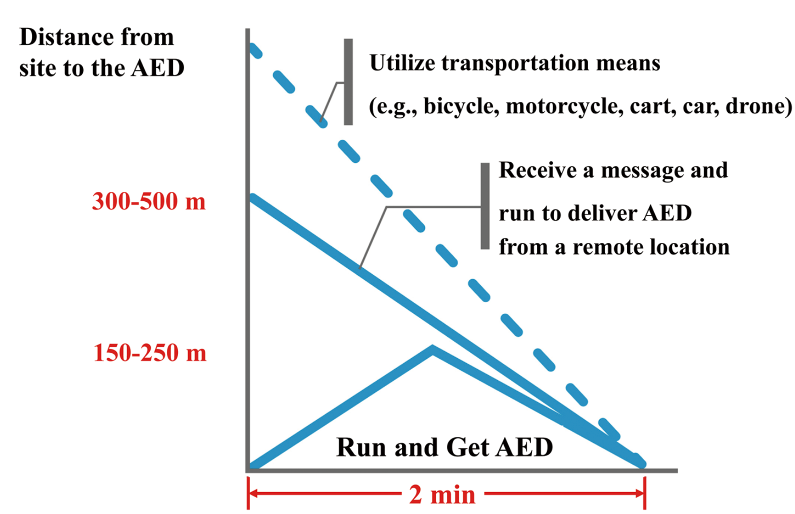

Figure 3. Ideas for delivering an automated external defibrillator (AED) within 2 min. The figure shows the distance and delivery methods whereby an AED can be delivered within 2 min to ensure an electric shock can be administered within 3 min after collapse. Adapted from Suggestion "Zero Sudden Cardiac Death During Sports".[124]

3.2 AED Placement Allowing for Electric Shock Delivery Within 3 min

SCAs that occur during sports activities are generally likely to be witnessed by bystanders and have a higher proportion of CPR administration and AED use. To achieve zero SCD during sports, the JCS proposes implementing an AED strategically and training staff and associated members to provide shocks by an AED within 3 min after collapse (**Figure 2**).[124] It takes 1 min to attach electrodes, complete the analysis, and charge the battery; therefore, to deliver an electric shock within 3 min, it is desirable to place the AED in a location where it can be obtained within 2 min.[124] The use of transportation may also be required. For example, at citizen marathons, it is reasonable that AEDs are placed at fixed points along the course (e.g., at intervals of 300–500 m), at first-aid stations and finish areas, as well as being installed near markers and guidance signs; from there, they can then be transported to where they are needed by bicycles, for example (**Figure 3**).

3.3 AED Installation at Training Facilities

AEDs are present at venues where tournaments and matches are held, and EAPs are often created. However, it is also recommended to check in advance whether an AED is installed at the facility where individuals usually train or at the venue where practice matches are held. If the training facility does not have an AED, teams should bring their own if they have one. If the teams or sportspersons do not have an AED on hand, renting an AED should be considered. It is a good idea to have an AED on hand and to bring it along when travelling to participate in training camps or games.

Furthermore, sports facility managers must strive not only to install AEDs appropriately but also to provide regular BLS training for all staff members to ensure the safety and security of facility users.

4. Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- What is the appropriate number of AEDs and the method for determining their placement depending on the scale of the sport?
- Are there any advantages of using technology for cardiac arrests that occur in sports settings?
- What is an appropriate high-risk screening method for SCA at each sporting event?

VI. Strategic Planning for a Public-Access Defibrillation System Using Technology

1. Current Evidence and Status in Japan

1.1 Effect of Public-Access Defibrillation Strategies on Survival and Proportion of SCA Patients Receiving AED Shocks

Early defibrillation plays a key role in improving survival after SCA. The increased use of public-access AEDs (public-access defibrillation [PAD]) by bystanders has been associated with an improved rate of survival with favorable neurological outcomes after OHCA.[138] In Japan, the number of AEDs in the community has been increasing annually since the use of AEDs by non-medical personnel was first approved in 2004, with an estimated >670,000 units now located throughout Japan.[139] PADs have been widely introduced and used in public settings and are no longer rare in Japan. Among individuals who experienced a bystander-witnessed OHCA of cardiac origin and received an AED shock, the 1-month survival with favorable neurological outcomes was 42.6% (523/1,229).[1] Since 2004, the general public has been able to use AEDs; consequently, 7,656 lives have been saved by AED shocks.[140]

However, according to the latest data, in 2022 only 4.3% (1,229/28,834) of patients received an AED shock in the case of bystander-witnessed cardiac arrest of cardiac origin.[1] Although many lives have been saved through the use of AEDs, considering the number of AEDs installed, the number of AED shocks delivered and survival remain suboptimal and require improvement.

Table 5. Location-Related Factors to Consider for Effective Installation of AEDs

1. High incidence of cardiac arrest (more people, more high-risk people)
2. High risk of cardiac arrest (e.g., baseball stadium [risk of commotio cordis]; stadiums hosting high-risk sports, such as marathons)
3. High chance of OHCA being witnessed by bystanders (more people, easy to find)
4. High chance of those experiencing OHCA being rescued by bystanders (many potential rescuers)
5. Time taken for EMS arrival (passenger plane, remote area, remote island)

Adapted from The AED Exploratory Committee of the Japanese Circulation Society (2012).[2] AED, automated external defibrillator; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest.

1.2 Strategic AED Installation Considering Location-Related Factors

To increase AED usage and the number of AED shocks delivered, it is important to consider location-related factors. The incidence of cardiac arrest and patient survival rates differ significantly depending on the location of the cardiac arrest. Although OHCA documented at home accounts for approximately 65.0% of all cases of OHCA in Japan,[141,142] patients who experienced an OHCA in a public place had a higher chance of being found in VF (i.e., had a greater chance of receiving a shock from a PAD) and a greater chance of survival than those who experienced an OHCA in a private residence.[142,143] For PAD systems to be effective, they should be placed in environments where there is a high incidence of cardiac arrests, as well as where patients can be easily seen and rescued by bystanders. In contrast, the installation of AEDs in areas where access is difficult for EMS services and medical care should be considered as a minimum healthcare service (**Table 5**).[2]

1.3 Recommended Locations for AED Installation

The PAD trial proved that installing AEDs and providing CPR training to individuals in facilities with at least 250 adults aged >50 years who were present for 16 h a day or had a history of at least 1 witnessed OHCA every 2 years on average can increase the number of survivors to hospital discharge after OHCA in public locations.[144]

In Japan, because of the large total annual number of railway passengers, railway stations are common places where shocks by PADs are delivered. Although air travel is less common in Japan than in Western countries, cardiac arrests occur at a certain frequency at airports and in planes.

Table 6. Recommended Locations for AED Installation

- Railway stations
- Airports, airplanes
- Schools
- Sports facilities
- Large commercial and entertainment venues
- Entertainment facilities
- Other[A]

[A]Locations where more than 1 cardiac arrest is anticipated every 5 years, places or companies where there are always >250 adults present. Adapted from The AED Exploratory Committee of the Japanese Circulation Society (2012).[2] AED, automated external defibrillator.

School PAD programs have contributed to improved outcomes after OHCA among both students and teachers.[91] Many OHCAs occur at sports facilities, where the proportion of both the use of PADs and neurologically favorable outcomes after OHCA are the highest.[123] Based on these data, we recommend the placement of AEDs at the locations listed in **Table 6**.[2]

1.4 Strategic Improvements of the PAD System Using Digital Technology

There have been many efforts and reasons to activate and call citizen responders and AEDs to the cardiac arrest scene using digital technology. The 2020 JRC resuscitation guidelines strongly recommend the implementation of social media technology to call on the general public to achieve early CPR and early defibrillation.[64] To ensure the success of a system using social media and technology, it is essential to not only implement the system in collaboration with the fire department but also increase the number of citizen volunteers willing to help, and to continue to train them.

2. Case Examples

2.1 AED Mapping System Using Digital Technology and Collaborating With Volunteers

The AED N@VI app developed by the AED Foundation of Japan aims to improve accessibility to AEDs not only in usual settings but also in the case of SCAs.[145] It uses real-time data collected from over 13,000 volunteers to map AED locations, diverging from traditional methods. Although the AED N@VI app is still under development, it encourages public participation in registering AED locations, a strategy demonstrated to heighten awareness about the presence of AEDs,[146] and user reviews ensure the database's accuracy and usefulness.

2.2 Smartphone Activation System of Citizen Responders: AED Go

An AED transportation system using smartphone technology called AED Go has been implemented in 3 small and mid-sized cities (Owariasahi City, Aichi; Kashiwa City, Chiba; Nara City, Nara) in Japan since 2017.[147] In this system, information regarding the location of cardiac arrests and nearby AEDs is sent to the smartphones of registered volunteers close to the cardiac arrest scene by the dispatch center of a municipal fire department. The volunteers are able to transport the AED quickly to the scene of the cardiac arrest and start BLS before the arrival of EMS personnel. Preliminary studies have shown promising results, with volunteers reaching cardiac arrest scenes earlier than EMS personnel in some cases.[147a] Similar systems have been implemented in other countries, including Singapore, the UK, and Denmark, resulting in an increase in bystander CPR and AED use.[148–150] This system will be implemented in Japan at a larger scale in local communities and at mass gatherings, such as sporting or international events.

2.3 Advertisements Cerebrating the 20th Anniversary of the PAD System in Japan

The year 2024 marks 20 years since AEDs became available to the general public in Japan.[140] Since then, the number of AEDs installed has increased, and the number of OHCA patients saved by AEDs now exceeds 500 annually. However, there are still many cases where AEDs are not used when needed, and issues have been raised concerning the proper management of these devices. To address these challenges, the AED 20th Anniversary Project Execution Committee has been established, crossing organizational and group boundaries. This committee aims to further increase the installation and usage rates of AEDs, promote their proper management, and work towards further improvements in survival rate.

3. Policy Suggestions

3.1 AED Registration to an AED Map Covering All of Japan and Integration Into an EMS System

Despite the presence of approximately 670,000 AEDs in Japan,[139] the landscape of AED maps and installation information is fragmented, with no unified database capturing all available AEDs in the country. This situation is in stark contrast to that in Singapore where AED registry and mapping are centralized,[151] offering a model for Japan to potentially emulate. An AED map covering all of Japan that is updated in a timely manner is essential. Furthermore, integrating AED placement information into emergency response protocols (e.g., by providing callers to the emergency 119 number with the location of nearby AEDs) could leverage the system for more efficient AED utilization. This approach would not only speed up response times in critical situations, but would also engage the community more directly in lifesaving efforts.

3.2 AED Signage Using a Standardized JIS Mark

The immediate identification of the nearest AED is of key importance for its immediate use during emergencies. Signs identifying the presence of AEDs were designed to be visible from a distance. It is crucial for all citizens to be aware of and understand the meaning of these signs. In 2019, the Ministry of Economy, Trade, and Industry introduced a standardized JIS mark for AEDs, recommending prominent display to ensure easy identification.[152] It is recommended that those installing AEDs actively use this sign and display it in a size that is identifiable from a distance.

3.3 Optimizing AED Availability and Usability

In addition to installing AEDs, it is also important to ensure that people are aware of their presence/location and how to use them and used. It is desirable that the following points are considered:

- The location of the AED should allow for defibrillation within 5 min of a cardiac arrest.
- The AED should be placed in a location that is easily identifiable, such as near the entrance of a building.
- The AED should be accessible 24 h/day.
- AEDs should be installed in areas where there is a risk of cardiac arrest.

After installation of the AED, it is important to display its location on maps within the facility and to install appropriate signage where the AED is located.[2]

3.4 Implementation of a Smart AED Transportation and Citizen Responders Activation System Using Digital Technology

To achieve early CPR and defibrillation in line with the 2020 JRC resuscitation guidelines, smart AED transportation and citizen responders activation systems via digital technology, such as the AED Go app, are needed to call on the general public.[64] To maintain a sufficient number of registered "active" volunteers, it is important to develop a system that can be updated and maintained and that includes means of motivating the public to volunteer. Volunteers may be highly aware of saving lives, but refresher training courses are essential to maintain their BLS skills and knowledge. This training needs to be implemented over a wider area to make it more viable for nationwide implementation.

3.5 Use of AED Internal Recorded Data to Improve the PAD System and the Function of AEDs

An AED's internal recorded data provides information about the CPR scene, including the location and time at which the AED was used, temporal changes in the ECG waveforms, the exact timing of the electric shock, and the diagnostic accuracy of the AED. Autoshock AEDs have been available in Japan since 2021, and it is necessary to monitor their use. By obtaining detailed time-series data on AED utilization, valuable insights can be obtained for the strategic deployment of AEDs, enabling their allocation to the times and places where they are most needed. Therefore, it is important to use internal AED data.

4. Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- How does home AED usage affect patient survival and quality of life over an extended period?
- How frequently and effectively are home AEDs used by families, and is their use cost-effective?
- How effective are preventive strategies for sudden deaths using personal health records and wearable devices?

VII. Importance of Improvements Based on Objective Data and Assessments

1. Current Evidence and Status in Japan

1.1 Introduction to Japanese Resuscitation Efforts

Japan's journey towards CPR advancement has been notable, with significant developments since experiencing a delay in CPR diffusion. The formation of the JRC and collaboration with international bodies, such as the Resuscitation Council of Asia and ILCOR,[153] have been pivotal. The evidence collected in Japan has been cited in the Consensus on Resuscitation Science and Treatment Recommendations,[153] which forms the basis of guidelines, contributing to the development of resuscitation science worldwide.[64,154,155]

1.2 Plan-Do-Check-Act and Plan-Do-Study-Act Cycles in Japanese Resuscitation Efforts

The Plan-Do-Check-Act (PDCA) cycle is a well-established method for task management, which, in the context of medical practices in Japan, has evolved into the Plan-Do-Study-Act (PDSA) cycle. The PDCA cycle was introduced for the first time by the 2010 JRC guidelines and was based on the concept of "only what can be measured can be improved", which emphasizes the importance of improvements supported by research-based data.[154] Continuous quality improvement was further stressed in the 2015 and 2020 JRC guidelines, underlining the importance of data in enhancing the quality of healthcare.[64,155] Continuous quality improvement focuses on the necessity of measurement for improvement and the effective implementation of the PDSA cycle in Japan's Utstein statistics for prehospital emergency medical systems, aiming for enhancements based on objective data and research verification.

1.3 Legislative Measures for Cerebrovascular and Cardiovascular Diseases

The Japanese National Plan for Promotion of Measures Against Cerebrovascular and Cardiovascular Disease (the National Plan) is a critical piece of legislation aimed at combating major health challenges in Japan.[46,156] Enacted in 2019, it focuses on extending healthy life expectancy, reducing mortality, and implementing key measures, such as expediting awareness of prevention measures, service provision systems, and research on cardiovascular disease.[46,156,157] The National Plan presents a comprehensive approach with 3 major and 10 specific measures aimed at addressing these health issues. The 3 major measures are to: (1) spread awareness and accurate information on prevention; (2) enhance service provision systems related to health, medical care, and welfare services; and (3) promote research on cerebrovascular and cardiovascular diseases.[46,156,157] Researchers are encouraged to contribute by developing and evaluating effective prevention strategies, advancing medical treatments, and innovating healthcare services to manage and reduce the risk factors associated with cerebrovascular and cardiovascular diseases. These efforts are crucial for providing evidence-based recommendations that inform policies and practices under the National Plan.

2. Case Examples

2.1 Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: The Utstein Resuscitation Registry for OHCA

The Utstein-style standardized template, which is used to report on resuscitation performance and outcomes in cases of OHCA, was first developed in 1991.[158] Subsequently, the Utstein templates were updated in 2004,[159] 2015,[160] and

2024.[161] These templates, which include the characteristics of OHCA patients and the performance of bystanders and EMS service personnel in relation to the resuscitation process, have globally contributed to enhancing the epidemiological understanding of OHCA. They facilitate comparisons between and within systems, identify knowledge gaps, support clinical research, and improve care systems.[162] In Japan, large-scale population-based Utstein-style registries started in Osaka in 1996 and were developed to cover the entire nation since 2005. Owing to the enormous amount of evidence from the Utstein-style registries, improvements in EMS systems have been achieved based on objective data.[163]

2.1.1 Wider Dissemination of Chest Compression-Only CPR Based on Evidence From the Utstein-Style Registry in Japan

The JCS advocates for a simplified resuscitation technique, namely Call & Push, which is supported by significant clinical evidence.[62,163–166] This method aligns with international guidelines,[23,167] including the American Heart Association's endorsement of "hands-only" CPR.[168]

2.1.2 ILCOR's Efforts and Global Resuscitation Trends

ILCOR research and registry committees have collected data from existing OHCA registries across world, revealing wide variations in bystander CPR and AED use.[65,66] In Japan, a study in Osaka revealed no significant increase in bystander CPR despite educational efforts.[169] This finding highlights the need for more effective educational and motivational campaigns and the use of technologies to improve CPR rates, AED use, and outcomes.

2.1.3 Gender Disparities in Resuscitation and the "Mamorumaru" Initiative

In response to the finding that women are less likely to receive resuscitation,[71,72,170] the Japan AED Foundation initiated the "Mamorumaru" project to promote AED use in women while respecting privacy.[171]

2.2 Research and Implementation: The Osaka Resuscitation Academy

The Osaka Resuscitation Academy serves as a critical platform for sharing knowledge and research in the field of resuscitation, contributing to the translation of research findings into practical applications in emergency medical care.[172]

2.3 JCS Chest Pain Registry

Following the initiatives launched based on the Japanese National Plan for Promotion of Measures Against Cerebrovascular and Cardiovascular Disease,[46,156,157] the Education and Implementation for Cardiac Emergency Committee of the JCS launched the Japanese Chest Pain Registry in 2022. The main multicenter collaborative study consists of 8 facilities and will soon commence (UMIN000053978) following a pilot study. Guidelines have clearly outlined the symptoms of ACS (which is the leading cause of cardiac arrest), including chest pain; however, the nature of these symptoms may have changed with the progression of aging in modern society.[24] Registry studies on ACS have been actively conducted globally; however, they often only include diagnosed cases of AMI and lack comprehensive pre- and post-hospital data. Therefore, research on diagnostic performance in cases of ACS based on symptoms and prognostic prediction of outcomes is important.

3. Policy Suggestions

3.1 Emphasizing Quality Evaluation in Routine Practice and Interventions

As emphasized by ILCOR,[153] the 2020 JRC guidelines,[64] and the National Plan,[46,156,157] evidence-based standardized practices and quality improvement process are strongly recommended to effect a continuous reduction in SCD. In addition to using the Utstein-style template for OHCAs,[158–161] new registries (e.g., chest pain registries) are needed to develop new preventive measures against SCD.

4. Knowledge Gap

The knowledge gap that needs to be addressed comprises the following questions:

- What are the cost-effective measures to prevent SCD?
- How can new technologies, such as big data, be used to improve predictive capabilities for SCD?
- How can future Japanese evidence on advance care planning and treatment withdrawal in cases of resuscitation inform global and local medical resource allocation at resuscitation scenes and ensure patient dignity?

Sources of Funding

None.

Disclosures

Any conflicts of interest were declared according to the rules prescribed by the JCS. The declaration covered 3 years, from 2021 to 2023.

References

1. Fire and Disaster Management Agency. Report on a study on social system development to improve survival from emergency cardiovascular disease [in Japanese]. https://www.fdma.go.jp/publication/rescue/items/kkkg_r05_01_kyukyu.pdf (accessed February 13, 2024).
2. The AED Exploratory Committee of the Japanese Circulation Society. Recommendations regarding specific installation and placement standards for AEDs [in Japanese]. *Shinzo* 2012; **4:** 391–402.
3. The Japanese Circulation Society. Call & Push simplified CPR procedure: Chest compression and AED. You can save lives [in Japanese]. https://www.j-circ.or.jp/cpr/ (accessed February 25, 2024).
4. The Japanese Circulation Society. STOP MI campaign [in Japanese]. https://stop-mi.com/contents_3/ (accessed March 4, 2024).
5. Rumana N, Kita Y, Turin TC, Murakami Y, Sugihara H, Morita Y, et al. Trend of increase in the incidence of acute myocardial infarction in a Japanese population: Takashima AMI Registry, 1990–2001. *Am J Epidemiol* 2008; **167:** 1358–1364.
6. Nakamura M, Tanaka F, Segawa T, Takahashi T, Matsuura Y, Sakai T, et al. Temporal trends in the incidence and clinical features of acute myocardial infarction in a Japanese rural area from 2006 to 2014. *Circ J* 2017; **81:** 1854–1861.
7. Ohsawa M, Tanno K, Itoh T. Age-specific incidence rates of acute coronary syndrome in Japan: A special gift from a collaboration of cardiologists and epidemiologists. *Circ J* 2021; **85:** 1731–1734.
8. Tunstall-Pedoe H, Kuulasmaa K, Amouyel P, Arveiler D, Rajakangas AM, Pajak A. Myocardial infarction and coronary deaths in the World Health Organization MONICA Project: Registration procedures, event rates, and case-fatality rates in 38 populations from 21 countries in four continents. *Circulation* 1994; **90:** 583–612.
9. Toshima T, Hirayama A, Watanabe T, Goto J, Kobayashi Y, Otaki Y, et al. Unmet needs for emergency care and prevention of prehospital death in acute myocardial infarction. *J Cardiol* 2021; **77:** 605–612.
10. Löwel H, Dobson A, Keil U, Herman B, Hobbs MS, Stewart A, et al. Coronary heart disease case fatality in four countries. A community study. The Acute Myocardial Infarction Register Teams of Auckland, Augsburg, Bremen, FINMONICA, Newcastle, and Perth. *Circulation* 1993; **88:** 2524–2531.
11. Ogata S, Marume K, Nakai M, Kaichi R, Ishii M, Ikebe S, et al. Incidence rate of acute coronary syndrome including acute myocardial infarction, unstable angina, and sudden cardiac death in Nobeoka City for the super-aged society of Japan. *Circ J* 2021; **85:** 1722–1730.
12. Yannopoulos D, Bartos JA, Aufderheide TP, Callaway CW, Deo R, Garcia S, et al. The evolving role of the cardiac catheterization laboratory in the management of patients with out-of-hospital cardiac arrest: A scientific statement from the American Heart Association. *Circulation* 2019; **139:** e530–e552.
13. Kumar S, Abdelghaffar B, Iyer M, Shamaileh G, Nair R, Zheng W, et al. Coronary angiography in patients with out-of-hospital cardiac arrest without ST-segment elevation on electrocardiograms: A comprehensive review. *J Soc Cardiovasc Angiogr Interv* 2023; **2:** 100536.
14. Mehta RH, Starr AZ, Lopes RD, Hochman JS, Widimsky P, Pieper KS, et al. Incidence of and outcomes associated with ventricular tachycardia or fibrillation in patients undergoing primary percutaneous coronary intervention. *JAMA* 2009; **301:** 1779–1789.
15. Karam N, Bataille S, Marijon E, Tafflet M, Benamer H, Caussin C, et al. Incidence, mortality, and outcome-predictors of sudden cardiac arrest complicating myocardial infarction prior to hospital admission. *Circ Cardiovasc Interv* 2019; **12:** e007081.
16. Garcia-Garcia C, Oliveras T, Rueda F, Perez-Fernandez S, Ferrer M, Serra J, et al. Primary ventricular fibrillation in the primary percutaneous coronary intervention ST-segment elevation myocardial infarction era (from the "Codi IAM" Multicenter Registry). *Am J Cardiol* 2018; **122:** 529–536.
17. Kosugi S, Shinouchi K, Ueda Y, Abe H, Sogabe T, Ishida K, et al. Clinical and angiographic features of patients with out-of-hospital cardiac arrest and acute myocardial infarction. *J Am Coll Cardiol* 2020; **76:** 1934–1943.
18. Ando H, Yamaji K, Kohsaka S, Ishii H, Sakakura K, Goto R, et al. Clinical presentation and in-hospital outcomes of acute myocardial infarction in young patients. *JACC Asia* 2022; **2:** 574–585.
19. Sawano M, Yamaji K, Kohsaka S, Inohara T, Numasawa Y, Ando H, et al. Contemporary use and trends in percutaneous coronary intervention in Japan: An outline of the J-PCI registry. *Cardiovasc Interv Ther* 2020; **35:** 218–226.
20. Sueda S, Shinohara T, Takahashi N, Shite J, Shoji T, Akao M, et al. Questionnaire in patients with aborted sudden cardiac death due to coronary spasm in Japan. *Heart Vessels* 2020; **35:** 1640–1649.
21. Hokimoto S, Kaikita K, Yasuda S, Tsujita K, Ishihara M, Matoba T, et al. JCS/CVIT/JCC 2023 guideline focused update on diagnosis and treatment of vasospastic angina (coronary spastic angina) and coronary microvascular dysfunction. *Circ J* 2023; **87:** 879–936.
22. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al. 2023 ESC guidelines for the management of acute coronary syndromes. *Eur Heart J* 2023; **44:** 3720–3826.
23. Panchal AR, Bartos JA, Cabanas JG, Donnino MW, Drennan IR, Hirsch KG, et al. Part 3: Adult basic and advanced life support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2020; **142**(Suppl 2)**:** S366–S468.
24. Kimura K, Kimura T, Ishihara M, Nakagawa Y, Nakao K, Miyauchi K, et al. JCS 2018 guideline on diagnosis and treatment of acute coronary syndrome. *Circ J* 2019; **83:** 1085–1196.

24a. Hollenbeck RD, McPherson JA, Mooney MR, Unger BT, Patel NC, McMullan PW Jr, et al. Early cardiac catheterization is associated with improved survival in comatose survivors of cardiac arrest without STEMI. *Resuscitation* 2014; **85:** 88–95.

24b. Vyas A, Chan PS, Cram P, Nallamothu BK, McNally B, Girotra S. Early coronary angiography and survival after out-of-hospital cardiac arrest. *Circ Cardiovasc Interv* 2015; **8:** e002321.

25. Lemkes JS, Janssens GN, van der Hoeven NW, Jewbali LSD, Dubois EA, Meuwissen M, et al. Coronary angiography after cardiac arrest without ST-segment elevation. *N Engl J Med* 2019; **380:** 1397–1407.
26. Desch S, Freund A, Akin I, Behnes M, Preusch MR, Zelniker TA, et al. Angiography after out-of-hospital cardiac arrest without ST-segment elevation. *N Engl J Med* 2021; **385:** 2544–2553.
27. Hauw-Berlemont C, Lamhaut L, Diehl JL, Andreotti C, Varenne O, Leroux P, et al. Emergency vs delayed coronary angiogram in survivors of out-of-hospital cardiac arrest: Results of the randomized, multicentric EMERGE trial. *JAMA Cardiol* 2022; **7:** 700–707.
28. Kontos MC, Scirica BM, Chen AY, Thomas L, Anderson ML, Diercks DB, et al. Cardiac arrest and clinical characteristics, treatments and outcomes among patients hospitalized with ST-elevation myocardial infarction in contemporary practice: A report from the National Cardiovascular Data Registry. *Am Heart J* 2015; **169:** 515–522.e1.
29. Sonoda T, Wada H, Ogita M, Takahashi D, Nishio R, Yasuda K, et al. Clinical features and predictors of outcome in patients with acute myocardial infarction complicated by out-of-hospital cardiac arrest. *BMC Cardiovasc Disord* 2022; **22:** 185.
30. Nishiyama C, Iwami T, Kawamura T, Kitamura T, Tanigawa K, Sakai T, et al. Prodromal symptoms of out-of-hospital cardiac arrests: A report from a large-scale population-based cohort study. *Resuscitation* 2013; **84:** 558–563.
31. Nehme Z, Bernard S, Andrew E, Cameron P, Bray JE, Smith K. Warning symptoms preceding out-of-hospital cardiac arrest: Do patient delays matter? *Resuscitation* 2018; **123:** 65–70.
32. Marijon E, Uy-Evanado A, Dumas F, Karam N, Reinier K, Teodorescu C, et al. Warning symptoms are associated with survival from sudden cardiac arrest. *Ann Intern Med* 2016; **164:** 23–29.
33. Sohail H, Ram J, Hulio AA, Ali S, Khan MN, Soomro NA, et al. Prodromal symptoms in patients presenting with myocardial infarction. *Cureus* 2023; **15:** e43732.
34. An L, Li W, Shi H, Zhou X, Liu X, Wang H, et al. Gender difference of symptoms of acute coronary syndrome among Chinese patients: A cross-sectional study. *Eur J Cardiovasc Nurs* 2019; **18:** 179–184.
35. Ueda Y, Tahara Y, Itoh T, Tsujita K, Sakuma M, Amano T, et al. New strategy to prevent acute myocardial infarction by public education: A position statement of the Committee on Public Education About Emergency Medical Care of the Japanese

Circulation Society. *Circ J* 2021; **85:** 319–322.
36. National Institute of Public Health. National standardized mortality ratio (SMR) by major cause of death by municipality 2011–2020 [in Japanese]. https://www.niph.go.jp/soshiki/07shougai/datakatsuyou/data/smr2020.html (accessed March 4, 2024).
37. Iwate kenko jyuku [in Japanese]. The Yomiuri Shimbun. https://www.yomiuri.co.jp/local/iwate/news/20231105-OYTNT50224/ (accessed March 4, 2024).
38. Iwate wanko kouhoushitsu [in Japanese]. Menkoichannel. https://www.youtube.com/watch?v=i4sJceNkW8o (accessed March 4, 2024).
39. Genkimaru life [in Japanese]. Television Iwate. http://www.genkimaru.jp/detail.php?id=235 (accessed March 4, 2024).
40. Iwate Medical Association. Ogenkidesuka [in Japanese]. https://www.iwate.med.or.jp/wp/wp-content/uploads/2023/11/2023.11-1.pdf (accessed March 4, 2024).
41. Itoh T. Let's reduce it in all prefectures. Onset of myocardial infarction • STOP MI campaign begins! [in Japanese] Morioka Iho-jin 2019; **27:** 2–5. https://morioka-med.or.jp/wp/wp-content/uploads/2020/04/Vol.27.pdf (accessed March 4, 2024).
42. The Japanese Circulation Society. STOP MI campaign, Iwate Prefecture myocardial infarction precursor symptoms awareness campaign video [in Japanese]. https://stop-mi.com/report-cate/%e5%b2%a9%e6%89%8b%e7%9c%8c/ (accessed March 4, 2024).
43. Itoh T, Nakamura A, Nohara M, Onoda T, Satoh K, Nozaki T, et al. Acute coronary syndrome registry in Iwate prefecture from the Iwate Acute Coronary Syndrome Pilot Registry to the Iwate Prefecture Regional Heart Disease Registry. *J Coron Artery Dis* 2023; **29:** 20–25.
44. Dudas K, Lappas G, Stewart S, Rosengren A. Trends in out-of-hospital deaths due to coronary heart disease in Sweden (1991 to 2006). *Circulation* 2011; **123:** 46–52.
45. Müller D, Agrawal R, Arntz HR. How sudden is sudden cardiac death? *Circulation* 2006; **114:** 1146–1150.
46. Kuwabara M, Mori M, Komoto S. Japanese national plan for promotion of measures against cerebrovascular and cardiovascular disease. *Circulation* 2021; **143:** 1929–1931.
47. Takase B, Ikeda T, Shimizu W, Abe H, Aiba T, Chinushi M, et al. JCS/JHRS 2022 guideline on diagnosis and risk assessment of arrhythmia. *Circ J* 2024; **88:** 1509–1595.
48. Winkel BG, Risgaard B, Sadjadieh G, Bundgaard H, Haunsø S, Tfelt-Hansen J. Sudden cardiac death in children (1–18 years): Symptoms and causes of death in a nationwide setting. *Eur Heart J* 2014; **35:** 868–875.
49. Empana JP, Lerner I, Valentin E, Folke F, Böttiger B, Gislason G, et al. Incidence of sudden cardiac death in the European Union. *J Am Coll Cardiol* 2022; **79:** 1818–1827.
50. Nogami A, Kurita T, Abe H, Ando K, Ishikawa T, Imai K, et al. JCS/JHRS 2019 guideline on non-pharmacotherapy of cardiac arrhythmias [published erratum appears in *Circ J* 2021; **85:** 1692–1700]. *Circ J* 2021; **85:** 1104–1244.
51. Iwasaki Y, Noda T, Akao M, Inoue K, Kusano K, Tada H, et al. JCS/JHRS 2024 guideline focused update on management of cardiac arrhythmias [in Japanese]. https://www.j-circ.or.jp/cms/wp-content/uploads/2024/03/JCS2024_Iwasaki.pdf (accessed June 13, 2024).
52. Zeppenfeld K, Tfelt-Hansen J, de Riva M, Winkel BG, Behr ER, Blom NA, et al. 2022 ESC guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J* 2022; **43:** 3997–4126.
53. Wellens HJ, Schwartz PJ, Lindemans FW, Buxton AE, Goldberger JJ, Hohnloser SH, et al. Risk stratification for sudden cardiac death: Current status and challenges for the future. *Eur Heart J* 2014; **35:** 1642–1651.
54. Tfelt-Hansen J, Garcia R, Albert C, Merino J, Krahn A, Marijon E, et al. Risk stratification of sudden cardiac death: A review. *Europace* 2023; **25:** euad203.
55. Hayashi M, Shimizu W, Albert CM. The spectrum of epidemiology underlying sudden cardiac death. *Circ Res* 2015; **116:** 1887–1906.
56. Soteriades ES, Evans JC, Larson MG, Chen MH, Chen L, Benjamin EJ, et al. Incidence and prognosis of syncope. *N Engl J Med* 2002; **347:** 878–885.
57. Savage DD, Corwin L, McGee DL, Kannel WB, Wolf PA. Epidemiologic features of isolated syncope: The Framingham Study. *Stroke* 1985; **16:** 626–629.
58. Brignole M, Moya A, de Lange FJ, Deharo JC, Elliott PM, Fanciulli A, et al. 2018 ESC guidelines for the diagnosis and management of syncope. *Eur Heart J* 2018; **39:** 1883–1948.
59. Semsarian C, Ingles J, Wilde AAM. Sudden cardiac death in the young: The molecular autopsy and a practical approach to surviving relatives. *Eur Heart J* 2015; **36:** 1290–1296.
60. Behr E, Dalageorgou D, Christiansen M, Syrris P, Hughes S, Esteban MTT, et al. Sudden arrhythmic death syndrome: Familial evaluation identifies inheritable heart disease in the majority of families. *Eur Heart J* 2008; **29:** 1670–1680.
61. Imai Y, Kusano K, Aiba T, Ako J, Asano Y, Uchida T, et al. JCS/JCC/JSPCCS 2024 guideline on genetic testing and counseling in cardiovascular medicine. *Circ J* 2024; **88:** 2022–2099.
62. Iwami T, Kawamura T, Hiraide A, Berg RA, Hayashi Y, Nishiuchi T, et al. Effectiveness of bystander-initiated cardiac-only resuscitation for patients with out-of-hospital cardiac arrest. *Circulation* 2007; **116:** 2900–2907.
63. Song J, Guo W, Lu X, Kang X, Song Y, Gong D. The effect of bystander cardiopulmonary resuscitation on the survival of out-of-hospital cardiac arrests: A systematic review and meta-analysis. *Scand J Trauma Resusc Emerg Med* 2018; **26:** 86.
64. Japan Resuscitation Council. Japanese guidelines for emergency care and cardiopulmonary resuscitation 2020 [in Japanese]. Tokyo, Igaku-Shoin, 2021.
65. Kiguchi T, Okubo M, Nishiyama C, Maconochie I, Ong MEH, Kern KB, et al. Out-of-hospital cardiac arrest across the world: First report from the International Liaison Committee on Resuscitation (ILCOR). *Resuscitation* 2020; **152:** 39–49.
66. Nishiyama C, Kiguchi T, Okubo M, Alihodžić H, Al-Araji R, Baldi E, et al. Three-year trends in out-of-hospital cardiac arrest across the world: Second report from the International Liaison Committee on Resuscitation (ILCOR). *Resuscitation* 2023; **186:** 109757.
67. The Ministry of Education, Culture, Sports, Science, and Technology. Curriculum guidelines for Japanese junior high schools [in Japanese]. https://www.mext.go.jp/content/20230120-mxt_kyoiku02-100002604_02.pdf (accessed January 15, 2024).
68. The Ministry of Education, Culture, Sports, Science, and Technology. Curriculum guidelines for Japanese high schools [in Japanese]. https://www.mext.go.jp/content/20230120-mxt_kyoiku02-100002604_03.pdf (accessed January 15, 2024).
69. National Police Agency. Standard for training at designated driving schools [in Japanese]. https://www.npa.go.jp/laws/notification/koutuu/menkyo/menkyo20220307_18.pdf (accessed February 13, 2024).
70. Blewer AL, McGovern SK, Schmicker RH, May S, Morrison LJ, Aufderheide TP, et al. Gender disparities among adult recipients of bystander cardiopulmonary resuscitation in the public. *Circ Cardiovasc Qual Outcomes* 2018; **11:** e004710.
71. Matsuyama T, Okubo M, Kiyohara K, Kiguchi T, Kobayashi D, Nishiyama C, et al. Sex-based disparities in receiving bystander cardiopulmonary resuscitation by location of cardiac arrest in Japan. *Mayo Clin Proc* 2019; **94:** 577–587.
72. Perman SM, Shelton SK, Knoepke C, Rappaport K, Matlock DD, Adelgais K, et al. Public perceptions on why women receive less bystander cardiopulmonary resuscitation than men in out-of-hospital cardiac arrest. *Circulation* 2019; **139:** 1060–1068.
73. Shimamoto T, Nishiyama C, Ohura T, Kawamura T, Iwami T. Psychological conflicts in bystander cardiopulmonary resuscitation for out-of-hospital cardiac arrest. *Int J First Aid Educ* 2020; **3:** 10–21.
74. Shida H, Nishiyama C, Okabayashi S, Yamamoto Y, Shimamoto T, Kawamura T, et al. Laypersons' psychological barriers against rescue actions in emergency situations: A questionnaire survey. *Circ J* 2022; **86:** 679–686.
75. Tanigawa K, Iwami T, Nishiyama C, Kitamura T, Ando M, Goto M, et al. Are trained individuals more likely to perform bystander CPR? An observational study. *Resuscitation* 2011; **82:** 523–528.
76. Hansen CM, Rosenkranz SM, Folke F, Zinckernagel L, Tjørnhøj-Thomsen T, Torp-Pedersen C, et al. Lay bystanders' perspectives on what facilitates cardiopulmonary resuscitation and use of automated external defibrillators in real cardiac arrests. *J Am Heart Assoc* 2017; **6:** e004572.
77. Rott N, Böttiger BW, Lockey A. The World Restart a Heart initiative: How to save hundreds of thousands of lives worldwide. *Curr Opin Crit Care* 2021; **27:** 663–667.
78. Malsy M, Leberle R, Graf B. Germans learn how to save lives: A nationwide CPR education initiative. *Int J Emerg Med* 2018; **11:** 9.
79. Japan Heart Foundation. Japan heart day [in Japanese]. https://

www.kenko810.com/ (accessed February 13, 2024).
80. Homma Y. A resuscitation educational tool with a smartphone videogame cartoon character. *Resusc Plus* 2023; **17:** 100517.
81. Japan AED Foundation. Team ASUKA [in Japanese]. https://aed-zaidan.jp/report/20220928.html (accessed February 13, 2024).
82. Japan AED Foundation. Life-saving coaching app Liv [in Japanese]. https://aed-zaidan.jp/liv/index.html (accessed February 13, 2024).
83. Zijlstra JA, Beesems SG, Haan RJD, Koster RW. Psychological impact on dispatched local lay rescuers performing bystander cardiopulmonary resuscitation. *Resuscitation* 2015; **92:** 115–121.
84. Mathiesen WT, Bjørshol CA, Braut GS, Søreide E. Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims: A qualitative study. *BMJ Open* 2016; **6:** e010671.
85. Japanese Society for Emergency Medicine, Bystander Support Committee. Recommendations for the establishment of a system to support the psychological stress responses of bystanders [in Japanese]. https://jsem.me/news/content_1.html (accessed February 13, 2024).
86. Komaki City Fire Department. Mamorukun card [in Japanese]. https://www.city.komaki.aichi.jp/admin/soshiki/shobo/syoubousyo/2/1/2/6946.html (accessed March 6, 2024).
87. Møller TP, Hansen CM, Fjordholt M, Pedersen BD, Østergaard D, Lippert FK. Debriefing bystanders of out-of-hospital cardiac arrest is valuable. *Resuscitation* 2014; **85:** 1504–1511.
88. Bystander Support Network. About the bystander network. https://www.bystandernetwork.org/ (accessed February 13, 2024).
89. Kiyohara K, Sado J, Kitamura T, Ayusawa M, Nitta M, Iwami 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:** 1026–1032.
90. Kiyohara K, Sado J, Kitamura T, Ayusawa M, Nitta M, Iwami T, et al. Public-access automated external defibrillation and bystander-initiated cardiopulmonary resuscitation in schools: A nationwide investigation in Japan. *Europace* 2019; **21:** 451–458.
91. Nishiyama C, Kiyohara K, Matsuyama T, Kitamura T, Kiguchi T, Kobayashi D, et al. Characteristics and outcomes of out-of-hospital cardiac arrest in educational institutions in Japan: All-Japan Utstein Registry. *Circ J* 2020; **84:** 577–583.
92. Japan Society of School Health. Report on cardiopulmonary resuscitation (CPR) and automated external defibrillators (AED) in schools in 2018 [in Japanese]. https://www.gakkohoken.jp/book/ebook/ebook_H300010/data/213/src/H300010.pdf?d=1562032011843 (accessed February 13, 2024).
93. The Ministry of Education, Culture, Sports, Science and Technology. Regulation for Enforcement of School Health and Safety Act [in Japanese]. https://laws.e-gov.go.jp/law/333M50000080018 (accessed February 29, 2024).
94. Sumitomo N, Baba R, Doi S, Higaki T, Horigome H, Ichida F, et al. Guidelines for heart disease screening in schools (JCS 2016/JSPCCS 2016): Digest version. *Circ J* 2018; **82:** 2385–2444.
95. Japan Society of School Health. Survey report on health management in school life in 2013 [in Japanese]. https://www.gakkohoken.jp/book/ebook/ebook_H260030/H260030.pdf (accessed February 13, 2024).
96. Saitama City Board of Education. Accident response text during physical activities: ASUKA model [in Japanese]. https://www.city.saitama.jp/003/002/013/002/p019665_d/fil/asuka.pdf (accessed February 13, 2024).
97. 15-minute miracle: Teacher's lifesaving relay [in Japanese]. The Asahi Shimbun Newspapers Digital Edition, January 28, 2021. https://www.asahi.com/articles/ASP1V71NTP1QTNAB00C.html (accessed February 13, 2024).
98. Nishiyama C, Baba M, Kuroki H, Sato R, Kawamura T, Koike K, et al. Training of chest compression and AED use to incoming students at national university [in Japanese]. *Jpn Soc Emerg Med* 2017; **20:** 682–688.
99. Kyoto University. News for the BLS training among incoming new students [in Japanese]. https://www.kyoto-u.ac.jp/ja/news/2024-04-26 (accessed July 13, 2024).
100. Nishiyama C, Sato R, Baba M, Kuroki H, Kawamura T, Kiguchi T, et al. Actual resuscitation actions after the training of chest compression-only CPR and AED use among new university students. *Resuscitation* 2019; **141:** 63–68.
101. Kyoto University. Zattsu kyodai [in Japanese]. https://www.thats.pr.kyoto-u.ac.jp/2023/12/27/14027/ (accessed February 13, 2024).
102. Schroeder DC, Semeraro F, Greif R, Bray J, Morley P, Parr M, et al. Kids save lives: Basic life support education for schoolchildren: A narrative review and scientific statement from the International Liaison Committee on Resuscitation. *Circulation* 2023; **147:** 1854–1868.
103. Ordinance for enforcement of the school teacher's License Act (Ordinance of the Ministry of Education No. 26 of 1954) [in Japanese]. https://elaws.e-gov.go.jp/document?lawid=329M50000080026 (accessed February 13, 2024).
104. The Ministry of Education, Culture, Sports, Science, and Technology. Third plan for the promotion of school safety [in Japanese]. https://www.mext.go.jp/kaigisiryo/content/20210826-mxt_kyousei02-000017643_5.pdf (accessed February 13, 2024).
105. The Ministry of Education, Culture, Sports, Science, and Technology. Guidelines for school accident response (revised edition) [in Japanese]. https://anzenkyouiku.mext.go.jp/guideline-jikotaiou/data/outline/jikotaioushishin-all.pdf?v2403262 (accessed April 8, 2024).
106. 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:** 1398–1401.
107. Japan AED Foundation. EAP in school setting [in Japanese]. https://aed-zaidan.jp/user/media/aed-zaidan/files/download/School_EAP.pdf (accessed February 18, 2024).
108. The Japanese Circulation Society. Indicating AED location (in Japanese). http://www.j-circ.or.jp/aed/arrow/ (accessed September 27, 2024).
109. Jayaraman R, Reinier K, Nair S, Aro AL, Uy-Evanado A, Rusinaru C, et al. Risk factors of sudden cardiac death in the young: Multiple-year community-wide assessment. *Circulation* 2018; **137:** 1561–1570.
110. Han J, Lalario A, Merro E, Sinagra G, Sharma S, Papadakis M, et al. Sudden cardiac death in athletes: Facts and fallacies. *J Cardiovasc Dev Dis* 2023; **10:** 68.
111. Albert CM, Mittleman MA, Chae CU, Lee IM, Hennekens CH, Manson JE. Triggering of sudden death from cardiac causes by vigorous exertion. *N Engl J Med* 2000; **343:** 1355–1361.
112. Manabe T. Statistics onserious medical accidents in sports: J-SPORTSCAR study [in Japanese]. *Clin Sports Med* 2022; **39:** 32–37.
113. Kiyohara K, Nishiyama C, Kiguchi T, Nishiuchi T, Hayashi Y, Iwami T, et al. Exercise-related out-of-hospital cardiac arrest among the general population in the era of public-access defibrillation: A population-based observation in Japan. *J Am Heart Assoc* 2017; **6:** e005786.
114. Mitani Y, Ohta K, Ichida F, Nii M, Arakaki Y, Ushinohama H, et al. Circumstances and outcomes of out-of-hospital cardiac arrest in elementary and middle school students in the era of public-access defibrillation. *Circ J* 2014; **78:** 701–707.
115. Sado J, Kiyohara K, Kitamura T, Matsui S, Ayusawa M, Nitta M, et al. Sports activity and paediatric out-of-hospital cardiac arrest at schools in Japan. *Resuscitation* 2019; **139:** 33–40.
116. Finocchiaro G, Papadakis M, Robertus JL, Dhutia H, Steriotis AK, Tome M, et al. Etiology of sudden death in sports: Insights from a United Kingdom regional registry. *J Am Coll Cardiol* 2016; **67:** 2108–2115.
117. Marijon E, Tafflet M, Celermajer DS, Dumas F, Perier MC, Mustafic H, et al. Sports-related sudden death in the general population. *Circulation* 2011; **124:** 672–681.
118. Marijon E, Uy-Evanado A, Reinier K, Teodorescu C, Narayanan K, Jouven X, et al. Sudden cardiac arrest during sports activity in middle age. *Circulation* 2015; **131:** 1384–1391.
119. Toukola TM, Kauppila JP, Pakanen L, Kortelainen ML, Martikainen M, Huikuri HV, et al. Characteristics and prognosis of exercise-related sudden cardiac arrest. *Front Cardiovasc Med* 2018; **5:** 102.
120. Kiyohara K, Sado J, Matsuyama T, Nishiyama C, Kobayashi D, Kiguchi T, et al. Out-of-hospital cardiac arrests during exercise among urban inhabitants in Japan: Insights from a population-based registry of Osaka City. *Resuscitation* 2017; **117:** 14–17.
121. Kinoshi T, Tanaka S, Sagisaka R, Hara T, Shirakawa T, Sone E, et al. Mobile automated external defibrillator response system during road races. *N Engl J Med* 2018; **379:** 488–489.
122. Koshimizu K. Reduce deaths from contusions: Causes and countermesures for cardiac concussion [in Japanese]. *Train J* 2015; **37:** 22–27.
123. Murakami Y, Iwami T, Kitamura T, Nishiyama C, Nishiuchi T, Hayashi Y, et al. Outcomes of out-of-hospital cardiac arrest by public location in the public-access defibrillation era. *J Am*

Heart Assoc 2014; **3:** e000533.
124. The Japanese Circulation Society. Suggestion "Zero sudden cardiac death during sports" [in Japanese]. https://www.j-circ.or.jp/old/topics/files/aed_tegen.pdf (accessed March 4, 2024).
125. Tanaka H, Kinoshi T, Tanaka S, Sagisaka R, Takahashi H, Sone E, et al. Prehospital interventions and neurological outcomes in marathon-related sudden cardiac arrest using a rapid mobile automated external defibrillator system in Japan: A prospective observational study. *Br J Sports Med* 2022; bjsports-2021-104964.
126. Furuya S, Fukushima Y, Ohashi H, Shima K, Matsuda S, Takeda S, et al. A new challenge of life support training course "Sports Life Support License Training Course", by Japan Football Association [in Japanese]. *Jpn J Clin Sports Med* 2020; **28:** 370–375.
127. van de Sandt F, Umans V. Acute cardiac events and deployment of emergency medical teams and automated external defibrillators in large football stadiums in the Netherlands. *Eur J Cardiovasc Prev Rehabil* 2009; **16:** 571–575.
128. Luiz T, Preisegger T, Rombach D, Madler C. Cardiac arrest in spectators in German football stadiums. Precautionary measures, frequency and short-term outcome. *Anaesthesist* 2014; **63:** 636–642.
129. Goldberg SA, Battistini V, Cash RE, Kelleher M, Laporte C, Peters G, et al. A retrospective review of out of hospital cardiac arrest at Gillette Stadium: 10 years of experience at a large sports venue. *Resusc Plus* 2023; **14:** 100386.
130. Onozuka D, Hagihara A. Out-of-hospital cardiac arrests during the Japanese Professional Baseball Championship Series. *Am J Cardiol* 2018; **121:** 1471–1476.
131. Wilbert-Lampen U, Leistner D, Greven S, Pohl T, Sper S, Völker C, et al. Cardiovascular events during World Cup soccer. *N Engl J Med* 2008; **358:** 475–483.
132. Lin LL, Gu HY, Yao YY, Zhu J, Niu YM, Luo J, et al. The association between watching football matches and the risk of cardiovascular events: A meta-analysis. *J Sports Sci* 2019; **37:** 2826–2834.
133. Leeka J, Schwartz BG, Kloner RA. Sporting events affect spectators' cardiovascular mortality: It is not just a game. *Am J Med* 2010; **123:** 972–977.
134. Tajima T, Takazawa Y, Yamada M, Moriya T, Sato H, Higashihara J, et al. Spectator medicine at an international mega sports event: Rugby World Cup 2019 in Japan. *Environ Health Prev Med* 2020; **25:** 72.
135. Malik A, Hanson J, Han J, Dolezal B, Bradfield JS, Boyle NG, at al. Sudden cardiac arrest in athletes and strategies to optimize preparedness. *Clin Cardiol* 2023; **46:** 1059–1071.
136. Courson RW. Emergency action plans. *In:* Casa DJ, Stearns L, editors. Emergency management for sport and physical activity. Burlington: Jones & Bartlett Learning, 2015; 203–214.
137. (Deleted in proof.)
138. Kitamura T, Kiyohara K, Sakai T, Matsuyama T, Hatakeyama T, Shimamoto T, et al. Public-access defibrillation and out-of-hospital cardiac arrest in Japan. *N Engl J Med* 2016; **375:** 1649–1659.
139. Seizan T, Hiroyuki Y. A national survey of the number of AED sales, and a study of a system to enable an accurate count of the number of AEDs installed [in Japanese]. https://mhlw-grants.niph.go.jp/system/files/report_pdf/R4%E5%8E%9A%E5%8A%B4%E7%A7%91%E7%A0%94%E5%9D%82%E6%9C%AC%E7%8F%AD%28AED%E7%AD%89%29%E5%A0%B1%E5%91%8A%E6%9B%B8_p15-62%E5%88%86%E6%8B%85.pdf (accessed March 3, 2024).
140. Mitamura H, Iwami T, Takeda S, Nishiyama C, Homma Y, Shimamoto T, et al. Life saving of victims with out-of-hospital sudden cardiac arrest by lay citizens in the era of widespread dissemination of AEDs in Japan: A 20-year history and the future [in Japanese]. *Shinzo* 2024; **56:** 534–545.
141. Kiyohara K, Nishiyama C, Matsuyama T, Sado J, Kitamura T, Shimamoto T, et al. Out-of-hospital cardiac arrest at home in Japan. *Am J Cardiol* 2019; **123:** 1060–1068.
142. Iwami T, Hiraide A, Nakanishi N, Hayashi Y, Nishiuchi T, Uejima T, et al. Outcome and characteristics of out-of-hospital cardiac arrest according to location of arrest: A report from a large-scale, population-based study in Osaka, Japan. *Resuscitation* 2006; **69:** 221–228.
143. Kiguchi T, Kiyohara K, Kitamura T, Nishiyama C, Kobayashi D, Okabayashi S, et al. Public-access defibrillation and survival of out-of-hospital cardiac arrest in public vs. residential locations in Japan. *Circ J* 2019; **83:** 1682–1688.
144. Hallstrom AP, Ornato JP, Weisfeldt W, Travers A, Christenson J, McBurnie MA, et al. Public-access defibrillation and survival after out-of-hospital cardiac arrest. *N Engl J Med* 2004; **351:** 637–646.
145. Japan AED Foundation. AED N@VI [in Japanese]. https://aed-navi.jp/ (accessed March 5, 2024).
146. Ringh M, Hollenberg J, Palsgaard-Moeller T, Svensson L, Rosenqvist M, Lippert FK, et al. The challenges and possibilities of public access defibrillation. *J Intern Med* 2018; **283:** 238–256.
147. Hayashi M, Iwasaki Y. Addressing out-of-hospital cardiac arrest with current technology advances: Breaking the deadlock with a mobile network. *J Arrhythm* 2024; **40:** 753–766.
147a. Iwami T, Kiguchi T, Shimamoto T, Nishiyama C, Homma Y. Investigation of a smartphone-activated volunteer responders system for out-of-hospital cardiac arrest [in Japanese]. https://mhlw-grants.niph.go.jp/system/files/report_pdf/R5%E5%8E%9A%E5%8A%B4%E7%A7%91%E7%A0%94%E5%9D%82%E6%9C%AC%E7%8F%AD%28AED%E7%AD%89%29%E5%A0%B1%E5%91%8A%E6%9B%B8_p13-68nb%E5%88%86%E6%8B%85_0.pdf.
148. Ming NW, De Souza CR, Pek PP, Shahidah N, Ng YY, Arulanandam S, et al. myResponder smartphone application to crowdsource basic life support for out-of-hospital cardiac arrest: The Singapore experience. *Prehosp Emerg Care* 2021; **25:** 388–396.
149. Andelius L, Malta HC, Jonsson M, Gerds TA, Rajan S, Torp-Pedersen C, et al. Smartphone-activated volunteer responders and bystander defibrillation for out-of-hospital cardiac arrest in private homes and public locations. *Eur Heart J Acute Cardiovasc Care* 2023; **12:** 87–95.
150. Smith CM, Lall R, Fothergill RT, Spaight R, Perkins GD. The effect of the GoodSAM volunteer first-responder app on survival to hospital discharge following out-of-hospital cardiac arrest. *Eur Heart J Acute Cardiovasc Care* 2022; **11:** 20–31.
151. Chua SYI, Ng YY, Ong MEH. Getting R-AEDI to save lives in Singapore. *Singapore Med J* 2020; **61:** 60–62.
152. Japan AED Foundation. JIS mark for AEDs [in Japanese] https://aed-zaidan.jp/download.html (accessed July 17, 2024).
153. International Liaison Committee on Resuscitation (ILCOR). About ILCOR. https://www.ilcor.org/ (accessed July 17, 2024).
154. Japan Resuscitation Council. JRC guidelines for resuscitation 2010 [in Japanese]. Tokyo: Herusu Shuppan; 2011.
155. Japan Resuscitation Council. JRC guidelines for resuscitation 2015 [in Japanese]. Tokyo: Igaku Shoin; 2016.
156. Ministry of Health Labour and Welfare, Japan. Cerebrovascular and Cardiovascular Disease Control Act [in Japanese]. https://www.mhlw.go.jp/web/t_doc?dataId=80ab6708&dataType=0&pageNo=1 (accessed March 11, 2023).
157. Ministry of Health Labour and Welfare, Japan. The Japanese national plan for promotion of measures against cerebrovascular and cardiovascular disease [in Japanese]. https://www.mhlw.go.jp/stf/newpage_31654.html (accessed March 11, 2023).
158. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: The 'Utstein style'. Prepared by a task force of representatives from the European Resuscitation Council, American Heart Association, Heart and Stroke Foundation of Canada, Australian Resuscitation Council. *Resuscitation* 1991; **22:** 1–26.
159. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: Update and simplification of the Utstein templates for resuscitation registries. A statement for healthcare professionals from a task force of the international liaison committee on resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa). *Resuscitation* 2004; **63:** 233–249.
160. Perkins GD, Jacobs IG, Nadkarni VM, Berg RA, Bhanji F, Biarent D, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: Update of the Utstein Resuscitation Registry Templates for out-of-hospital cardiac arrest: A statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on

Cardiopulmonary, Critical Care, Perioperative and Resuscitation. *Resuscitation* 2015; **96:** 328–340.

161. Bray JE, Grasner JT, Nolan JP, Iwami T, Ong MEH, Finn J, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: 2024 Update of the Utstein Out-of-Hospital Cardiac Arrest Registry Template. *Circulation* 2024; **150:** e203–e223.
162. Nishiyama C, Brown SP, May S, Iwami T, Koster RW, Beesems SG, et al. Apples to apples or apples to oranges?: International variation in reporting of process and outcome of care for out-of-hospital cardiac arrest. *Resuscitation* 2014; **85:** 1599–1609.
163. Iwami T, Nichol G, Hiraide A, Hayashi Y, Nishiuchi T, Kajino K, et al. Continuous improvements in "chain of survival" increased survival after out-of-hospital cardiac arrests: A large-scale population-based study. *Circulation* 2009; **119:** 728–734.
164. Bohm K, Rosenqvist M, Herlitz J, Hollenberg J, Svensson L. Survival is similar after standard treatment and chest compression only in out-of-hospital bystander cardiopulmonary resuscitation. *Circulation* 2007; **116:** 2908–2912.
165. SOS-KANTO Study Group. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): An observational study. *Lancet* 2007; **369:** 920–926.
166. Iwami T, Kitamura T, Kawamura T, Mitamura H, Nagao K, Takayama M, et al. Chest compression-only cardiopulmonary resuscitation for out-of-hospital cardiac arrest with public-access defibrillation: A nationwide cohort study. *Circulation* 2012; **126:** 2844–2851.
167. Soar J, Böttiger BW, Carli P, Couper K, Deakin CD, Djärv T, et al. European Resuscitation Council Guidelines, 2021: Adult advanced life support. *Resuscitation* 2021; **161:** 115–151.
168. American Heart Association. CPR & first aid emergency cardiovascular care. https://cpr.heart.org/en/ (accessed March 1, 2024).
169. Kawai S, Kobayashi D, Nishiyama C, Shimamoto T, Kiyohara K, Kitamura T, et al. Wider dissemination of simplified chest compression-only cardiopulmonary resuscitation training combined with conventional cardiopulmonary resuscitation training and 10-year trends in cardiopulmonary resuscitation performed by bystanders in a city. *Circ J* 2023; **88:** 1304–1312.
170. Kiyohara K, Katayama Y, Kitamura T, Kiguchi T, Matsuyama T, Ishida K, et al. Sex disparities in the use of public-access AED pads among patients with OHCA in public locations. *Resuscitation* 2020; **150:** 60–64.
171. MAMORUMARU. About mamorumaru [in Japanese]. https://mamorumaru-aed.org/?page_id=82 (accessed September 27, 2024).
172. The Osaka Resuscitation Academy. Home [in Japanese]. https://osakalifesupport.or.jp/resuscitation_acad/ (accessed March 1, 2024).

Appendix. Disclosure of Potential Conflicts of Interest (COI): Strategies for Reducing Sudden Cardiac Death by Public Awareness — A Statement From the Education and Implementation for Cardiac Emergency Committee of the Japanese Circulation Society — (2021/1/1–2023/12/31)

Author	Member's own declaration items									COI of the marital partner, first-degree family members, or those who share income and property			COI of the head of the organization/department to which the member belongs (if the member is in a position to collaborate with the head of the organization/department)	
	Employer/leadership position (private company)	Stakeholder	Patent royalty	Honorarium	Payment for manuscripts	Research grant	Scholarship (educational) grant	Endowed chair	Other rewards	Employer/leadership position (private company)	Stakeholder	Patent royalty	Research grant	Scholarship (educational) grant
Chika Nishiyama														
Satoshi Yoshimura														
Takuya Taniguchi														
Tetsuya Amano				Novartis Pharma K.K. Kowa Pharmaceutical Co., Ltd. Daiichi Sankyo Co., Ltd. Otsuka Pharmaceutical Co., Ltd. Bayer Yakuhin, Ltd. Takeda Pharmaceutical Company Limited Nippon Boehringer Ingelheim Co., Ltd.										
Hirohiko Ando				Abbott Medical Japan LLC Terumo Corporation Kaneka Medix Corporation										
Yosuke Homma														
Tomohiko Imamura														
Tomonori Itoh														
Takeyuki Kiguchi														
Kosuke Kiyohara														
Satomi Konno														
Hisaki Makimoto						Mitsubishi Electric Corporation								
Tomohiro Manabe														
Yasushi Matsuzawa														
Hideo Mitamura														
Nogiku Niwamae				Mochida Pharmaceutical Co., Ltd.										
Masashi Sakuma				Bayer Yakuhin, Ltd.										
Kayoko Sato														
Yasuhiro Satoh														
Yoshio Tahara														

Author	Member's own declaration items									COI of the marital partner, first-degree family members, or those who share income and property			COI of the head of the organization/department to which the member belongs (if the member is in a position to collaborate with the head of the organization/department)	
	Employer/leadership position (private company)	Stakeholder	Patent royalty	Honorarium	Payment for manuscripts	Research grant	Scholarship (educational) grant	Endowed chair	Other rewards	Employer/leadership position (private company)	Stakeholder	Patent royalty	Research grant	Scholarship (educational) grant
Kenichi Tsujita				Amgen K.K. Abbott Medical Japan LLC. Otsuka Pharmaceutical Co., Ltd. Kowa Company, Ltd. Daiichi Sankyo Co., Ltd. Takeda Pharmaceutical Company Limited Terumo Corporation Nippon Boehringer Ingelheim Co., Ltd. Novartis Pharma K.K. Bayer Yakuhin, Ltd. Pfizer Japan Inc. AstraZeneca K.K. Medtronic Japan Co., Ltd. Kyowa Kirin Co., Ltd. Janssen Pharmaceutical K.K.		PPD-SNBL K.K. Alexion Pharma G.K. CSL Behring K.K. JIMRO Co., Ltd. AnGes, Inc. Bayer Yakuhin, Ltd. Pfizer Japan Inc. Sugi Bee Garden Co., Ltd. Daiichi Sankyo Co., Ltd. Bristol-Myers Squibb K.K. Mochida Pharmaceutical Co., Ltd. EA Pharma Co., Ltd. Novo Nordisk Pharma Ltd. PRA Health Sciences K.K.	ITI CO., LTD. Abbott Medical Japan Co., Ltd. AMI Co., Ltd. Otsuka Pharmaceutical Co., Ltd. Ono Pharmaceutical Co., Ltd. Daiichi Sankyo Co., Ltd. Takeda Pharmaceutical Company Limited Japan Boehringer Ingelheim Co., Ltd. Bayer Yakuhin, Ltd. Boston Scientific Japan K.K.	ITI CO., LTD. Abbott Japan LLC Kaneka Medix Corporation GM Medical Co., Ltd. Terumo Corporation Nipro Corporation Fides-one, Inc. Boston Scientific Japan K.K. Abbott Medical Japan Co., Ltd. Cardinal Health Japan G.K. Medtronic Japan Co., Ltd. Japan Lifeline Co., Ltd. Fukuda Denshi Co., Ltd. MEDICAL APPLIANCE Co., LTD. Philips Japan, Ltd. Orbusneich Medical K.K. Getinge Group Japan K.K. BIOTRONIK Japan, Inc. Japan Boehringer Ingelheim Co., Ltd.						
Yayoi Tetsuou Tsukada														
Masato Uchida														
Yasunori Ueda						Novartis Pharma K.K.	Abbott Japan LLC Orbusneich Medical K.K.							
Taku Iwami						Healthtech Laboratory, Inc. Towa Pharmaceutical Co., Ltd. Nihon Kohden Corporation TIS Inc.	ZOLL Medical Corporation Ritsuan STC Inc.							