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Characteristics and Outcomes of Bath-Related Out-of-Hospital Cardiac Arrest in Japan

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Background: Characteristics and outcomes of emergency patients with bath-related sudden cardiac arrest in prehospital settings have not been sufficiently investigated.

Methods and Results: From a prospective population-based registry, which covers all out-of-hospital cardiac arrests (OHCAs) in Osaka City, a total of 642 patients who had a bath-related OHCA from 2012 to 2014 were enrolled in the analyses. The characteristics and outcomes of OHCA were compared by three locations of arrest: home baths (n=512), public baths (n=102), and baths in other public institutions (n=28). Overall, bath-related OHCAs mainly occurred in winter (December–February, 48.9%, 314/642). The proportion of OHCAs that were witnessed by bystanders was 6.4% (33/512) in home baths, 17.6% (18/102) in public baths, and 25.0% (7/28) in baths in other public institutions. The proportion of public-access automated external defibrillator pad application was 0.8% (4/512) in home baths, 6.9% (7/102) in public baths, and 50.0% (14/28) in baths in other public institutions. Only 1 survivor with a favorable neurologic outcome was observed in a home bath, whereas there were no patients who survived with favorable neurologic outcomes in public baths and baths in other public institutions.

Conclusions: Bath-related OHCAs mainly occurred in winter, and the outcome of victims was exceedingly poor, irrespective of location of arrest. The establishment of preventive measures as well as earlier recognition of cardiac arrest by bystanders are needed. (*Circ J* 2016; **80:** 1564 – 1570)

Key Words: Bath; Cardiopulmonary resuscitation; Outcomes; Out-of-hospital cardiac arrest

Over 120,000 cardiac arrests in prehospital settings occur annually in Japan, and approximately two-thirds of them were of presumed cardiac origin.[1] In accordance with the dissemination of defibrillation and chest compressions by bystanders,[2–6] the survival from an out-of-hospital cardiac arrest (OHCA) has been improving recently in many communities.[7–9] However, the OHCA survival rate is still low, and further assessment of factors associated with the OHCA occurrence and outcome is needed.

Editorial p 1523

Traditionally, Japanese are in the habit of taking a long, deep, hot bath almost daily, unlike their European and American counterparts.[10] Although habitual bathing of this style was suggested to be related with better self-rated health,[11] many preceding studies demonstrated that this habit was associated with the occurrence of sudden cardiac arrest, especially during winter among the senior population.[12–16] The risk of cardiac arrest was also reported to be 10-fold greater during bathing than during sleep in elderly people in Japan.[16] The number of sudden deaths during bathing was estimated to be approximately 17,000 in 2011 in Japan,[17] and it is one of the critical issues in public health.

However, the epidemiology of emergency patients with bath-related OHCA has not been sufficiently investigated. In the present study, we collected data from approximately 650 bath-related OHCA patients during the 3-year study period from the large population-based registry of Osaka City, and assessed their characteristics and outcomes to provide some

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clues for prevention and improvement of pre-hospital care for people who experience bath-related OHCAs.

Methods

Study Design and Settings

Osaka City, the third largest city in Japan, has a population of approximately 2.7 million (2010) in an area of 222 km². The Osaka Municipal Fire Department has registered the ambulance records of Osaka City, and linked them to the data on resuscitation, simultaneously collected according to the Utstein-style guidelines.[18,19] It is a prospective population-based registry, which covers all OHCA patients who are treated by emergency medical service (EMS) personnel in Osaka City. Cardiac arrest was defined as the cessation of cardiac mechanical activities, as confirmed by the absence of circulation signs.[18,19] As do-not-resuscitate orders or living wills are not generally accepted in Japan, EMS providers are not permitted to terminate resuscitation in the field. Therefore, almost all OHCA patients treated by EMS personnel were transported to hospital and recorded to the registry, excluding cases of decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis. The present study enrolled patients who had a bath-related OHCA and were then transported to medical institutions from 1 January 2012 to 31 December 2014. Here, we defined "bath-related OHCA" as an OHCA that occurred in a bathtub, wash place, sauna, or dressing room. OHCAs that were caused by suicide in bathrooms and were not resuscitated by bystanders or EMS personnel were excluded from the analyses.

The EMS System in Osaka City

The EMS system of Osaka City, administrated by the Osaka Municipal Fire Department, is activated by dialing 119 on the telephone. There are 25 fire stations and a single emergency dispatch center in this area, and life support is provided 24 h a day. Each fire ambulance has 3 EMS personnel with at least 1 emergency life-saving technician (ELST) who has highly trained pre-hospital emergency care skills. ELSTs are authorized to use an automated external defibrillator, to insert an intravenous line, and to place advanced airway management devices for OHCA patients under online medical control direction. Specially trained ELSTs are permitted to insert tracheal tubes and to administer intravenous epinephrine. All EMS personnel perform cardiopulmonary resuscitation (CPR) according to the Japanese CPR guidelines.[20] Public-access defibrillation programs have been promoted in Japan since July 2004. Detailed characteristics of the EMS system in Osaka City have been described elsewhere.[21–23]

Data Collection and Quality Control

Data collection for the registry was prospectively implemented based on the worldwide standardized Utstein-style reporting guidelines for OHCA.[18,19] The data forms were filled out by the EMS personnel in collaboration with physicians in charge. The data were integrated into the registry system in the Information Center for Emergency Medical Services of Osaka, and then checked by the investigators. When incomplete data were found, the EMS personnel in charge were asked to complete the datasheet. In the present study, we obtained the following data from the registry: gender, age, origin of cardiac arrest, past history of heart disease, activities of daily living (ADL) before arrest, witness of arrest, location of arrest, first documented rhythm, bystander-initiated CPR, public-access AED use, dispatcher instruction, intravenous fluid, epinephrine, advanced airway management, and time-course of resuscitation (ie, time of call received, EMS contact with patients, and hospital arrival). The origin of cardiac arrest was presumed to be cardiogenic unless it was clinically determined to be a non-cardiac cause (ie, external injury, respiratory disease, malignant tumor, and stroke). The first documented rhythm was diagnosed by the EMS personnel with semi-automated defibrillators at the scene, and it was regarded as ventricular fibrillation when bystanders provided shocks using public-access automated external defibrillators (AEDs). Both bystander-initiated chest compression-only CPR and conventional CPR with rescue breathing were considered as bystander CPR. Application of AED pads to a patient's chest was defined as "2 pads were directly attached to the patient's skin in an appropriate position".[24–26] In addition, outcomes after OHCA, including pre-hospital return of spontaneous circulation (ROSC), hospital admission, 1-month survival, and neurologic outcome, were assessed. Neurologic outcomes were assessed with the Glasgow-Pittsburgh Cerebral Performance Category (CPC) scale as: 1: good performance; 2: moderate disability; 3: severe cerebral disability; 4: coma/vegetative state; and 5: death/brain death.[18,19]

Key Group Definition

Because characteristics and outcomes of OHCAs would differ by location of cardiac arrest, our assessments were conducted for 3 locations; that is, "home baths," "public baths," and "baths in other public institutions." The proportion of private residences that had at least 1 bathroom was 88.3% in Osaka City in 2008.[27] Public bath facilities in Japan, subject to the Public Bath House Act, refer to facilities that offer a public bath using warm water, hot saltwater (including bath), onsen (hot spring), or others. There were approximately 400 public bath facilities (including small bath houses, sauna baths and large bath houses with many different services) in Osaka City in 2014.[28] Bathrooms in other public institutions, such as hotels, inns, nursing homes, and sports facilities, were categorized in the "other baths in other public institutions" category in this study.

Outcome Measures

The outcome measures were pre-hospital ROSC, hospital admission, 1-month survival after an OHCA, and 1-month survival with favorable neurologic outcome, defined as a CPC scale of 1 or 2.[18,19]

Statistical Analysis

The number of bath-related OHCA occurrences was counted for 3 locations of arrest (ie, "home baths," "public baths," and "baths in other public institutions") by month. Background characteristics, prehospital care by EMS personnel, and outcomes of OHCA patients were compared for the locations of arrest using the Kruskal-Wallis test for continuous variables or Fisher's exact test for categorical variables. All of the tests were 2-tailed and a P value of <0.05 was considered statistically significant. All statistical analyses were performed by using SPSS statistical package ver20.0J (IBM Corp, Armonk, NY, USA).

Ethics

The protocol of this study was approved by the Ethics Committees of Kyoto University. The requirement of giving individual informed consent was waived by the Personal Information Protection Law and the National Research Ethics Guidelines of Japan.

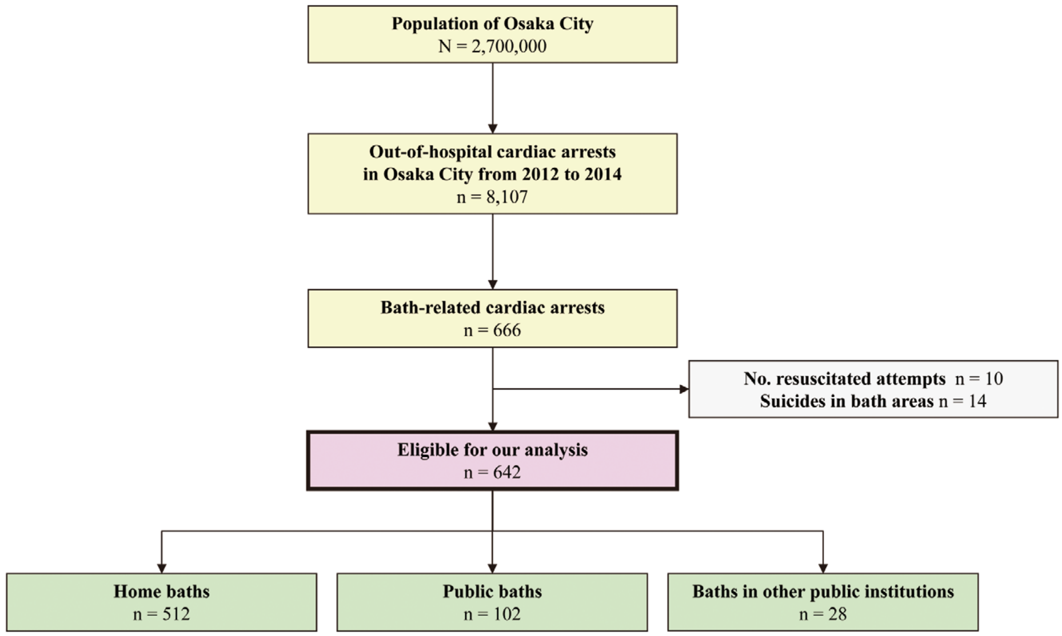

Figure 1. Flow of out-of-hospital cardiac arrest patients between January 2012 and December 2014 in Osaka City, Japan.

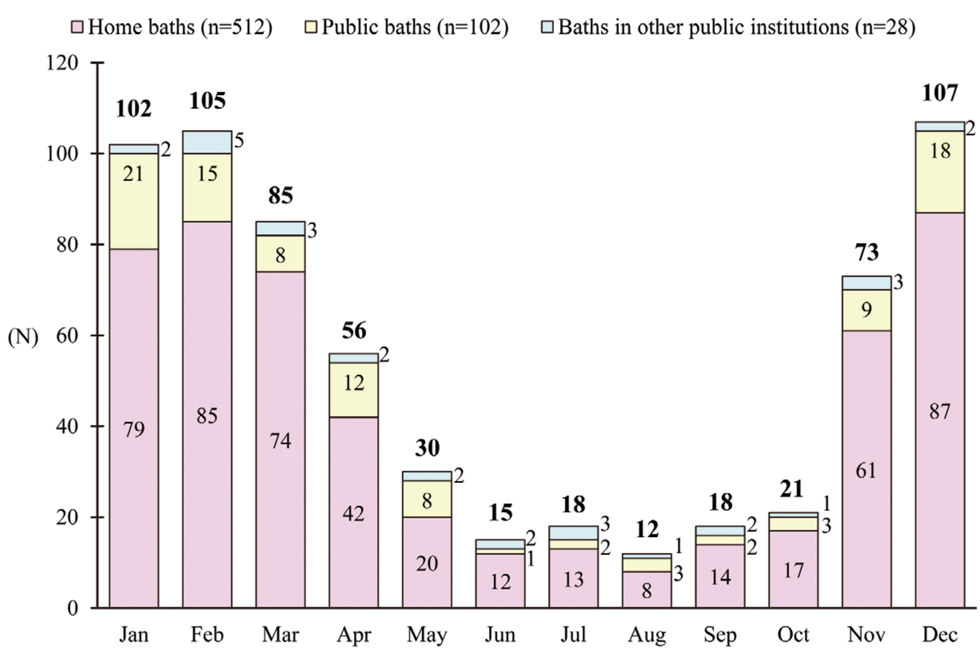

Figure 2. Monthly distribution of the number of bath-related out-of-hospital cardiac arrests that have occurred by location.

Results

Figure 1 shows an overview of bath-related OHCA patients. During the study period of 3 years, a total of 666 bath-related OHCAs were documented in Osaka City. After excluding the patients who were not resuscitated by bystanders or EMS personnel (n=10) or committed suicide (n=14), 642 patients were eligible for analyses. The majority of bath-related OHCAs (79.8%, 512/642) occurred in home baths, and 15.9% was observed in public baths (102/642).

Table 1. Patient and Emergency Medical Service Characteristics of Out-of-Hospital Cardiac Arrests by Type of Bath

	Home baths (n=512)	Public baths (n=102)	Baths in other public institutions (n=28)	P-value
Age (years, median [IQR])	79 (72–84)	72 (67–79)	82 (76–85)	<0.001
Men, n (%)	273 (53.3)	94 (92.2)	14 (50.0)	<0.001
Past history of ischemic heart diseases, n (%)	28 (5.5)	0 (0.0)	2 (7.1)	0.016
Activities of daily living before arrest, n (%)				<0.001
Good	465 (90.8)	73 (71.6)	21 (75.0)	
Disability	35 (6.8)	3 (2.9)	6 (21.4)	
Unknown	12 (2.3)	26 (25.5)	1 (3.6)	
Origin, n (%)				0.955
Presumed cardiac	369 (72.1)	75 (73.5)	22 (78.6)	
Drowning	124 (24.2)	24 (23.5)	5 (17.9)	
Other	19 (3.7)	3 (2.9)	1 (3.6)	
Witness status, n (%)				<0.001
Bystanders	33 (6.4)	18 (17.6)	7 (25.0)	
EMS	4 (0.8)	4 (3.9)	0 (0.0)	
None	475 (92.8)	80 (78.4)	21 (75.0)	
Detailed place of arrest, n (%)				<0.001
Bathtub	445 (86.9)	86 (84.3)	23 (82.1)	
Wash place	62 (12.1)	8 (7.8)	5 (17.9)	
Sauna	0 (0.0)	5 (4.9)	0 (0.0)	
Dressing room	5 (1.0)	3 (2.9)	0 (0.0)	
First documented rhythm, n (%)				0.005
Ventricular fibrillation	6 (1.2)	3 (2.9)	0 (0.0)	
Pulseless electrical activity	42 (8.2)	18 (17.6)	6 (21.4)	
Asystole	464 (90.6)	81 (79.4)	22 (78.6)	
Bystander-initiated CPR, n (%)	202 (39.5)	61 (59.8)	20 (71.4)	<0.001
Public-access AED pad application, n (%)	4 (0.8)	7 (6.9)	14 (50.0)	<0.001
Shock by a public-access AED, n (%)	0 (0.0)	0 (0.0)	3 (10.7)	<0.001
Dispatcher instruction, n (%)	290 (56.6)	44 (43.1)	10 (35.7)	0.009
Intravenous fluid, n (%)	182 (35.5)	46 (45.1)	4 (14.3)	0.009
Epinephrine, n (%)	29 (5.7)	21 (20.6)	1 (3.6)	<0.001
Advanced airway management, n (%)	404 (78.9)	87 (85.3)	20 (71.4)	0.178
Time of day, n (%)				<0.001
Daytimes (9:00 am–4:59 pm)	102 (19.9)	42 (41.2)	17 (60.7)	
Nights (5:00 pm–8:59 am)	410 (80.1)	60 (58.8)	11 (39.3)	
Day of the week, n (%)				0.673
Weekdays (Monday–Friday)	379 (74.0)	75 (73.5)	23 (82.1)	
Weekends (Saturday–Sunday)	133 (26.0)	27 (26.5)	5 (17.9)	
EMS response time (from call to contact with a patient) (min, median [IQR])	7 (6–9)	7 (6–9)	7 (6–8)	0.071
Hospital arrival time (from call to hospital arrival) (min, median [IQR])	30 (25–35)	30 (23–35)	28 (23–31)	0.093

AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; IQR, interquartile range.

The monthly distribution in the number of bath-related OHCA occurrences by location of arrest is shown in Figure 2. Overall, bath-related OHCAs mainly occurred in winter (December–February, 48.9%, 314/642), whereas the occurrences considerably decreased in summer (June–August, 7.0%, 45/642).

Table 1 shows the patients' characteristics and pre-hospital care by the location of arrest. The patients in public baths were mostly men (92.2%, 94/102) and were relatively young (median age, 72 years). Most of the OHCA patients in home baths had good ADL before arrest (90.8%, 465/512), while the proportion of patients with good ADL was relatively low in public baths (71.6%, 73/102) and in baths in other public institutions (75.0%, 21/28). However, note that information on ADL was not obtained from 25.5% (26/102) of patients in public baths. The proportion of presumed cardiac origin ranged from 72.1% to 78.6% by location of arrest. The proportion of the patients whose arrest was witnessed by bystanders was 6.4% (33/512) in home baths, 17.6% (18/102) in public baths, and 25.0% (7/28) in baths in other public institutions. Bystander-initiated CPR was conducted on 39.5% (202/512) of patients in home baths, 59.8% (61/102) in public baths, and 71.4% (20/28) in baths in other public institutions. The proportion of public-access AED pad applications was significantly high among the patients in baths in other public institutions (50.0%, 14/28), while it was low among the patients

Table 2. Outcomes of Out-of-Hospital Cardiac Arrest by Type of Bath

	Home baths (n=512)	Public baths (n=102)	Baths in other public institutions (n=28)	P-value
Prehospital ROSC, n (%)	13 (2.5)	7 (6.9)	3 (10.7)	0.143
Hospital admission, n (%)	54 (10.5)	18 (17.6)	3 (10.7)	0.007
1-month survival, n (%)	7 (1.4)	2 (2.0)	1 (3.6)	0.301
CPC 1 or 2, n (%)	1 (0.2)	0 (0.0)	0 (0.0)	1.000

CPC, cerebral performance category; ROSC, return of spontaneous circulation.

in public baths (6.9%, 7/102) and in home baths (0.8%, 4/512). Overall, there were few patients of cardiac arrest with ventricular fibrillation (VF) regardless of location, and only 3 patients in baths in other public institutions received shocks by a public-access AED. The EMS response time (from call to contact with a patient) and hospital arrival time (from call to hospital arrival) were almost same despite location of arrest.

Table 2 shows the outcomes of patients after a bath-related OHCA by location of arrest. Overall, the patients with a bath-related OHCA had a poor outcome regardless of location. The proportion of 1-month survival ranged from 1.4% (in home baths) to 3.6% (in baths in other institutions). Only 1 survivor with a favorable neurologic outcome was observed in home baths, while there were no patients who survived with a favorable neurologic outcome in public baths and baths in other public institutions.

Discussion

By using the exhaustive OHCA registry of Osaka City, the present study clearly depicted the epidemiology of bath-related OHCAs, including new findings about the actual situation of pre-hospital care and their prognosis by location of arrest. The most striking result of this study was an extremely poor prognosis of bath-related OHCAs. Taking a long, deep, hot bath is a Japanese traditional custom, and many people commonly visit public bath houses; there are over 26,000 facilities that were registered as public bath houses in Japan.[28] Although 740,000 bath-related accidents (including falling, loss of consciousness, and others) are estimated to happen every year in Japan,[29] the actual situation of pre-hospital care, detailed characteristics, and outcomes of bath-related OHCAs have been poorly understood, especially for those occurring in public baths. Therefore, our findings would purvey essential information for pre-hospital prevention and treatment of bath-related OHCAs. The information would also draw the attention of cardiologists to consider the mechanism, prevention, and treatment of bath-related OHCAs.

Consistent with previous studies,[12–16] the majority of the proportion of bath-related OHCAs was observed during winter from our findings. Low external temperature is suggested to increase sympathetic nerve tone and catecholamine release, which increases heart rate, ventricular contractility, vascular resistance, and blood pressure.[30,31] Besides, a rapid increase in body temperature by deep bathing causes a rapid fall in blood pressure that develops approximately 4 min after immersion, and it would lead to syncope in the bathtub.[12,32] Thus, hypotensive syncope would be one of the causes of sudden death by drowning during hot bathing, attributed to large differences between the high water temperature and the low ambient temperature during winter.

In contrast, most of our study subjects did not have a past history of ischemic heart disease and showed relatively good ADL before arrest. This seems to be inconsistent with preceding studies, which suggest that underlying cardiac diseases are risk factors of sudden death during bathing because the significant changes in electrocardiogram during bathing occurred, especially among elderly people with cardiac diseases.[32,33] However, according to the examination of a large number of autopsied bath-related deaths,[15] although water inhalation signs were observed in 79% of the cases and cardiac lesions were the most common pathological finding (45%), no less than 36% of the cases exhibited no remarkable pathological findings. Therefore, further pathological and physiological investigations are needed to elucidate detailed biological mechanisms of bath-related OHCAs in order to lead to prevention and improved outcomes in the future.

In this study, only 1 patient survived with a favorable neurologic outcome among all bath-related OHCA patients. A previous study indicated that the proportion of survivors with favorable neurologic outcomes after OHCAs, which were caused by drowning irrespective of location and behavior, was 0.8%.[34] Another study also reported that the proportion of survivors with favorable neurologic outcomes after bystander-witnessed OHCA of cardiac origin was 5.4% at home and 20.8% in public places.[35] The outcomes of our study subjects were much poorer compared with these results. One plausible explanation of the differences between previous studies and ours would be differences in body temperature of the patients when suffering a cardiac arrest. Previous studies suggested that target body temperature management or therapeutic hypothermia increases the chances of survival with a favorable neurologic outcome, and hypothermia may ameliorate myocardial damage in acute myocardial infarction.[36–38] As the particularity of bath-related OHCAs would be higher body temperature immediately after cardiac arrests, it may cause a poorer prognosis. Other explanations would be that bath-related OHCAs were less likely to be witnessed by bystanders (6.4% in home baths and 17.6% in public baths), as well as the fact that OHCAs with VF were very few (1.2% in home baths and 2.9% in public baths). A previous report from Osaka Prefecture showed that 36% of OHCAs were witnessed by bystanders in private residences and 47% in public settings.[39] Thus, it might be difficult for the general public to recognize cardiac arrests during immersion in bathtubs, even in public bath houses.

One of the important findings from this study was that the proportion of the patients to whom AED pads were applied by bystanders was only 7% in public baths, and it was much lower than that for baths in other public institutions (50%). According to the guidelines for appropriate public-access AED placement in Japan,[40] public baths are facilities where installation of public-access AEDs is recommended. Although the number of public-access AEDs in Japan has been rapidly increasing and has reached over 500,000 throughout Japan in 2014,[29] our results indicated that a sufficient number of public-access AEDs may not be placed in public bath houses in our study area. Considering that not a low proportion (15.9%) of bath-related OHCAs occurred in public baths, the appropriate placement of AEDs in public bath houses should be strongly promoted. In addition, the employees of public bath facilities would be urged to attend a regular training course of basic life support (BLS), including CPR implementation and AED use. In order to improve the survival rate after an OHCA in community settings, further efforts by governments and medical authorities should be made to increase the number of individuals capable of conducting BLS, especially those who are working in the institutions where the risk of an OHCA occurrence is high, like public bath houses. However, given that the first documented rhythm of most patients was pulseless electrical activity or asystole (ie, unshockable rhythms), the prevention of bath-related OHCAs is most important. The Japan Resuscitation Council Resuscitation Guidelines 2015 provides some preventive countermeasures specific to bath-related OHCAs: (1) warm the bathroom and dressing room in order to reduce temperature differences between the water and the ambient air in winter; (2) refrain from bathing in hot water for a long time, and take a half-body bath instead of a deep bath; (3) family members should pay special attention to elderly people with a high risk of sudden heart attack during bathing; (4) avoid bathing just after the consumption of alcohol or a sleep-inducing drug; and (5) install a system that can make contact with outside the bathroom.[41] In addition, considering the low proportion of witnessed arrests, efforts to inform the public, including staff members of public bathhouses, of the risk of sudden cardiac arrest during bathing would also be needed for earlier recognition of cardiac arrest by bystanders.

There are several limitations in this study. First, we did not obtain information on several background factors that could have influenced the OHCA occurrence, such as past medical history, medication, and life habits including tobacco consumption. For example, alcohol drinking just before bathing would also contribute to bath-related death.[15,42] Second, because the classification of presumed cardiac arrests was determined by exclusion diagnosis in accordance with the Utstein-style guidelines for cardiac arrest data reporting,[19] the origin of arrest could not be exactly determined. Third, as the study area was limited to one metropolis, the results might, therefore, not easily apply to other areas. And as the occurrence of a bath-related OHCA should be strongly influenced by environmental factors, further research is needed to focus on other areas, especially cold regions.

From the large population-based registry of Osaka City, we reported the characteristics and outcomes of bath-related OHCAs. In this population, the majority of the proportion of bath-related OHCAs was observed during winter, and the outcome of those patients was exceedingly poor. Establishment of preventive measures specific to bath-related OHCAs, as well as earlier recognition of cardiac arrests by bystanders, are needed.

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Disclosures

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