


# Impact of air temperature on occurrence of bath-related cardiac arrest

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## Abstract

The mortality of the bath-related cardiac arrest (BRCA) is extremely high. While air temperature is reported to be associated with the BRCA occurrence, it is unclear whether daily minimum temperatures or the difference between maximum and minimum air temperatures influences BRCA occurrence the most.

A retrospective cohort study of adult patients was conducted between January 2015 and February 2020 at Hirosaki University Hospital Emergency Department. The following data were collected: age, sex, day of cardiac arrest event, location of the event, initial cardiac rhythm, presence of return of spontaneous circulation, and overall mortality (status at 1 month after cardiac arrest event). Based on the day of the event and the location in which the event occurred, daily minimum and maximum temperatures were obtained from the Japan Meteorological Agency database.

A total of 215 eligible cardiac arrest cases were identified, including 25 cases of BRCA. Comparing BRCA and non-BRCA, initial shockable cardiac rhythm (4.0% vs 44.7%), presence of return of spontaneous circulation (8.0% vs 34.7%), and overall mortality (96.0% vs 71.6%) differed significantly ( $P < .05$  each). Daily minimum and maximum temperatures showed no significant relationships with BRCA or non-BRCA. Daily minimum temperature was a risk factor of BRCA occurrence after adjusting for age and temperature difference (risk ratio, 0.937; 95% confidence interval, 0.882–0.995).

Daily minimum temperature represents a potential risk factor for BRCA occurrence.

**Abbreviations:** BRCA = bath-related cardiac arrest, OHCA = out-of-hospital cardiac arrest, ROSC = return of spontaneous circulation.

**Keywords:** bath-related cardiac arrest, daily temperature, mortality, prevention

## 1. Introduction

Individuals in East-Asian countries commonly soak in the bathtub to relax and maintain physical hygiene. However, this bathing culture can lead to bath-related accidents.<sup>[1]</sup> While the mortality of the bath-related cardiac arrest (BRCA) is reported to be extremely high, the risk factors of its occurrence are still unexamined.<sup>[2,3]</sup>

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Previous studies have shown that BRCA occurs more frequently in winter than in summer.<sup>[4–8]</sup> Although seasonal differences tend to alter the mortality of BRCA, a study conducted in the southern area of Japan reported that the mortality rate of BRCA was similar to that in other areas, meaning that regional differences appeared unlikely to impact the mortality rate of BRCA.<sup>[9]</sup> A study in Korea also reported that the number of bath-related deaths tended to increase during winter.<sup>[5]</sup> Another potential characteristic of BRCA is that the age of affected individuals appears considerably high in many studies of East-Asian countries,<sup>[5,6,9,10]</sup> and a study investigating BRCA in a Japanese urban area reported that the age of patients was extremely high (median, 79 years).<sup>[4]</sup>

Although these results suggest that winter season and higher age might be risk factors associated with BRCA occurrence, only a few studies have directly analyzed the relationship between the BRCA occurrence and daily temperatures, which change throughout the year.<sup>[11]</sup> In addition, it is unclear whether daily minimum temperatures or the difference between maximum and minimum air temperatures influences BRCA occurrence the most. Therefore, this study aimed to examine the impact of air temperature parameters on the occurrence of BRCA.

## 2. Methods

### 2.1. Study design and participants

This retrospective cohort study included adult patients over 20 years old diagnosed with out-of-hospital cardiac arrest (OHCA) brought to the Emergency Department of Hirosaki University

Hospital between January 2015 and February 2020. OHCA cases related to suicide, trauma, or intoxication, or OHCA developing during hospitalization were excluded. In addition, OHCA cases lacking information of initial cardiac rhythm were excluded from the analysis.

## 2.2. Setting

Hirosaki University Hospital is located in Tsugaru district, at the northern part of Japan. The emergency department of the hospital is the only tertiary emergency center in the area; thus, all of the cardiac arrest patients with special conditions (e.g., BRCA cases) in this area are transferred to the our hospital. In addition, the paramedics select the OHCA patients who most likely require extracorporeal cardiopulmonary resuscitation and/or the postresuscitation intensive care to be transferred to our center according to pre-defined protocol. On average, 35% of the OHCA patients in this area are seen at our hospital.

## 2.3. Data collection

We reviewed the medical charts of the included patients and collected the following data: age, sex, day of OHCA event, location in which OHCA occurred (i.e., city or town), initial cardiac rhythm, presence of return of spontaneous circulation (ROSC), and overall mortality (status at 1 month after the OHCA event). Based on the day of the event and the location in which the event occurred, daily minimum and maximum temperatures were obtained using the Japan Meteorological Agency database.<sup>[12]</sup> Besides, we calculated daily temperature differences by calculating the difference between the daily minimum and maximum temperatures from the database. We defined all OHCA occurring in the dressing room, washing area, or inside the bathtub as BRCA incidents and all OHCA occurring in other areas as non-BRCA incidents. All BRCA cases were further examined for the accident situation: the place of discovery (i.e., washing area, dressing room, sauna, or inside the bathtub), bystander cardiopulmonary resuscitation, and suggestion of drowning as determined by whether the patient's face was submerged in the bathwater.

## 2.4. Data analysis

Fisher exact test was applied for categorical variables, and the Mann–Whitney *U* test was applied for continuous variables. We also conducted a Poisson regression analysis to identify risk factors of BRCA occurrence as this analysis regression is useful to predict a dependent variable that consists of count data given independent variables. We selected regression model variables based on a review of the literature and our study interests.<sup>[10,11]</sup> Values of  $P < .05$  were considered statistically significant. Statistical analysis was conducted using IBM SPSS Statistics version 23.0 (Armonk, NY: IBM Corp).

## 2.5. Ethics

The ethics board approved this study of Hirosaki University Graduate School (ID: 2019-1132). Due to the retrospective nature of the study (data were collected from patient medical charts), the need to obtain informed consent was waived in accordance with the above guidelines.

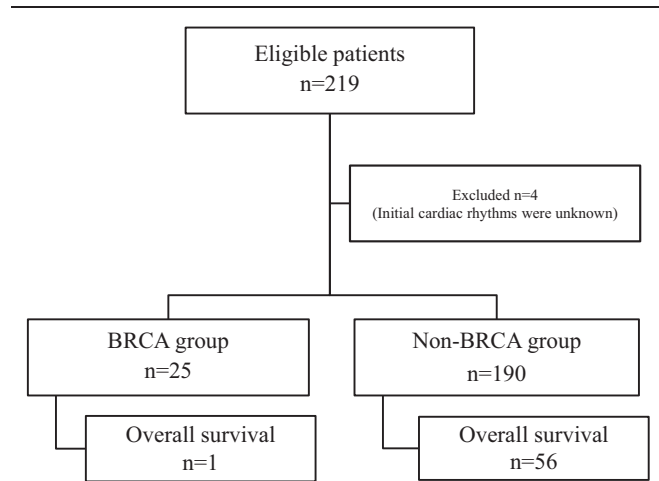


Figure 1. Patient flow chart.

## 3. Results

A total of 219 adult OHCA patients were identified during the study period, of which 4 cases were excluded due to a lack of information (Fig. 1). Details of the remaining 215 eligible OHCA patients are shown in Table 1. Median age was 71 years old (range, 20–101 years), and most patients were male ( $n=155$ ; 72.1%). Eighty-six cases (40.0%) had shockable cardiac rhythm, and 68 patients (31.6%) successfully attained ROSC. The overall mortality rate was 73.7%. Of 215 eligible cardiac arrest patients, BRCA was identified in 25 cases (11.6%). In the 25 BRCA cases (Table 2), the discovery site was as follows: washing area,  $n=3$ ; dressing room,  $n=1$ ; sauna,  $n=1$ ; and inside the bathtub,  $n=20$ . Of the 20 BRCA cases found inside the bathtub, 16 BRCA patients were found with the face submerged in the bathwater. Only 1 patient survived BRCA, and that patient had been found in the washing area with initial shockable cardiac rhythm and attempted bystander cardiopulmonary resuscitation. The months of the BRCA occurrence were presented in Table S1, Supplemental Digital Content, <http://links.lww.com/MD/G393>.

No significant differences between BRCA and non-BRCA groups were found for age (median, 75 years; range, 69–80 vs median, 69 years; range, 60–81 years;  $P=.15$ ) and sex (male: 84.0% vs 70.5%;  $P=.235$ ). Daily maximum temperature (median, 8.3°C; range, 5.1–13.1°C vs median, 13.2°C; range, –3.0 to 22.4°C;  $P=.24$ ), daily minimum temperature (median, 1.2°C; range, –3.0 to 3.7°C vs median, 2.2°C; range, –2.9 to 12.0°C;  $P=.12$ ), and daily temperature differences (median, 7.7°C; range, 5.9–11.5°C vs median, 8.3°C; range, 5.7–10.6°C;  $P=.89$ ) did not show significant differences between BRCA and non-BRCA groups. However, significant differences between

Table 1

### Clinical characteristics of patients (n=215).

Age, median (range), years	71 (20–101)
Male, % (n)	72.1 (155)
Shockable cardiac rhythm, % (n)	40.0 (86)
ROSC, % (n)	31.6 (68)
Overall death, % (n)	73.7 (160)
Proportion of BRCA patients, % (n)	11.6 (25)

BRCA = bath-related cardiac arrest, ROSC = return of spontaneous circulation.

**Table 2****Clinical characteristics of BRCA patients (n=25).**

Bystander CPR, % (n)	4.0 (1)
Found in washing area, % (n)	12.0 (3)
Found in dressing room, % (n)	4.0 (1)
Found in sauna, % (n)	4.0 (1)
Found in the bathtub, % (n)	80.0 (20)
Face submerged in the bathtub, n	64.0 (16)

BRCA = bath-related cardiac arrest, CPR = cardiopulmonary resuscitation.

BRCA and non-BRCA groups were apparent for initial shockable cardiac rhythm (4.0% vs 44.7%;  $P < .001$ ), ROSC (8.0% vs 34.7%;  $P = 0.01$ ), and overall mortality rate (96.0% vs 71.6%;  $P = 0.01$ ) (Table 3).

The results of Poisson regression analysis showed that daily minimum temperature was significantly associated with the occurrence of BRCA after adjusting for age and temperature differences (risk ratio, 0.937; confidence interval: 0.882–0.995), meaning that BRCA occurrence increases 1.07 times with every 1°C of temperature decrease (Table 4).

#### 4. Discussion

This is the first cohort study to investigate the impact of temperature on the occurrence of BRCA, revealing that daily minimum air temperature is a potential risk factor of BRCA occurrence. The impact of daily minimum temperature on BRCA occurrence may be related to temperature differences between outside and inside the bathroom. A recent study indicated that the temperature difference between outside and bathwater may affect cardiovascular hypotensive reactions leading to syncope,<sup>[10]</sup> which can result in unintended submersion, mainly when syncope occurs while still inside the bathtub. In addition, East-Asian individuals tend to take hotter baths and stay in the bath relatively longer in winter than in summer,<sup>[13]</sup> increasing the likelihood of heat-shock, which often leads to syncope.<sup>[14]</sup>

The prognosis of BRCA patients was significantly unfavorable. This may be related to the clinical condition of BRCA patients, such as whether the initial rhythm was shockable and the patients' cardiac arrest was witnessed. A previous study noted that only a few cases of witnessed BRCA had been reported, with the vast majority of BRCA occurring unwitnessed.<sup>[10]</sup> Bathroom areas, including the washing area and dressing room, are typically isolated from the sight of others, so OHCA occurring in a bathroom area may be less likely to be witnessed compared with OHCA in non-bathroom areas.<sup>[10,15–19]</sup> Considering the ex-

**Table 4****A multiple regression for variables predicting BRCA incidents (Poisson regression analysis).**

Variable	RR	95% confidence interval
Daily min. temperature	0.937	0.882–0.995
Age	1.014	0.985–1.044
Temperature difference	1.077	0.975–1.190

BRCA = bath-related cardiac arrest, min. = minimum, RR = risk ratio.

remely poor prognosis of the BRCA patients, the prevention of its occurrence is the most important to improve the morbidity of the patients.

Several preventive measures have been recommended to reduce the occurrence and mortality rate of BRCA. First, we believe that BRCA tends to occur behind a closed door, representing one of the most potent forces driving mortality, and the lack of a witness when BRCA occurs means a delay in saving the patient. Recent efforts such as bathtub systems that monitor breathing, heart rate, and movement in the bathing individual and automatically send a notification to other family members or a security company may contribute to more timely discovery of BRCA.<sup>[20]</sup> Second, we mentioned that daily minimum temperature might change bathing behaviors, as bathers tend to increase the water temperature and bathe for a longer duration on cold days, representing potential risk factors for heatstroke and syncope. To prevent this, extra caution may be necessary on cold days, such as reducing bath temperature and shortening bathing duration.<sup>[19]</sup> Moreover, sustaining a warmer room temperature in bath-related areas (especially in the dressing room) on cold days can be recommended to prevent sudden changes in body temperature that may result in syncope and BRCA.

Several limitations to this study should be considered. First, this was a retrospective study at a single center and this might give rise to selection bias. However, it is certain that all the BRCA cases in this area have been transported to our center; thus the selection bias does not influence the occurrence of the BRCA in this area. Second, since BRCA has previously been mainly reported from East-Asian countries, the generalizability of our findings to Western countries remains unclear. However, in this era of globalization, many immigrants from East-Asian countries have moved to Western countries. Many aspects of their traditional culture are often retained in the new countries of residence, so our findings may provide useful insights for resuscitation research worldwide.<sup>[21,22]</sup> Third, only 2 variables were examined as the predictors of the BRCA in our regression

**Table 3****Comparison of patients with BRCA and non-BRCA groups.**

	BRCA n=25	Non-BRCA n=190	P
Male, n (%)	21 (84.0)	134 (70.5)	.24
Age, median (range), years	75 (69–80)	69 (60–81)	.15
Daily max. temperature, median (range), °C	8.30 (5.1–13.1)	13.2 (3.0–22.4)	.24
Daily min. temperature, median (range), °C	1.2 (–3.0 to 3.7)	2.15 (–2.9 to 12.0)	.12
Temperature difference, median (range), °C	7.7 (5.9–11.5)	8.30 (5.7–10.6)	.89
Shockable cardiac rhythm, n (%)	1 (4.0)	85 (44.7)	<.01
ROSC, n (%)	2 (8.0)	66 (34.7)	.01
Overall mortality, n (%)	24 (96.0)	136 (71.6)	.01

BRCA = bath-related cardiac arrest, ROSC = return of spontaneous circulation.

analysis due to the small sample size and the number of the BRCA patients. A multicenter study with larger sample size is needed to address these limitations.

## 5. Conclusions

One possible risk factor for BRCA occurrence was daily minimum temperature. A more advanced study is warranted due to the small sample size and lack of patient information.

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