GLOBAL HEART

Association of Outdoor Relative Humidity and Temperature on In-Hospital Cardiac Arrest Prognosis

RESEARCH LETTER

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Environmental risk factors are a public health concern, and the literature on the health effects of climate variations is growing [1]. Climate factors such as air temperature (T; °C) and relative humidity (RH; %) have been linked to cardiovascular conditions such as myocardial infarction [2], sudden death [3], and cardiovascular mortality [4, 5]. Cardiovascular conditions are the most often cause of cardiac arrest (CA) [6], so climate factors could also influence CA outcomes. Emerging evidence demonstrates the association between climate conditions and out-of-hospital cardiac arrest [7, 8]. These results may be due to the interference of climate variability on outcomes affected by stress on the cardiovascular system by increased blood pressure, heart rate, increased blood viscosity, coagulability, and decreased systemic perfusion [9].

However, the relationship between climate influence and in-hospital cardiac arrest (IHCA) has not yet been evaluated. Thus, this study aimed to evaluate the association between outdoor air temperature, relative humidity, and IHCA outcomes.

This study was a subanalysis of an unpublished retrospective cohort that evaluated the risk factors of IHCA and was approved by the ethics committee of the Botucatu Medical School (56979721.9.0000.5411). The inclusion criteria were patients over 18 years old with IHCA, attended by the Rapid Response Team (RRT) in Botucatu Medical School University Hospital wards from May 2018 to December 2021. Exclusion criteria were the presence of do-not-resuscitate orders or recurrent IHCA. Demographic, laboratory, and clinical information were collected from the registry for electronic medical records. After that, data were complemented with air temperature (T; °C) and relative humidity (RH; %) on the day of diagnosis. Hospital wards were not climatized. Those data were collected in a nearby meteorology station (Faculty of Agronomical Sciences – Unesp, São Paulo State University, Botucatu, Brazil).

The RRT is a team triggered to the bedside to evaluate patients with signs of clinical deterioration, including CA, in our hospital. The outcomes of no-return of spontaneous circulation (no-ROSC) and in-hospital mortality were evaluated. We defined no-ROSC as the absence of ROSC or ROSC for less than 20 minutes. The statistical analyses were performed with SigmaPlot software for

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Table 1 Baseline characteristics, laboratory and climatic data of 382 patients with in-hospital cardiac arrest according to return of spontaneous circulation (ROSC) and mortality. Data are expressed as the mean ± SD, median (25–75%) or percentage. CPR = cardiopulmonary resuscitation; ROSC = return of spontaneous circulation; RH = relative humidity.

VARIABLE	ROSC		*P* VALUE	MORTALITY		*P* VALUE
	Yes (165)	No (217)		Yes (365)	No (22)	
Age (years)	65.0 (55.0–73.0)	69.0 (58.0–78.0)	0.007	67.0 (57.0–77.0)	53.0 (43.5–68.5)	<0.001
Male gender, n (%)	86 (52.1)	120 (55.3)	0.607	167 (45.8)	12 (54.5)	0.560
Initial rhythm, n (%)						
Shockable	18 (10.9)	16 (7.4)	0.307	32 (8.8)	2 (9.1)	0.737
Non-shockable	147 (89.1)	201 (92.6)		333 (91.2)	20 (90.9)	
Duration of CPR (min)	14.0 (7.0–20.0)	30.0 (20.0–35.0)	< 0.001	24.0 (15.0–32.0)	6.0 (2.0–12.5)	<0.001
Medical history, n (%)						
Arterial hypertension	100 (60.6)	143 (65.9)	0.338	238 (65.2)	8 (36.4)	0.012
Diabetes	109 (66.1)	138 (63.6)	0.695	132 (36.2)	5 (22.7)	0.294
Epinephrine, n (%)	161 (97.6)	216 (99.5)	0.223	362 (99.2)	20 (90.9)	0.018
Amiodarone, n (%)	146 (88.5)	199 (91.7)	0.379	35 (9.6)	2 (9.1)	0.767
Minimum Temperature (°C)	17.0 (14.5–19.0)	16.7 (14.2–19.0)	0.948	16.8 (14.3–19.0)	16.4 (14.8–18.8)	0.999
Medium Temperature (°C)	21.1 (18.6–23.4)	20.8 (18.9–23.1)	0.683	20.9 (18.9–23.1)	21.6 (18.8–23.5)	0.771
Maximum Temperature (°C)	26.7 (23.4–29.7)	26.6 (23.9–29.3)	0.850	26.6 (23.9–29.4)	27.5 (23.3–30.7)	0.501
Minimun RH (g/kg)	41.8 (32.6–54.7)	43.3 (35.0–57.9)	0.189	42.9 (34.7–57.4)	42.2 (31.3–53.9)	0.456
Medium RH (g/kg)	66.4 (54.9–76.4)	68.2 (60.2–78.5)	0.067	67.3 (56.8–77.9)	69.3 (55.8–76.2)	0.638
Maximum RH (g/kg)	85.1 (77.7–91.5)	87.2 (80.5–92.7)	0.055	86.2 (79.1–92.0)	88.5 (80.3–92.5)	0.417
Hemoglobin (g/dL)	12.0 (± 2.5)	11.8 (± 2.5)	0.552	11.9 (± 2.6)	12.2 (± 1.9)	0.580
Hematocrit (%)	36.5 (± 7.4)	36.2 (± 7.4)	0.727	36.3 (± 7.5)	36.9 (± 5.2)	0.713
Urea (mg/dL)	55.0 (36.0–95.0)	58.5 (36.5–98.0)	0.231	57.0 (38.0–96.8)	27.5 (22.3–51.3)	<0.001
Creatinine (mg/dL)	1.0 (0.7–1.7)	1.1 (0.7–2.0)	0.426	1.1 (0.8–1.9)	0.7 (0.6–1.3)	0.005
Sodium (mmol/L)	136 (131–139)	136 (133–139)	0.162	136 (133–139)	135 (131–137)	0.136
Potassium (mmol/L)	4.3 (3.9–4.9)	4.4 (3.9–4.9)	0.662	4.3 (3.9–4.9)	4.3 (4.0–4.9)	0.947

Windows v12.0 (Systat Software Inc., San Jose, CA, USA). Data are expressed as the percentage, mean ± standard deviation, and medians with 25th and 75th percentiles. Comparisons between two groups for continuous variables were performed using Student's t-test or the Mann–Whitney test. Comparisons between two groups for categorical variables were made using the c2 or Fisher's exact test. We constructed the multivariable logistic regression model for no-ROSC and the penalized likelihood with Firth logistic regression method for in-hospital mortality (due to the higher mortality rate in our sample). For both outcomes, the climate variables were adjusted by clinically relevant variables defined by the literature (epinephrine administration, initial shockable rhythm, time of CPR, gender, and age) or by variables that exhibited significant differences in the univariate analysis. The significance level was 5%.

In total, 407 patients were evaluated. However, 25 patients were excluded, 17 with do-not-resuscitate orders and 8 with recurrent IHCA. The mean age was 65.4 ± 14.8 years, 53.9% were male, and 91.1% of initial cardiac arrest rhythms were non-shockable. The no-ROSC rate was 56.8%, and in-hospital mortality was 94.2%. According to ROSC, the demographic, clinical, laboratory, and climate data are shown in Table 1. In this analysis, the only statistical factors related to ROSC were age and cardiopulmonary resuscitation (CPR) duration. However, in the multivariable logistic regression, the medium relative humidity (RH) was associated with no-ROSC when adjusted by age, gender, initial shockable rhythm, duration of CPR, and epinephrine administration [Odds ratio (OR) = 1.020; CI 95% = 1.003–1.038; p = 0.023], for each increase of 1g/kg of medium RH, there is an increase of 2% in the chance of no-ROSC. Also, the maximum RH was associated with no-ROSC when adjusted by the same factors [OR = 1.023; CI 95% = 1.003–1.044; p = 0.025]; for each increase of 1g/kg of maximum RH, there is an increase of 2.3% in the chance of no-ROSC. The other climatic parameters were not associated with no-ROSC. In multivariable logistic regression, there was no association between RH or temperature and in-hospital mortality. In addition, we performed a sensitivity analysis excluding patients admitted from March 2020 onwards to evaluate the possible impact of the COVID-19 pandemic on changes in local air pollution levels. Only 180 patients were included in this analysis, and we adjusted the models for the same factors. The association we observed with RH and no-ROSC with all the cohorts was lost with these 180 patients. For the association between medium RH and no-ROSC [OR = 1.014; CI 95% = 0.988–1.042; p = 0.294], and for maximum RH and no-ROSC [OR = 1.031; CI 95% = 0.995–1.068; p = 0.094]. This fact could be due to a reduction in the sample size.

Regarding the changes in the environment, the effects of extreme weather on human health have been studied in recent years. The temperature-mortality curves were generally U-shaped, with higher risks in extreme temperatures [4]. The temperature could modulate blood pressure, heart rate, blood viscosity, coagulability, and systemic perfusion [9]. The effects of RH are less clear. However, some studies suggest that high RH could reduce the body´s efficiency at transporting away metabolic heat, while low humidity could lead to dehydration [4]. Thus, our study highlights the importance of humidity in IHCA prognosis. We should consider some limitations of our study, such as the retrospective design and the use of RH instead of absolute humidity, which is a better indicator of indoor humidity [10]. In conclusion, there is an association between RH and ROSC, but not mortality after IHCA.

ETHICS AND CONSENT

This study was a subanalysis of an unpublished retrospective cohort that evaluated the risk factors of IHCA and was approved by the ethics committee of the Botucatu Medical School (56979721.9.0000.5411).

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Taline Lazzarin: conception, design, analysis, and interpretation of data, drafting the article. Edson Luiz Fávero Junior: conception, design, acquisition of data, drafting the article. Caroline Casagrande Delai, Victor Rocha Pinheiro, Raquel Simões Ballarin, Felipe Antonio Rischini, Bertha Furlan Polegato, Paula Schmidt Azevedo, Antônio Ribeiro da Cunha and Adriana Polachini do Valle: acquisition of data, drafting the article. Sergio Alberto Rupp de Paiva: analysis and interpretation of data, revising the article critically for important intellectual content. Leonardo Zornoff: analysis and interpretation of data, revising it critically for important intellectual content. Marcos Ferreira Minicucci: conception, design, analysis and interpretation of data and revising it critically for important intellectual content. All authors made the final approval of the version to be submitted and agree to be accountable for all aspects of the work.

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