Am J Cardiovasc Dis 2021;11(1):148-154
www.AJCD.us /ISSN:2160-200X/AJCD0129161

Original Article

Effect of seasonality in hospitalizations and deaths from acute myocardial infarction in southern Brazil from 2009 to 2018

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Received December 28, 2020; Accepted February 1, 2021; Epub February 15, 2021; Published February 28, 2021

Abstract: Introduction: Acute myocardial infarction (AMI) is one of the main causes of morbidity and mortality in Brazil and worldwide. Seasonality and climate change seem to be associated with hospitalization for AMI. Objective: to analyze the effect that seasonality and temperature have on the number of hospitalizations and deaths due to AMI, stratified by gender and age group, from 2009 to 2018 in a region of southern Brazil. Methods: An Ecological study, composed of cases of hospitalizations and deaths by AMI in the Association of Municipalities of the Laguna Region (AMUREL), SC, Brazil. Data on AMI were collected by the Department of Informatics of the Unified Health System (DATASUS) and data on average monthly temperature (degrees Celsius) of the Laguna region (SC, Brazil) were provided by the National Institute of Meteorology (INMET). The data analysis was performed through linear regression and ANOVA test with Tukey post-hoc. Results: 2947 hospitalizations were analyzed. The monthly average hospitalization per AMI was 24.6±8.1 cases (7.0±2.2/100,000 inhabitants) with a lethality of 14.4±6.8%. The results showed that there is no difference in AMI hospitalization between the months of the year, but showed a significant negative correlation between temperature and AMI hospitalizations (r=-0.219; P=0.022; β=-0.165). It was also shown that men and elderly had more cases of AMI hospitalization, but women and elderly had more lethality. When the lethality rate was analyzed during the study period, there was a significant negative correlation, indicating the reduction of AMI deaths with time. Conclusion: There was an association between temperature reduction and AMI hospitalization, where each 6°C reduction in temperature was related to an increase of 1 hospitalization per AMI/100,000 inhabitants. It is hoped that the results may assist in the formulation of public environmental policies for the prevention of risk factors for AMI.

Keywords: Seasons, hospitalization, mortality, myocardial infarction

Introduction

Cardiovascular diseases (CVD) are among the main causes of morbidity and mortality in Brazil and worldwide. At the beginning of this decade, CVD was responsible for just over 30% of all deaths, and of these, 31% were from coronary artery disease (CAD) [1, 2]. CAD's are a physiological disorder in which there is an insufficiency in blood and oxygen demand to the heart. Its most important manifestation is acute myocardial infarction (AMI), which leads to partial or total occlusion of a coronary vessel [3].

Studies show that there is a fundamental participation of the environment in relation to the health of the human body. In this sense, CAD's can be triggered and even aggravated by extreme temperatures, both high and low. The change in air temperature affects body homeostasis and enables the emergence of CVDs [4-7].

Between seasons, winter makes the physiological response of the human body is vasoconstriction, a contraction of the caliber of the arteries so that the body dissipates less heat to the environment. The vasoconstriction decreases the peripheral blood circulation, with consequent reduction of oxygen supply and increase in blood pressure. Furthermore, the fatty plaques and clots present in the blood are easier to occlude the arteries, which increases the risk of AMI [8-10].

Exposure to heat and heat waves are also associated with increased hospitalizations and deaths due to AMI, due to a still undefined mechanism. Perhaps due to hypotension resulting from vasodilatation and/or hypovolemia caused by dehydration. This association is most frequently found in the elderly, but an increase in the incidence of AMI deaths at all ages is observed due to the gradual increase in temperature in recent years [11].

There are few studies on the effect that temperature and seasonality have on hospitalization and mortality due to AMI in Brazil. Due to the geographic location of southern Brazil, there is a predominance of the subtropical climate, with well-defined seasons [12, 13]. Therefore, the objective of this study was to analyze the effect that seasonality and temperature have on the number of hospitalizations and deaths due to AMI, stratified by gender and age group, from 2009 to 2018 in a region of southern Brazil.

Methods

A time-series ecological study was conducted, composed of cases of hospitalizations and deaths by AMI in the Association of Municipalities of the Laguna Region (AMUREL), composed of 18 municipalities and approximately 400,000 inhabitants. It is located at 28°28' south latitude and 48°46' west longitude, being at an average altitude of 15 meters, between the coastal region and the southern highlands of the state of Santa Catarina, Brazil. This region has a subtropical climate, characterized as mesothermic, where there is a great thermal amplitude and well demarcated seasons of the year [12, 13].

Inclusion criteria

Data on hospitalization and lethality by AMI in the AMUREL region (SC, Brazil) registered in the Department of Informatics of the Unified Health System (DATASUS) (http://www2.datasus.gov.br/DATASUS/index.php?a-rea=0205) in Brazil were included. The period analyzed included the dates between January 2009 and December 2018.

Exclusion criteria

Missing or incomplete data in the database.

Variables

The dependent variables were: Absolute frequency of AMI hospitalizations by gender and age group. Relative frequency of AMI by sex and age group. The denominator is 100,000 inhabitants, based on the population in effect each year, according to information from the Brazilian Institute of Geography and Statistics (IBGE) (https://www.ibge.gov.br/). Lethality, defined by the ratio between the total number of deaths and the number of hospitalizations.

The independent variables were: Time in months, characterized in an isolated and aggregate way. Average monthly air temperature, in degrees Celsius (°C), given by the National Institute of Meteorology (INMET) (https://portal.inmet.gov.br/). The measurements were collected at the weather station located in the city of Laguna (SC, Brazil).

Ethical statement

As this was an ecological study, based on secondary data in the public domain, without the identification of the participants and that used population aggregates as a unit of analysis, it was not necessary to submit and review the project by an ethics committee, in accordance with the terms of National Health Council Resolution 510/2016 Article 1, Single Paragraph items II, III and V.

Data analysis

The data were organized in Microsoft Excel and analyzed in SPSS 20.0 software. The quantitative variables were described through measures of central tendency and dispersion. The qualitative variables were described through absolute frequency and percentage. For seasonal variation comparison, the monthly data of mean temperature, hospitalization, hospitalization rate per 100,000 inhabitants and lethality were analyzed by the ANOVA test with Tukey post-hoc. For comparison of time (in months) and mean temperature (°C) with the hospitalization rate and lethality by gender and age group, linear regression was performed. This analysis was described by Pearson's correlation coefficient (r) and angular coefficient (β). The level of statistical significance adopted was 5% ($P < 0.05$).

Table 1. Analysis of temperature, hospitalization, hospitalization rate per 100,000 inhabitants and number of deaths per AMI, for the months in the AMUREL region between 2009-2018

	Temperature (°C) (Mean ± SD)	AMI Hospitalization (Mean ± SD)	AMI Hospitalization/100,000 Inhab. (Mean ± SD)	AMI Lethality (%) (Mean ± SD)
January	23,6±1,4	22,0±7,2	6,3±2,0	15,1±7,6
February	23,6±0,9	23,5±6,7	6,7±1,8	14,2±6,6
March	22,9±0,7#	25,5±8,0	7,3±2,2	12,4±5,2
April	21,4±0,7#	21,6±7,2	6,1±1,9	11,4±6,8
May	18,7±1,0#	24,7±6,5	7,0±1,7	15,3±9,6
June	16,1±1,4#	26,5±10,7	7,5±2,9	13,9±5,2
July	15,4±1,0#	28,2±7,1	8,0±1,8	16,7±7,7
August	16,5±1,3#	24,8±8,2	7,1±2,2	15,4±8,1
September	17,4±0,8#	24,6±8,6	7,0±2,4	14,3±5,0
October	18,6±0,6#	25,6±10,5	7,3±3,0	17,9±7,2
November	20,4±0,7#	24,9±8,6	7,1±2,6	13,5±5,8
December	22,3±0,6	22,8±8,7	6,5±2,5	13,0±6,9
p	< 0,001*	0,890	0,872	0,792
TOTAL	19,9±3,0	24,6±8,1	7,0±2,2	14,4±6,8

#Statistically significant difference in relation to January. SD: Standard deviation. AMI: Acute myocardial infarction. *P < 0,05.

Table 2. Hospitalization, hospitalization rate per 100,000 inhabitants, and deaths per AMI in gender, and per age group between 2009 and 2018

	Gender			Age group		
	Male	Female	P	40-59 years	> 60 years	P
AMI Hospitalization	15,7±6,0	8,9±3,6	< 0,001*	10,0±3,9	14,6±5,6	< 0,001*
AMI Hospitalization/100,000 inhabitants	9,2±3,5	5,1±2,0	< 0,001*	11,0±4,3	34,1±12,8	< 0,001*
Lethality (%)	14,6±7,0	22,7±13,9	0,002*	34,8±22,2	44,7±20,3	< 0,001*

AMI: Acute myocardial infarction. *P < 0,05.

Results

Seasonal variations of temperature, hospitalizations and deaths per AMI

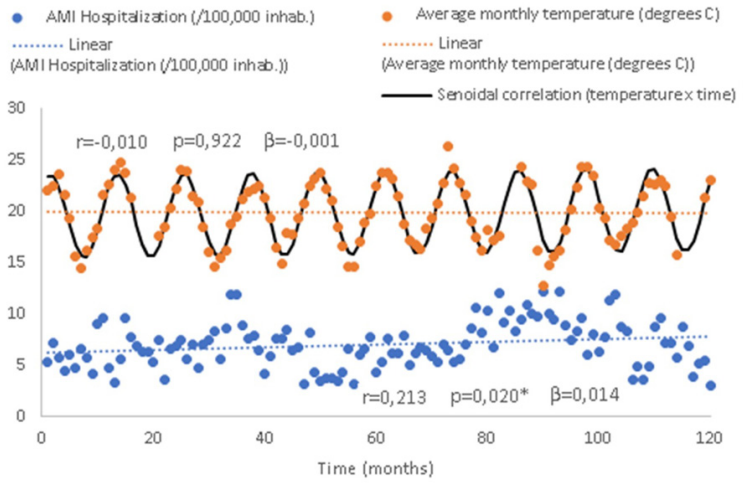
Between 2009 and 2018, 2,947 AMI hospitalizations in the AMUREL region (SC, Brazil) were analyzed during the 120 months. Of these, 402 died. The average hospitalization per AMI was 24.6±8.1 cases (7.0±2.2/100,000 inhabitants) with a lethality rate of 14.4±6.8%. The highest and lowest mean monthly temperature values were 23.6°C and 15.4°C, found in January/February and July, respectively. When analyzing seasonality, compared to the months of the years, it can be observed that temperature showed statistical difference, while no statistical difference was observed in AMI hospitalizations, rate of hospitalization per inhabitant and lethality (**Table 1**).

Hospitalization and deaths per AMI in gender and per age group

Regarding hospitalization and deaths by AMI by gender, it was noted that there is a higher hospitalization and hospitalization rate in males; however, when it comes to lethality, females have a higher rate. By age group, both showed statistical differences, with those over 60 years of age showing higher hospitalization, hospitalization rate, and lethality, as shown in **Table 2**.

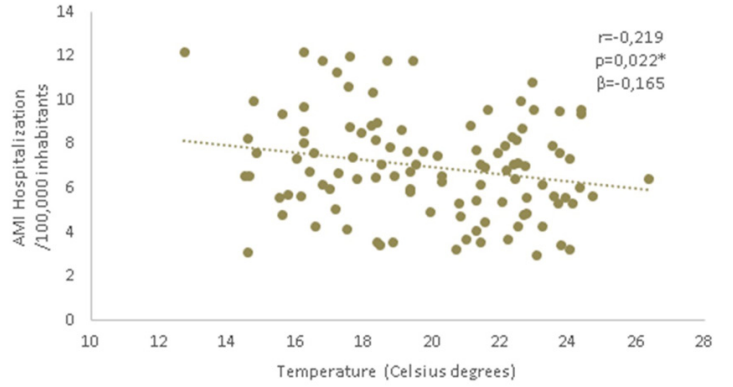
Time series of AMI hospitalizations and temperature

In the time series analysis, a significant positive correlation was observed with AMI hospitalization, indicating an increase in the number of cases, specifically in males and females, and in persons over 60 years of age. In this temporal



	AMI Hospitalization (/100,000 inhabitants)			
	Male	Female	40-59 anos	>60 anos
Time (meses)	r=0,181 p=0,047* β=0,018	r=0,258 p=0,004* β=0,015	r=0,029 p=0,757 β=0,003	r=0,333 p<0,001* β=0,123

Figure 1. Sinusoidal correlation between temperature and time and linear correlation between hospitalizations and time per AMI. AMI: Acute myocardial infarction. *P < 0,05.



	AMI Hospitalization (/100,000 inhabitants)			
	Male	Female	40-59 years	>60 years
Temperature (ºC)	r=-0,234 p=0,015* β=-0,269	r=-0,102 p=0,293 β=-0,071	r=-153 p=0,112 β=-0,217	r=-0,214 p=0,025* β=-0,898

Figure 2. Correlation between AMI hospitalizations and temperature with classification by gender and age group. AMI: Acute myocardial infarction. *P < 0,05.

evaluation, one can also observe the periodic pattern of temperature, according to **Figure 1**.

Correlation between AMI hospitalizations and temperature

By correlating AMI hospitalizations and mean monthly temperature, it was possible to observe a significant negative correlation, i.e., the lower the temperature, the higher the number of AMI hospitalizations. Added to this, it was observed an association between males with higher hospitalizations at lower temperatures, as well as for people over 60 years old, according to **Figure 2**.

Correlation of AMI lethality with time and temperature

In the case of AMI lethality, there was a significant negative correlation, indicating a reduction over time, however, only in males and those over 60 years. Based on temperature, there was not even an evident statistical correlation, according to **Table 3**.

Discussion

The results of this study showed that, despite the variation in temperature over the months, the effect of monthly seasonality did not cause changes in hospitalizations and lethality by AMI in the region assessed. Only an association between temperature reduction and increased hospitalizations was demonstrated. This finding is also found in other studies [3, 5, 6, 12, 14-17].

In the present study, a higher hospitalization due to AMI was observed in men, with higher lethality in women. This finding is corroborated by other studies [16, 18], which point out differences between genders in the vascular structure and progression of atherosclerotic disease. While in men the coronary artery disease is more localized and progresses more rapidly, in women the coronary atheroma plaques are more diffuse and progress slowly. This causes a later hospitalization in women, however more severe. This finding can also be explained by the difference

Table 3. Analysis of total AMI lethality and its correlation with time and temperature, with classification by gender and age group

	AMI Lethality (%)				
	Total	Male	Female	40-59 anos	> 60 anos
Time (months)	r=-0,253	r=-0,243	r=-0,169	r=-0,009	r=-0,238
	P=0,006*	P=0,015*	P=0,107	P=0,945	P=0,012*
	β=-0,050	β=-0,049	β=-0,066	β=-0,006	β=-0,139
Temperature (°C)	r=-0,031	r=-0,024	r=-0,032	r=0,165	r=0,130
	P=0,757	P=0,825	P=0,775	P=0,228	P=0,199
	β=-0,064	β=-0,050	β=-0,140	β=1,195	β=0,855

AMI: Acute myocardial infarction. *P < 0,05.

in the hemodynamic pattern of left ventricular failure between the sexes. In this situation, women have more left ventricular diastolic dysfunction than men in the course of AMI, which may contribute to higher mortality [3, 18].

Regarding the analysis of the age groups of the present study, the patients above 60 years old have a higher rate of hospitalization and lethality compared to those below 59 years old. In the study by Honda et al [8], published in 2015, it was also shown that mortality is higher in the elderly compared to the younger. Bathia et al [19] in their study, which also presented this same finding, explains that the elderly already have numerous coexisting disorders: ischemic heart disease, hypertension, diabetes, chronic obstructive pulmonary disease, chronic renal failure, as well as bone and joint disorders. And, due to the overlapping of comorbidities, a non-specific clinical presentation of AMI may occur. Gulati et al [20] commented that the most common etiology of AMI in young individuals is a rupture of atherosclerotic plaque, present in approximately 90% of patients, and should be suspected in those who smoke or have dyslipidemia, diabetes or high blood pressure. It is also important to review the history of recreational drugs, as they cause coronary vasospasm and thus point to the diagnosis of AMI when typical symptoms are present [20].

About the average monthly temperature, the present study presented a sinusoidal correlation corresponding to the months under study, indicating the influence of the subtropical climate in the region [12, 13], without a significant increase in the average monthly temperature over the months in these 10 years of the study.

About the AMI hospitalizations in AMUREL region (SC, Brazil), there was an increase in the study period in both genders, with a greater increase in females. In relation to the age group, only those above 60 years old had a significant correlation, and these presented an increase in the number of cases, which corroborates the study by Ribeiro et al [1], who stated in his study the increase in hospitalizations from 2007 to 2012 for AMI in Brazil. As already mentioned by the analysis of Bathia et al [19], the elderly are more likely to have CVD or preexisting diseases.

According to Bai et al [15], a study conducted in the State of Ontario in Canada, short-term exposure to cold temperatures significantly increases the daily rates of AMI hospitalizations. This finding reinforces the present study, which found the higher rate of hospitalizations when the temperature is lower, and also directly related to the higher incidence only in men and more in those over 60 years. Several studies have similar results [3, 5, 7, 8, 17]. According to the beta coefficient in this study, approximately every 6°C reduction in temperature, there is an increase of 1 hospitalization per 100,000 inhabitants. Differently, studies present this relation to the highest and lowest average temperature in AMI hospitalizations, i.e., in heat waves and exposure to cold [4, 6, 14, 17]. Ledo et al [3] report that the elderly suffer from electrolyte homeostasis and physiological changes in renal function in a very hot climate, and have a reduction in skin thermal sensitivity and decreased skin vasoconstriction, which leads to a weaker thermoregulation system and more stress due to cold.

Finally, the lethality of the cases was analyzed and we observed a decrease in the total num-

bers, in men, and those above 60 years during the years under study, but without correlation with mean temperature in any variable. A progressive increase of AMI mortality with age, and also a reduction in mortality rates by Brazil, in both genders, would probably be explained by early diagnosis, quality of pre-hospital care, care protocols, availability of intensive care beds and specialized health team for AMI treatment [21].

In relation to the limitations of this study, because it has an ecological design and encompasses data conglomerates, individual data cannot be inferred. Also, by collecting secondary data from DATASUS and INMET, they may be underestimated, undernotified or incorrect.

Conclusion

The present study showed that hospitalizations due to AMI in the AMUREL region (SC, Brazil) are predominantly in the elderly and in men, and the deaths affect more women and individuals over 60 years.

Over the years it was observed the increase of hospitalizations in both sexes and in the age groups above 60 years, as well as the increasing hospitalization the lower the temperature in men and in the elderly, with reduction of lethality over the years.

In view of the association between temperature and AMI, this is considered a risk factor for AMI and its complications.

It is therefore preferable to have public policies and the urgency to intensify efforts to improve living conditions, prevention and control of risk factors for AMI, as well as access to health services, from primary to tertiary care, so that not only does the population have a quality curative medicine, but also a preventive medicine capable of altering the morbidity and mortality of this pathology, including the associated mechanisms and risk factors.

Disclosure of conflict of interest

None.

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