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ORIGINAL ARTICLE

Cardiovascular Diseases Mortality Rates in Nine Cities of Rio Grande do Sul from 2009 to 2019: Temporal Trends and Demographic Differences

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Abstract

Background: Cardiovascular diseases (CVD) are the leading cause of morbidity and mortality statistics in Brazil and worldwide. The evaluation of the temporal and spatial distribution of mortality due to CVD is essential to support actions aimed at monitoring the implementation of health policies.

Objectives: To analyze the temporal trend of mortality due to CVD from 2009 to 2019, as well as the main causes of death according to gender and age group in nine cities of Rio Grande do Sul (RS).

Methods: This is an ecological study based on data from the Mortality Information System. The rates were stratified according to gender, age group and cause, which were composed of ischemic heart diseases (IHD), cerebrovascular diseases and hypertensive diseases (HD). Prais-Winsten regression was used for time trend estimates.

Results: Three out of the nine cities analyzed showed a significant reduction in the overall mortality rates due to CVD in the timeframe evaluated ($p<0.05$). When the cause of death was analyzed, there was a decreasing trend in mortality due to IHD in Caxias do Sul, Ijuí and Porto Alegre. In these cities and also in Passo Fundo and Uruguaiana, there was a decrease in mortality due to cerebrovascular diseases. The cities of Ijuí, Porto Alegre and Santa Maria recorded an increase in hypertensive disease mortality rates. In most cities, there was an increase in rates related to greater age and male sex.

Conclusion: Heterogeneity was observed in the trend of mortality due to CVD throughout the historical series, which may be related to the execution of public policies and the control of cardiovascular risk factors in the evaluated territories.

Keywords: Cardiovascular Diseases; Mortality; Noncommunicable Diseases; Health Information Systems.

Introduction

Cardiovascular diseases (CVD) are the leading cause of morbidity and mortality in Brazil and worldwide,[1] accounting for 28% of all deaths that occurred nationwide in 2016.[2] The high mortality rates due to CVD place Brazil among the ten countries in the world with the highest cardiovascular death rate.[3] This position in the global ranking can be attributed to the high accumulation of cardiovascular risk factors.[4] According to the Framingham Heart Study, more than half of CVD mortality is associated with modifiable risk factors including hypercholesterolemia, diabetes, systemic arterial hypertension, obesity and smoking.[5] On the other hand, non-modifiable factors such as male gender and advanced age are also associated with the occurrence of cardiovascular outcomes.[6-8]

In Rio Grande do Sul (RS), mortality due to CVD represented 31% of all deaths that occurred between 1998 and 2012.[9] Thus, the study of this population, through the analysis of sentinel cities, these being reference health centers for the state regions, is relevant considering that cardiovascular mortality is associated with several factors, and its distribution can be differentiated according to the context in which

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the population groups are inserted.[10] Still, few studies addressed the spatial and temporal distribution of these rates in the state territory over time, although more than 1/3 of the deaths in the state are due these pathologies.[4]

The knowledge about the health status of a population, based on mortality statistics, is an efficient tool to assess the quality of health care and can serve as a basis for the construction of metrics used in the execution of actions for public health policies' promotion, evaluation, and planning.[11]

Thus, this study aimed to analyze the temporal trend of mortality due to CVD and its main causes of death, according to gender and age group, in nine cities in the state of RS, from 2009 to 2019.

Methods

This is a time-series ecological study on the mortality trend from diseases of the circulatory system, defined by the International Classification of Diseases, 10th Revision (ICD-10) as chapter IX and codes I00 to I99, in the period from 2009 to 2019 in nine cities in the state of RS. In addition to the analysis of general CVD, the data were categorized according to ICD 10 groups into ischemic heart diseases (IHD) (I20-I25), cerebrovascular diseases (I60-I69) and hipertensive disorders (HD) (I10-I15).

The units of analysis were composed of a total of nine cities: Porto Alegre, Pelotas, Santa Maria, Uruguaiana, Ijuí, Passo Fundo, Caxias do Sul, Santa Cruz do Sul and Canoas, which represent about 1/3 (31%) of the entire population of the state, among which, eight cities are the headquarters of the intermediate subregions of RS according to the Brazilian Institute of Geography and Statistics (IBGE),[12] and the ninth, respectively, is the largest city in the metropolitan area of Porto Alegre, after the capital.

For data collection, carried out between November 2020 and May 2021, the following variables were used: gender (male/female), age group (20 to 39 years, 40 to 59 years, 60 to 69 years, 70 to 79 years and 80 years or more), the underlying cause of death (diseases of the circulatory system, IHD, cerebrovascular diseases and HD and place of residence (nine cities in the RS).

Data on deaths, by place of residence, were extracted from the Mortality Information System (SIM) from the TabNet aggregated database, available at the Interface of the Unified Health System Department of Informatics (DATASUS) <https://datasus.saude.gov.br/>. Demographic statistics on the resident population of the cities were obtained from the estimates of IBGE. Data were collected to estimate the gross and standardized annual rates according to the age distribution of the cities.

Based on the extracted data (number of absolute deaths and population residing in the period) mortality rates were calculated. The calculation of the rates was performed using the following indicator: [number of deaths (by general diseases of the circulatory system and by specific cause), in a given place and period/total population of the same place and period]. All fees were expressed by the unit of 100,000 inhabitants. Mortality rates were also calculated according to gender and age being used in the denominator of the calculations, population estimates for gender and age groups in each year analyzed.

All exported data from SIM and IBGE were organized in spreadsheets and later exported to statistical software for cleaning and data analysis. For the temporal trend analysis, the Prais-Winsten generalized linear analysis model was used, in which the independent variables (X) were the years of the occurrence of deaths and mortality rates were considered dependent variables (Y). The Prais-Winsten model is indicated to correct serial autocorrelation in time series. To verify the existence of autocorrelation of the series, the Durbin-Watson test was applied. The trend of mortality coefficients was interpreted as increasing ($p<0.05$), decreasing ($p<0.05$) and stable ($p\geq0.05$), being considered a significance level of $p<0.05$. Finally, the variation in mortality rates due to CVD was performed by calculating the absolute and relative differences comparing the year 2019 to 2009. The level of significance adopted was $\alpha< 5\%$. All analyses were performed in the Stata Program version 12.0 (College Station, TX: StataCorp LLC), licensed under the 30120505989.

Due to the use of unrestricted public domain access data for the accomplishment of the study, it is exempted by the National Commission of Ethics in Research (CONEP) for analysis of the Research Ethics Committee / CONEP system, through CNS resolution No. 510/2016.

Results

From 2009 to 2019, a total of 282,589 deaths were observed considering the nine cities in Rio Grande do Sul, of which 74,910 (26.5%) were due to diseases of the circulatory system. When stratification of these deaths due to cause, it was found that in the period studied there were 26,430 (35.3%) deaths due to cerebrovascular diseases, 23,318 (31.1%) due to IHD, 7,625 (10.2%) due to HD, and 17,537 (23.4%) were due to other causes of diseases of the circulatory system.

General and stratified by gender and age mortality rates due to CVD are presented in Table 1. Throughout the time series, a statistically significant reduction in the rates of general CVD was observed in three cities: Canoas (p=0.038), Caxias do Sul (p=0.001) and Porto Alegre (p<0.001). When analyzing the overall mortality rates due to CVD by sex in females, there was a significant reduction in six cities: Caxias do Sul (p=0.02), Ijuí (p=0.038), Pelotas (p=0.031), Porto Alegre (p<0.001), Uruguaiana (p=0.005), Santa Maria (p=0.042). In Caxias do Sul (95% CI: -4.44; -0.49), Ijuí (95% CI: -6.21; -0.23), Pelotas (95% CI: -5.36; -0.32), Uruguaiana (95% CI: -5.6; -1.4) and Santa Maria (95% CI: -7.23; -0.16) a reduction of around 3 deaths/year was recorded, while in Porto Alegre (95% CI: -7.0; -3.73) a greater decrease was observed, around 5 deaths per 100,000 inhabitants per year. In males, there was significant variation in only two cities, and these Canoas (p=0.034; 95% CI: -6.54; -0.31), and Porto Alegre (p<0.001; 95% CI: -6.51; -3.31) with a reduction of approximately 4 deaths/year. Concerning age groups, there was an exponential increase in rates with advancing age, with the highest values in the age group of 80 years or more. The greatest increases were in males, who presented rates often higher than in women in any age group (Table 1).

Table 2 shows the rates for general IHD, by gender and age group. For the general rates, there was a statistically significant decrease in three cities: Caxias do Sul (p<0.001), Ijuí (p=0.025) and Porto Alegre (p<0.001). Between 2009 and 2019, there was a reduction of nearly 2 deaths/year per 100,000 inhabitants in Ijuí (95% CI: -4.6; -0.4) and Porto Alegre (95% CI: -3.75; -1.63), while in Caxias do Sul this reduction was less prominent, around 1 death/year (95% CI: -1.65; -0.69). The other cities analyzed showed stability in the overall mortality rates due to IHD throughout the time series. Among men, there was a decrease in rates only in Caxias do Sul and Porto Alegre, while in females this statistically significant reduction was observed in the cities of Caxias, Porto Alegre, Ijuí and Santa Maria. In the age groups, behavior similar to the CVD death rates were observed with a gradual increase in the number of deaths as age advances (Table 2).

Regarding the general mortality rates due to cerebrovascular diseases, a decreasing trend was observed in five cities in the nine cities analyzed. A reduction of approximately 1 death/year was recorded per 100,000 inhabitants in Ijuí (95% CI: -2.63; -0.54) and in Passo Fundo (95% CI: -1.57; -0.39), while for Caxias do Sul (95% CI: -2.96; -0.73), Porto Alegre (95% CI: -2.98; -1.74) and Uruguaiana (95% CI: -3.87; -0.95) the decrease was around 2 deaths/year. In the female group, statistically significant reductions were observed in five out of the nine cities analyzed. On the other hand, among men, only the cities of Porto Alegre and Caxias showed a declining trend throughout the time series (Table 3).

In the opposite direction, the other causes of death from diseases of the circulatory system, in which they showed a declining trend during the years 2009 to 2019, for HD there was an increase in the general rates, and in both sexes, in three of the nine cities of RS evaluated. An upward trend, demonstrated by increases in deaths, year by year, was observed in Ijuí (4.29: 95% CI: 2.99; 5.58), Porto Alegre (1.48; 95% CI: 0.83; 2.13) and Santa Maria (1.76: 95% CI: 0.71; 2.81) (Table 4).

The relative (Δ%) and absolute (Δ absolute) variations in mortality rates due to CVD, when comparing the years 2009 to 2019, can be observed in Figure 1. The city of Porto Alegre presented the highest relative variation (-22.3%) in the analyzed period, indicating a decrease of 51 deaths per 100,000 inhabitants. In the following, three other cities also registered a reduction in their coefficients of variation, including Caxias do Sul (-17%), Pelotas (-7%) and Ijuí (-6%), which represent, respectively, a reduction of 27, 19 and 13 deaths per 100,000 inhabitants. On the other hand, Santa Cruz do Sul presented the highest percentage increase in mortality rates due to CVD (13.2%), corresponding to an increase of 29 deaths per 100,000 inhabitants, followed by Santa Maria with 9%. In the other cities, there were no statistically significant variations along the time series.

Discussion

More than 1/4 of all deaths that occurred between 2009 and 2019 in sentinel cities of RS were due to diseases of the circulatory system, of which 35.3% were caused by cerebrovascular diseases, 31.1% due to IHD and 10.2% to HD. The temporal trend analysis

Table 1 – Mortality rates due to diseases of the circulatory system, general and stratified by gender and age group, in nine cities of RS, from 2009-2019 (per 100,000 inhabitants)

General									
	Mortality rate				**Age groups (years)**				
Cities	**2009-2019**	**CV***	**95% CI***	**p §**	**20-39**	**40-59**	**60-69**	**70-79**	**≥80**
Canoas	195.2	-2.93	-5.65; -0.21	0.038	10.2	132.9	548.7	1344.1	3692.9
Caxias do Sul	137.5	-2.33	-3.33; -1.33	0.001	7.4	76.2	318.1	935.9	3276.2
Ijuí	202.1	-1.97	-4.12; 0.18	0.069	6.5	78.9	328.3	1106.3	3466.5
Passo Fundo	178.3	0.08	-2.13; 2.28	0.939	9.2	111.5	425.7	1170.5	3378.1
Pelotas	231.3	-2.09	-4.93; 0.76	0.132	11.8	131.4	466.9	1195.5	3322.1
Porto Alegre	213.7	-5.67	-7.23; -4.11	<0.001	9.7	105.1	389.1	1020.4	3301.4
Santa Cruz do Sul	248.1	1.21	-2.49; 4.92	0.478	10.5	126.9	461.9	1393.8	4735.2
Santa Maria	220.1	-0.69	-5.49; 4.09	0.749	9.0	111.5	438.9	1194.3	3828.9
Uruguaiana	160.6	-1.58	-4.62; 1.47	0.271	11.2	135.0	520.8	1170.8	2638.3
Male									
Canoas	199.5	-3.42	-6.54; -0.31	0.034	11.9	178.3	731.2	1764.3	4076.8
Caxias do Sul	132.7	-1.07	-2.20; 0.07	0.063	10.0	98.7	409.7	1148.2	3528.8
Ijuí	269.9	0.29	-2.96; 3.56	0.840	12.3	102.1	444.8	1445.2	3876.5
Passo Fundo	182.9	-0.14	-4.70; 4.40	0.945	11.3	148.5	558.1	1567.0	3653.2
Pelotas	235.0	-0.75	-3.43;1.93	0.544	13.6	182.1	664.8	1563.1	3480.2
Porto Alegre	208.9	-4.91	-6.51; -3.31	<0.001	12.8	144.3	543.7	1348.0	3737.6
Santa Cruz do Sul	240.6	1.24	-3.38; 5.87	0.558	11.9	168.3	621.2	1842.9	5378.1
Santa Maria	216.2	2.53	-2.31; 7.38	0.268	10.4	146.1	603.9	1553.6	4084.4
Uruguaiana	169.7	1.39	-2.62; 5.41	0.452	15.5	164.6	710.7	1411.0	2692.5
Female									
Canoas	190.1	-1.74	-4.84; 1.35	0.235	8.5	92.4	405.6	1072.4	3525.7
Caxias do Sul	136.9	-2.47	-4.44; -0.49	0.020	4.8	55.4	242.0	783.7	3146.5
Ijuí	193.8	-3.22	-6.21; -0.23	0.038	0.7	57.8	229.6	848.9	3242.2
Passo Fundo	172.0	1.01	-0.62; 2.67	0.195	7.2	80.0	322.2	904.1	3240.3
Pelotas	228.7	-2.84	-5.36; -0.32	0.031	10.1	88.6	315.2	959.1	3252.7
Porto Alegre	216.8	-5.37	-7.00; -3.73	<0.001	6.7	73.1	279.9	824.4	3118.4
Santa Cruz do Sul	252.6	1.49	-2.40; 5.30	0.407	9.0	89.1	334.0	1107.2	4464.6
Santa Maria	221.9	-3.69	-7.23; -0.16	0.042	7.6	81.7	312.3	957.3	3707.8
Uruguaiana	152.4	-3.56	-5.60; -1.40	0.005	7.0	107.5	355.5	995.1	2610.4

**CV: coefficient of variation; ‡CI: confidence interval; RS: Rio Grande do Sul; §Level of statistical significance p <0.05 estimated by Prais-Winsten.*

Table 2 – Mortality rates due to ischemic heart diseases (IHD), general and stratified by gender and age group, in nine cities of RS, from 2009 to 2019 (per 100,000 inhabitants)

General									
	Mortality rate				Age groups (years)				
Cities	2009-2019	CV*	95% CI*	p §	20-39	40-59	60-69	70-79	≥80
Canoas	67.5	-2.69	-5.60; 0.22	0.066	3.3	55.5	209.5	477.7	1019.6
Caxias do Sul	39.0	-1.18	-1.65; -0.69	<0.001*	2.3	28.2	113.0	269.8	717.7
Ijuí	55.6	-2.50	-4.60; -0.40	0.025*	1.1	26.6	113.1	302.1	837.5
Passo Fundo	50.1	0.77	-0.37; 1.91	0.162	2.0	39.7	141.5	325.1	785.5
Pelotas	63.2	-0.05	-1.21; 1.11	0.927	2.4	44.0	144.3	310.5	819.4
Porto Alegre	71.7	-2.69	-3.75; -1.63	<0.001*	2.2	37.9	148.1	357.8	1015.3
Santa Cruz do Sul	81.9	0.54	-2.93; 4.02	0.733	2.9	56.2	204.0	471.6	1187.8
Santa Maria	57.0	-0. 52	-2.68; 1.63	0.590	2.5	42.4	150.4	301.4	738.5
Uruguaiana	44.3	1.76	-0.85; 4.36	0.162	1.9	42.2	185.0	321.2	518.3
Male									
Canoas	78.6	-3.26	-6.73; 0.21	0.063	4.9	84.2	300.8	655.7	1316.3
Caxias do Sul	43.9	-0.60	-1.17; -0.31	0.041*	3.7	41.5	158.7	364.8	873.7
Ijuí	66.3	-0.97	-3.81; 1.87	0.462	2.2	42.6	171.5	428.0	1048.7
Passo Fundo	60.0	0.81	-0.55; 2.18	0.211	3.5	61.4	206.7	473.8	981.0
Pelotas	70.6	0.72	-0.72; 2.17	0.284	3.3	65.2	217.2	433.7	916.0
Porto Alegre	78.6	-2.50	-3.88; -1.12	0.003*	3.2	56.7	219.3	510.9	1330.7
Santa Cruz do Sul	92.2	1.03	-2.4; 4.47)	0.514	4.1	81.9	291.4	682.3	1521.1
Santa Maria	65.0	0.59	-2.59; 3.79	0.682	4.1	54.5	226.9	397.6	903.8
Uruguaiana	57.2	1.91	-0.85; 4.66	0.153	0.4	5.8	28.3	43.5	76.4
Female									
Canoas	56.7	-2.04	-4.48; 4.12	0.093	1.7	30.0	138.3	364.4	894.3
Caxias do Sul	32.8	-1.44	-2.01; -0.87	<0.001*	0.8	15.8	75.5	202.9	640.3
Ijuí	45.2	-3.74	-5.61; -1.86	0.001*	0.0	12.1	63.8	207.4	724.8
Passo Fundo	40.5	0.89	-0.44; 2.23	0.163	0.6	21.2	90.9	226.0	690.9
Pelotas	56.9	-0.81	-2.40; 0.77	0.276	1.5	26.0	88.8	232.3	780.1
Porto Alegre	65.4	-2.62	-3.69; -1.54	<0.001*	1.2	22.4	98.1	267.3	886.0
Santa Cruz do Sul	71.5	-0.02	-3.96; 3.92	0.990	1.8	32.8	134.5	338.8	1051.7
Santa Maria	49.3	-1.62	-3.23; -0.13	0.048*	1.2	31.1	103.1	231.8	650.7
Uruguaiana	32.4	1.92	-0.84; 4.69	0.150	0.0	27.9	100.0	238.8	394.0

**CV: coefficient of variation; IHD: ischemic heart diseases; RS: Rio Grande do Sul; *CI: confidence interval; §Level of statistical significance p <0.05 estimated by Prais-Winsten.*

Table 3 – Mortality rates due to cerebrovascular diseases stratified by gender and age group in nine cities of RS, from 2009-2019 (per 100,000 inhabitants)

General									
	Mortality rate				Age groups (years)				
Cities	2009-2019	CV*	95% CI*	p §	20-39	40-59	60-69	70-79	≥80
Canoas	67.8	0.09	-1.12; 1.22	0.928	3.5	38.9	182.9	507.3	1332.8
Caxias do Sul	39.9	-1.85	-2.95; -0.73	0.005*	1.8	19.6	81.1	272.5	1023.4
Ijuí	62.3	-1.58	-2.62; -0.54	0.007*	3.6	21.9	82.4	352.1	1112.5
Passo Fundo	65.7	-0.98	-1.57; -0.38	0.005*	3.3	35.9	153.0	444.9	1298.7
Pelotas	90.2	-1.12	-2.68; 0.43	0.138	4.0	42.0	173.8	488.0	1379.5
Porto Alegre	72.5	-2.36	-2.97; -1.73	<0.001*	2.5	33.2	124.7	357.9	1151.9
Santa Cruz do Sul	93.5	-0.46	-2.79; 1.86	0.663	3.4	35.6	140.9	521.8	2063.4
Santa Maria	60.4	1.24	-1.50; 3.98	0.334	2.9	35.9	160.6	495.8	1833.2
Uruguaiana	66.9	-2.41	-3.87; -0.94	0.005*	6.2	53.2	172.9	509.0	1257.5
Male									
Canoas	65.4	0.32	-0.54; 1.18	0.425	3.2	44.1	238.0	661.1	1460.8
Caxias do Sul	37.1	-1.58	-2.55; -0.60	0.005*	2.0	23.4	95.1	333.1	1163.8
Ijuí	65.1	-0.21	-1.52; 1.10	0.719	6.5	25.7	101.8	453.2	1390.4
Passo Fundo	65.3	1.14	-2.80; 0.50	0.151	4.6	35.2	208.0	618.5	1392.1
Pelotas	87.0	-0.48	-2.23; 1.27	0.550	3.6	55.5	240.8	617.5	1415.3
Porto Alegre	66.0	-2.02	-2.74; -1.31	<0.001*	2.8	39.7	167.9	451.9	1239.5
Santa Cruz do Sul	85.3	-0.43	-3.44; 2.57	0.752	3.6	41.0	187.9	698.9	2314.2
Santa Maria	84.9	-0.51	-1.92; 0.88	0.427	4.7	59.6	231.4	415.1	967.4
Uruguaiana	62.8	-0.96	-2.51; 0.59	0.195	7.8	62.6	203.1	568.1	1127.1
Female									
Canoas	69.6	0.42	-1.69; 1.77	0.957	3.8	34.3	140.1	409.9	1282.7
Caxias do Sul	40.9	-1.70	-3.02. -0.38	0.017	1.7	16.1	69.7	230.4	955.2
Ijuí	59.1	-2.55	-4.00; -1.10	0.003*	0.7	18.5	66.1	276.5	964.2
Passo Fundo	65.3	-0.99	-2.28; 0.31	0.119	1.9	36.5	110.4	329.5	1258.1
Pelotas	93.3	-1.43	-2.63; -0.22	0.025*	4.3	30.6	122.9	406.5	1369.3
Porto Alegre	77.8	-2.29	-2.99; -1.60	<0.001*	2.3	27.4	94.4	302.9	1119.0
Santa Cruz do Sul	100.2	-0.16	-2.72; 2.40	0.889	3.1	30.8	103.6	410.8	1965.6
Santa Maria	98.7	-3.70	-4.91; -2.49	<0.001*	0.6	27.5	89.9	249.3	796.2
Uruguaiana	70.9	-3.45	-5.51; -1.39	<0.001*	4.7	44.4	147.2	467.4	1330.4

**CV: coefficient of variation; *CI: confidence interval; RS: Rio Grande do Sul; §Level of statistical significance p <0.05 estimated by Prais-Winsten.*

Table 4 – Mortality rates due to hipertensive diseases (HD) stratified by gender and age group, in nine cities of RS, from 2009-2019 (per 100,000 inhabitants)

General									
	Mortality rate				Age groups (years)				
Cities	2009-2019	CV*	CI95%ǂ	p §	20-39	40-59	60-69	70-79	≥80
Canoas	18.6	-0.23	-1.08; 0.61	0.546	0.5	13.7	49.0	116.4	386.8
Caxias do Sul	24.0	1.71	-0.36; 3.79	0.095	0.8	11.4	49.9	152.9	687.9
Ijuí	37.3	4.29	2.99; 5.58	<0.001*	0.4	11.8	60.3	219.5	658.3
Passo Fundo	18.1	0.51	-0.41; 1.44	0.243	0.7	9.8	30.8	118.7	424.1
Pelotas	24.7	-0.49	-2.62; 1.62	0.608	1.3	16.1	46.7	125.8	348.2
Porto Alegre	18.5	1.48	0.82; 2.13	0.001*	0.7	8.3	29.5	78.9	330.0
Santa Cruz do Sul	28.5	1.32	-0.33; 2.97	0.104	1.1	11.3	52.1	152.4	611.6
Santa Maria	18.0	1.76	0.71; 2.81	0.004*	0.6	10.8	35.7	96.5	307.1
Uruguaiana	9.6	-0.80	-2.01; 0.40	0.167	1.0	9.8	35.2	67.7	114.7
Male									
Canoas	15.1	-0.47	-0.92; 0.83	0.906	0.7	16.6	47.9	132.9	294.2
Caxias do Sul	20.6	1.67	-0.15; 3.49	0.067	1.0	13.7	68.7	171.6	613.9
Ijuí	30.3	3.29	1.70; 4.87	0.001*	0.7	13.3	69.7	241.7	506.7
Passo Fundo	14.4	0.03	-0.96; 1.02	0.951	0.3	9.8	27.6	136.2	353.4
Pelotas	23.2	-1.05	-2.48; 0.38	0.130	1.3	20.9	66.6	158.7	291.0
Porto Alegre	14.9	1.44	0.66; 2.23	0.002*	0.9	10.8	35.4	87.8	302.5
Santa Cruz do Sul	23.8	1.14	-0.12; 2.39	0.071	1.8	15.1	63.3	141.4	651.9
Santa Maria	15.7	1.36	0.63; 2.09	0.002*	0.4	12.0	47.9	116.1	258.8
Uruguaiana	10.0	-0.35	-1.56; 0.85	0.527	1.0	9.2	54.0	82.5	100.2
Female									
Canoas	21.8	-0.43	-1.86; 1.0	0.515	0.3	11.2	106.2	106.3	429.1
Caxias do Sul	26.6	1.93	-0.35; 4.21	0.088	0.6	9.3	34.4	140.4	729.1
Ijuí	43.8	5.46	3.34; 7.58	<0.001*	0.0	10.4	52.4	203.5	744.2
Passo Fundo	21.4	1.01	-0.18; 2.19	0.088	1.1	8.0	33.5	107.3	461.8
Pelotas	25.9	-0.36	-2.99; 2.26	0.760	1.4	11.9	31.5	105.0	374.8
Porto Alegre	21.6	1.55	0.91; 2.2	<0.001*	0.4	6.3	25.5	74.0	342.7
Santa Cruz do Sul	32.6	1.53	-0.51; 3.57	0.124	0.4	7.7	43.3	160.1	597.0
Santa Maria	20.0	2.07	0.74; 3.41	0.007*	0.8	9.6	26.5	83.9	331.4
Uruguaiana	9.1	-1.14	-2.44; 0.15	0.077	0.9	10.2	18.9	57.2	122.7

**CV: coefficient of variation; ǂCI: confidence interval; RS: Rio Grande do Sul; HD: hypertensive diseases; §Level of statistical significance p <0.05 estimated by Prais-Winsten.*

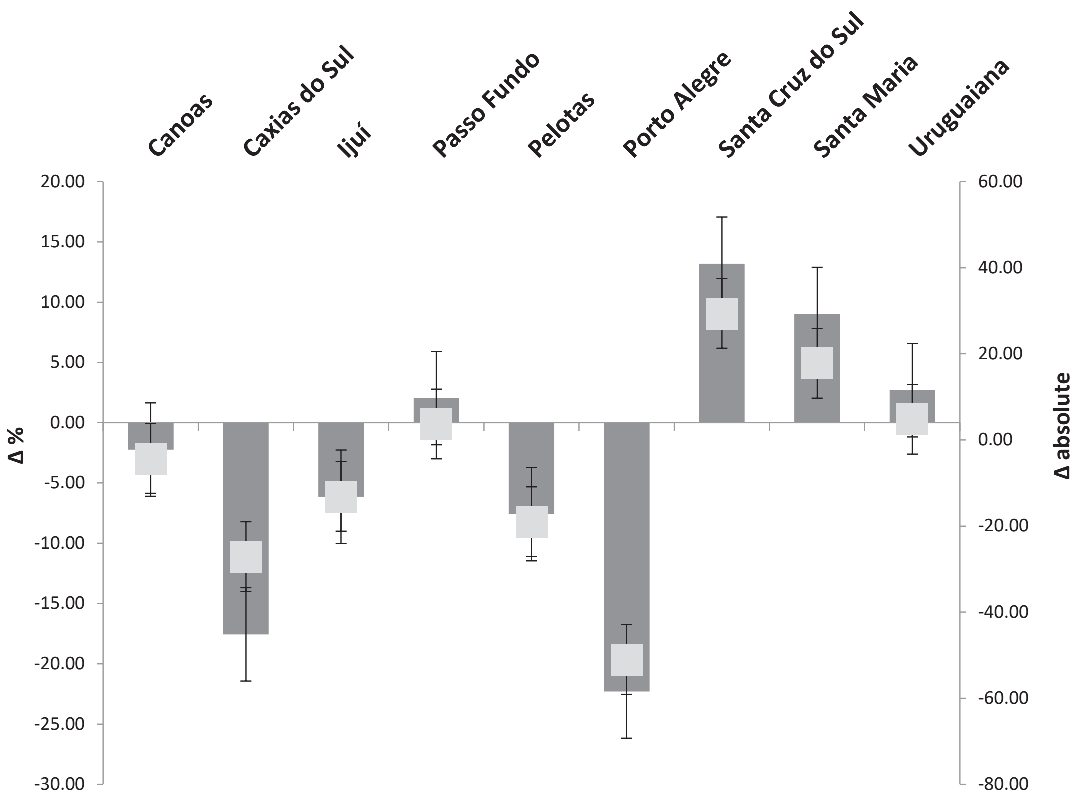

Figure 1 – Relative and absolute variation in the general mortality rates due to diseases of the circulatory system in 2019 compared to 2009 in the nine cities of RS.

of mortality rates due to CVD, general and by groups of causes, showed heterogeneity throughout the analyzed period. However, in most cases, stability in the rates of CVD and IHD were observed, as well as a significant reduction in mortality due to cerebrovacular diseases in the studied cities. On the other hand, there was an increase in HD mortality in three of the nine cities analyzed.

Between 2009 and 2019, it was observed that CVD accounted for 26.5% of all deaths in the nine cities analyzed. A similar result was described in 2016 by a study that analyzed the RS between 1998 and 2012 and showed that CVD were the main causes of death, with mortality rates of 31%.[13] Between 1990 and 2015, a 45.2% reduction in mortality from CVD in RS[14] was demonstrated in an ecological study, which was also verified in the present analysis.

The three cities that recorded significant reductions in mortality due to CVD are the most populous in the state, with the highest gross domestic product (GDP) values and are ranked among the 100 largest economies in the country.[12] In addition, these cities have broad coverage of public health services.[15] The most significant variation in mortality due to CVD occurred in the city of Porto Alegre, which in addition to being the state capital, has the highest percentage share in total state GDP (16.9%,) and has the lowest illiteracy rates and infant mortality rate compared to Canoas and Caxias do Sul.[12]

The relationship between the influence of socioeconomic indicators on mortality rates due to CVD has been consistently documented in the literature.[16-18] An analysis conducted in 2017 found that the reduction in cardiovascular mortality in Brazilian states was lower in those with worse socioeconomic conditions.[14] In addition, data published in 2008 confirmed a positive correlation between poverty and poor living conditions with mortality from CVD.[16] Another study conducted in 2013, which analyzed the evolution of mortality in three States of Brazil, reported that the decrease in mortality rates due to CVD was preceded by a reduction in infant mortality, and an increase in GDP per capita and schooling.[19] In addition to the hypothesis of the social determinants of health,[17] another mechanism that can justify this association is related to greater access and availability of care in health services in those cities with better socioeconomic indicators; in addition to lifestyle and exposure to risk factors determined by the socioeconomic level of the population.[18]

Regarding age, it was found that mortality rates due to CVD increased with the advancing age, with the highest values in the age group of 80 years or more. According to the information described by the Framingham Heart Study, even individuals free of heart diseases had a nontrivial risk of developing CVD of 35% in males and 24% in females at the age of 70.[5] In addition, a cohort of more than 3.6 million individuals aged ≥ 40 years showed that each additional decade of life was associated with approximately double the risk of vascular disease, demonstrating that age alone contributes to the development of CVD.[8]

Regarding differences according to gender, crude death rates were higher in men in all age groups. The higher occurrence of cardiovascular events in men may be associated with hereditary variations in sex chromosomes and by the more significant accumulation of risk factors.[20] Studies with populations of 31,000 patients recorded a 20% lower risk of cardiovascular outcomes in women when compared to the opposite sex.[21]

The reduction and stability observed in mortality rates due to CVD in sentinel cities of the RS may be associated with the implementation of public policies, such as the Plan to Combat Chronic Noncommunicable Diseases (NCD), in addition to the expansion of public health interventions coverage, facilitated access to health services, and the distribution of drugs that ensure control of cardiovascular risk factors; in addition to improvements in the management of acute cardiovascular events.[22] Corroborating this hypothesis, a study demonstrated that in the United States the advancements in the treatment of CVD and the control of risk factors contributed 47% and 44%, respectively, to the reduction of mortality from CVD.[23]

Concerning IHD, mortality rates were stable in the vast majority of the cities studied, and in the three cities in which there was a decrease, these were not more than 2 deaths/year per 100,000 inhabitants. At the national level, another study showed that between 2007 and 2012 there were no significant changes in mortality rates due to IHD in both sexes.[24]

After stratification of mortality rates due to IHD according to gender, there was a reduction in females in four cities, ranging from 2 to 4 deaths/year, and in males in two cities, with a reduction of 1 to 2 deaths/year per 100,000 inhabitants. At the national level, between 2007 and 2012 there was a 0.1 % increase in the mortality rate due to IHD in males and a reduction of 0.4% in females.[24] Furthermore, ischemic heart disease is described as the main cause of cardiovascular death throughout the national territory, from 1990 to 2015, except for Amapá.[14] This data differs from the results presented by this study, in which cerebrovascular diseases proved to be the main cause of death in sentinel cities of RS.

Regarding cerebrovascular diseases, there was a low variation rate in five cities, and reductions of around 2 deaths/year were observed in three of these. In females, this variation was significant in six cities, with a decrease of 2 to 3 deaths/year per 100,000 inhabitants, while in men, only two cities showed significant reductions, from approximately 1 to 2 deaths/year. This data is in line with the Brazilian trend of mortality due to cerebrovascular diseases, described in 2016, which observed reductions of 1.4% in deaths in men and around 2% in women between 2007 and 2012.[24] It is believed that the decline in mortality due to CVD is the result of public policies and other strategies for controlling cardiovascular risk factors, such as systemic arterial hypertension, smoking and dyslipidemia, through easier access to diagnosis and treatment, in addition to better management of acute events.[25]

The temporal analysis of mortality from HD showed an increase in this indicator in three cities, ranging from 2 to 4 deaths/year. Similarly, between 1980 and 2012, HD maintained increases in their mortality rates in Brazil.[25]

Several factors may explain the increase found in deaths due to HD, including the increased prevalence of systemic arterial hypertension, resulting from greater coverage of the public health system that allowed more frequent and earlier diagnosis. Furthermore, population growth and population aging caused more individuals to reach older ages, increasing the probability of death from chronic diseases.[26] In addition, there may have been changes in the way death certificates are filled out, with greater attention to primary causes of death, observed by the decline in rates of ill-defined causes.[27]

The mortality rates due to HD standardized by sex show a significant increase in three cities, with an increase of 2 to 5 deaths/year in females, and 1 to 3 deaths/year in males. These data differ from the variations recorded at the national level. Between 1990 and 2015 there was a 17% reduction in mortality from hypertensive heart diseases in men and 19.2% in women.[14]

Regarding the most significant increase in mortality due to HD in females, this result is a consequence of the higher prevalence of hypertension in women, which was 29% in 2019 in Porto Alegre, compared to 27% in the opposite sex.[4] In addition to the established cardiovascular risk factors, women present several unique factors related to both their gynecological and obstetric history, including menopause, use of oral contraceptives, pregnancy and its complications, as well as environmental factors such as double working hours and stress.[28]

This study represents the first study developed with cardiovascular mortality topic in a 10-year time interval considering the nine sentinel cities of RS. It is also noteworthy that these cities represent about 1/3 of the entire population of the state, constituting themselves as reference centers in health in the seven regions of RS. Another point to be noted is that mortality indicators are widely used to prioritize investments in the health system, monitor the progress of public policies and guide scientific research and the allocation of resources in the health area. And time series solutions allow evaluating the movement of health indicators over time, allowing the measurement and recognition of factors that interfere with these variables and thus allowing the evaluation of health actions and policies.

However, some limitations must be recognized. Because it is an ecological study, it is not possible to extend the applicability of the results at the individual level, since the analyses were developed from aggregated data, obtained in population strata. Another possible limitation relates to the quality of secondary data usage records, which may be subject to underreporting and inadequate completion. However, there has been a trend toward a reduction in death rates from ill-defined causes,[27] which represents improvements in the quality of the death certificate completion.

Conclusion

The analysis of the temporal trend of mortality due to CVD and the main causes of death, between 2009 and 2019, showed heterogeneity among the cities of the RS evaluated, in addition to the presence of rates, mostly higher in males and with an exponential increase with advancing age.

These results may have implications for future strategies and intersectoral actions of health promotion and disease prevention, since it provides a basis for the development of public policies directed to the particularities of each geographic unit evaluated.

Author contributions

Conception and design of the research and critical revision of the manuscript for intellectual content: Sandri P, Rosa Filho LA, de Almeida ES, da Silva SG; acquisition of data and analysis and interpretation of the data: Sandri P; statistical analysis and writing of the manuscript: Sandri P, da Silva SG.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

Due to the use of unrestricted public domain access data for the accomplishment of the study, it is exempted by the National Commission of Ethics in Research (CONEP) for analysis of the Research Ethics Committee / CONEP system, through CNS resolution Numer 510/2016.

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