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Trend of infant mortality in cities of metropolitan region of Porto Alegre, Brazil from 1996 to 2021

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Abstract *The aim is to verify the trend in infant mortality (IM) and preventable infant mortality (PIM) in municipalities in the metropolitan region of Porto Alegre from 1996 to 2021 and their associations with per capita public spending on health and population coverage of the Family Health Strategy (FHS). Ecological study with data from information systems: on mortality, live births, public budgets and primary health care. The deaths described in the Ministry of Health's list were considered preventable. Statistical analysis used Prais-Winsten regression. A decrease in MIE was observed in the municipalities studied with the exception of Esteio. There was an association between per capita public spending on health and the study outcomes in Novo Hamburgo, Canoas and Porto Alegre. An association was found between the FHS coverage and IM in Novo Hamburgo, Sapucaia do Sul, Canoas and Porto Alegre. PIM was associated with FHS coverage in Novo Hamburgo, Canoas and Porto Alegre. Despite the decrease in the IM and PIM coefficients, the association of this indicator was more impacted by per capita public spending on health than by the FHS population coverage.*

Keywords *Infant Mortality, Causes of death, Healthcare Financing, Public Expenditures on Health, Family Health Strategy*

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Introduction

Despite the reduction in infant mortality (IM) observed in Brazil. national levels are still higher than those identified in high-income countries[1-2]. It is well-known that IM can be influenced by numerous factors. such as socioeconomic conditions[3-4]. characteristics of the newborn and the mother. and availability of health services[3-5]. including childbirth care[6]. but evidence has been consolidated regarding the determining role of public policy financing[7-8-9].

There is a clear insufficiency of public spending on health in Brazil when compared to developed countries. Some international evidence has shown that countries with universal systems have presented public spending on health that reaches at least 70% of total spending. In Brazil. public spending on health was 47% of the total. lower than the previous 53% that private spending on health had reached. Furthermore. This percentage has typically been much lower when compared with other countries. such as Canada. 71.1%; the United Kingdom. 83.2%; and Norway. 85.5%[10-11-12].

As a way of dealing with the economic crisis. The government opted to contain public spending. Constitutional amendment No. 95 of 2016 froze the federal budget. including health spending. for 20 years.[13] According to Donieke and collaborators[14]. "In 2017, the government had already failed to meet the minimum investment in the health budget guaranteed by the Constitution. around R$692 million." These restrictions created expectations of direct consequences for health indicators. causing an increase in IM[15]. One study analyzing the economic slowdown and IM showed that in middle- and low-income countries. Even after controlling demographic and infrastructure variables. A 1% reduction in the Gross Domestic Product (GDP) per capita resulted in an increase in IM[16]. In 2008, the Health Surveillance Secretariat of the Ministry of Health released a list of preventable deaths through interventions by the Unified Health System. with comprehensive objectives that include reducing IM in Brazil. The list of preventable deaths was updated in 2010 and were considered to be those that would not occur with the provision of effective care at the appropriate time and place[17]. highlighting the importance of primary health care (PHC) as the gateway and organizer of the healthcare network.

Thus, the Family Health Strategy (FHS) became the predominant model of PHC in Brazil. Important findings from Macinko *et al.*[18] have already revealed the impact of the FHS in reducing IM. After, several studies also highlighted the impact of the FHS on IM and preventable infant mortality (PIM)[19-22].

Thus, the present study verified the trends of IM and PIM in municipalities in the metropolitan region of Porto Alegre from 1996 to 2021 and their associations with per capita public spending on health and population coverage of FHS in order to subsidize the health departments and their respective municipal health councils. with the aim of detecting inequities in the determinants of the health-disease process.

Methods

An ecological study was carried out to verify trends of the IM and PIM coefficients in the main municipalities of the metropolitan region, which are part of the Trensurb line (Novo Hamburgo, São Leopoldo, Sapucaia do Sul, Esteio, Canoas and Porto Alegre), in the period between 1996 and 2021.

The number of deaths was available in the Mortality Information System (*Sistema de Informações sobre Mortalidade* – SIM) on the website of the Department of Information Technology of the Unified Health System (*Departamento de Informática do Sistema Único de Saúde* – DATASUS). The population data on live births for each municipality in all the years of this study were obtained from the Live Birth Information System (*Sistema de Informações sobre Nascidos Vivos* – SINASC). also available on DATASUS. Information on public health spending was collected from the Public Health Budget Information System (*Sistema de Informações sobre Orçamentos Públicos em Saúde* – SIOPS) and the population coverage of the Family Health Strategy was obtained from the website of the Department of Primary Care (*Departamento de Atenção Básica* – DAB). The number of deaths in children under one year of age was collected in each municipality from 1996 (first year of implementation of the 10th Revision of the International Classification of Diseases) to 2021 (last year available in SIM).

Preventable deaths in children under one year of age were classified as: reducible by immunoprevention actions; by adequate attention to women's health during pregnancy. childbirth. the fetus. and the newborn; by resolute actions to promote health or linked to these; and by ill-defined causes of death[17]. Infant mor-

tality rates were calculated using the formula: [(number of deaths in children under one year of age with mothers residing in the municipality in the year/number of live births with mothers residing in the municipality in the year) x 1000].

PIM rates were calculated using the formula: [(number of preventable deaths in children under one year of age with mothers residing in the municipality in the year/number of live births with mothers residing in the municipality in the year) x 1000].

Proportional mortality rates in the neonatal period (from birth to 27 days) and preventable neonatal mortality (PNM) were calculated among infant deaths for each year of the historical series in the municipalities using the following equations: (number of neonatal deaths x 100 / number of infant deaths) and (number of preventable neonatal deaths x 100 / number of preventable infant deaths).

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Public spending on health was determined through the Summary Reports of Budget Execution of each municipality available in SIOPS, from 2000 to 2020. The total amount of resources applied by the municipalities were determined based on the expenditure settled in each year of the direct administration subfunction in health in SIOPS. Per capita public spending on health was prepared as the ratio of the total spending made in each municipality in the year and the population of the municipalities according to the year.

To reduce price variations due to inflation on the values presented. the deflator resource was used. The values of all years of the historical series of per capita public spending on health were brought to the present day. through correction by the National Broad Consumer Price Index (IPCA) of 2020, the last year of the series[23-24].

The population coverage of FHS between 1998 and 2020 was obtained from the website of the DAB and presented as a percentage[25]. The annual average was calculated for each municipality.

The trends in the IM and PIM coefficients. per capita health expenditure and population coverage of FHS in the municipalities were verified. The associations between mortality coefficients, per capita public health expenditure. and population coverage of FHS in each municipality were analyzed.

The data were tabulated using Microsoft Excel 2010® spreadsheets. in which information was displayed by municipality and year to construct the indicators. The Stata 11 program was used for statistical analysis.

The temporal trend was analyzed based on the Prais-Winsten Generalized Regression models. indicated for a time series of more than seven years, as it corrects for first-order serial autocorrelation. a common occurrence in a time series. which overestimates adjustment measures[26].

The results with a p-value<0.05 were statistically significant. with the trend considered to be increasing when the regression coefficient was positive and decreasing when the regression coefficient was negative. The trend with a p-value > 0.05 was considered stationary or insignificant. In the association analysis, the IM coefficients and the PIM coefficients were the dependent variables and per capita public spending on health and population coverage of FHS were the independent variables.

This study was carried out with secondary data available in public information systems. protecting the identification of individuals. This study was exempt from the requirement for approval by a research ethics board in accordance with Resolution 466/2012 of the National Health Council.

Results

Between 1996 and 2021, the IM ranged from 21.9 in Canoas (1996) to 1.7 deaths per thousand live births in Esteio (2011). With the exception of the municipality of Esteio, all other municipalities had average coefficients between 11 and 13 deaths per thousand live births. During the period studied, neonatal mortality predominated in all municipalities, with average percentages above 60% (Table 1).

In relation to PIM, in 1996, Canoas had the highest coefficient of the period. with 16.3 deaths per thousand live births. while in 2020. Esteio had the lowest value. with only one death per thousand live births (Table 2). The descriptive analysis showed that in all municipalities the average coefficients in the period were below nine deaths per thousand live births. except in São Leopoldo. In the historical series. most of the PIM was concentrated in the neonatal component. with average percentages above 70% in most municipalities, except Porto Alegre and Canoas (Table 2).

It is important to note that in 2021, the most significant year of the pandemic in Brazil. São Leopoldo was the only municipality that presented IM and PIM coefficients of higher than the average for the period.

Regarding the trend analysis. between 1996 and 2021, there was a statistically significant decrease in IM in all municipalities (Table 3). Regarding the PIM trend, a significant drop in the coefficients was observed in all municipalities. except in Esteio. which showed stability (Table 3).

All municipalities showed a significant growth trend in relation to per capita public spending on health. except Sapucaia do Sul. whose values in the area were stable (Table 4). Between 1998 and 2020, there was a significant increase in the population coverage of FHS in all of the municipalities analyzed in this study (Table 4).

The highest and lowest values of per capita public spending on health in the period were found in Esteio, with R$1.638.48 in 2020 and R$87.49 in 1996, respectively. Regarding the average amounts invested in health in the municipalities, only Porto Alegre reached levels above R$1.000 per inhabitant (Supplementary Table 1).

In 1998, only Esteio and Porto Alegre had some form of FHS coverage. both with percentages below 5% of the population. Throughout the period, the highest FHS coverage was found in 2018, in the municipality of Canoas, with 63.4%. In 2020, the last year of the historical series. two municipalities had FHS coverage between 60% and 65% and São Leopoldo had a coverage percentage below 20% (Supplementary Table 2). The median percentages of population coverage by FHS were analyzed, with emphasis on Porto Alegre and Sapucaia do Sul. which obtained percentages above 20% in 2010 and 2011.

A significant and inverse association was found between both IM and PIM and per capita public spending on health in the municipalities of Novo Hamburgo. Canoas and Porto Alegre, that is, an increase of one real per capita per year in the aforementioned municipalities led to a decrease from four to seven infant deaths per thousand live births and from three to four preventable infant deaths per thousand live births (Table 5).

Similarly, an association between outcomes and FHS population coverage was observed. The IM coefficients showed a significant association with the average percentage of FHS population coverage in the municipalities of Novo Hamburgo, Sapucaia do Sul, Canoas and Porto Alegre. The PIM coefficients were associated with the average percentage of FHS coverage in Novo Hamburgo, Canoas and Porto Alegre only. For each 1% increase in FHS population coverage, the decrease in outcomes was less than one death per thousand live births (Table 5).

Table 1. Description of infant mortality rates and neonatal mortality rates in municipalities in the metropolitan region of Porto Alegre from 1996 to 2021.

Year	Novo Hamburgo		São Leopoldo		Sapucaia do Sul		Esteio		Canoas		Porto Alegre	
	IM	NM (%)	IM	NM (%)	IM	NM (%)	IM	NM (%)	IM	NM (%)	IM	NM (%)
1996	19.6	67.5	18.3	60.8	16.9	60.5	9.9	72.2	21.9	55.5	18.5	52.6
1997	15.9	65.2	11.8	59.6	13.5	78.8	15.0	68.2	16.8	63.3	15.7	59.1
1998	13.4	53.7	13.9	60.4	14.2	57.1	11.0	58.8	14.9	43.9	16.4	51.6
1999	14.4	64.5	13.7	64.9	15.3	70.0	10.9	64.7	14.0	69.1	12.2	58.2
2000	13.5	65.5	15.0	79.7	13.8	55.9	12.4	66.7	15.4	61.9	14.8	56.5
2001	13.8	57.1	16.2	57.1	8.3	38.9	14.7	60.9	13.6	66.7	14.2	60.3
2002	12.8	63.6	13.3	59.6	14.2	65.5	13.3	55.0	14.5	56.9	14.0	51.4
2003	15.0	56.9	13.1	54.8	12.2	50.0	8.6	66.7	15.4	57.9	13.3	55.9
2004	17.2	70.7	10.2	68.6	9.5	73.7	16.0	45.8	12.7	55.2	12.2	61.1
2005	12.2	78.1	8.5	53.6	12.1	73.9	10.7	68.8	16.0	62.0	12.9	56.2
2006	10.4	41.2	13.6	66.7	15.8	61.5	7.7	50.0	13.3	62.1	12.1	58.7
2007	13.5	57.1	11.4	50.0	12.4	73.7	7.2	63.6	11.8	63.2	11.9	53.3
2008	17.1	64.0	11.9	70.3	14.4	52.4	5.4	75.0	11.5	71.4	11.6	65.3
2009	8.9	76.9	14.9	67.4	11.7	68.4	9.6	75.0	12.7	58.3	9.8	61.2
2010	14.2	73.8	11.2	66.7	11.2	66.7	6.2	42.9	8.3	80.0	10.5	64.6
2011	10.6	76.5	10.3	77.4	7.4	92.3	1.7	100.0	13.0	59.4	9.3	63.4
2012	11.9	71.1	15.6	77.8	7.4	78.6	13.9	58.8	7.2	64.7	9.2	62.2
2013	10.7	58.8	10.0	77.4	11.5	72.7	9.8	81.8	9.6	70.6	9.3	62.3
2014	9.4	76.7	12.4	63.2	8.6	76.5	14.0	80.0	10.3	65.5	9.8	67.4
2015	11.7	65.9	14.8	80.4	9.2	52.6	7.3	88.9	11.0	66.7	9.2	69.2
2016	9.2	82.8	11.5	75.8	11.0	76.2	13.8	73.3	10.2	52.8	9.0	64.3
2017	12.8	78.1	11.1	66.7	10.2	78.9	11.8	92.3	8.6	53.5	9.0	68.1
2018	8.3	69.2	12.8	75.7	9.7	52.9	6.2	85.7	9.8	68.8	9.0	66.7
2019	8.8	81.5	11.4	67.7	11.6	88.9	8.5	77.8	9.9	70.8	8.7	64.6
2020	9.2	74.1	6.9	94.7	8.60	92.9	2.0	100.0	8.1	83.3	7.8	69.7
2021	8.1	77.3	13.4	83.3	10.9	62.5	7.8	85.7	7.0	73.3	9.2	67.7
Average	12.4	68.0	12.6	68.5	11.6	68.2	9.8	71.5	12.2	63.8	11.5	61.2

IM: Infant mortality rate per 1.000 inhabitants; NM: neonatal mortality rate.

Table 2. Description of avoidable infant mortality rates and neonatal mortality rates in municipalities in the metropolitan region of Porto Alegre from 1996 to 2021.

Year	Novo Hamburgo		São Leopoldo		Sapucaia do Sul		Esteio		Canoas		Porto Alegre	
	PIM	PNM (%)	PIM	PNM (%)	PIM	PNM (%)	PIM	PNM (%)	PIM	PNM (%)	PIM	PNM (%)
1996	15.1	70.3	14.8	63.3	13.8	61.3	8.2	80.0	16.3	61.1	14.0	52.8
1997	7.5	72.6	8.5	67.7	10.2	80.0	10.9	68.6	13.4	67.9	12.4	61.4
1998	8.7	54.3	11.3	65.1	10.6	61.5	9.1	57.1	10.3	47.4	11.6	50.9
1999	9.0	69.2	8.7	75.0	11.4	73.3	7.0	72.7	10.0	71.7	9.1	62.4
2000	9.3	68.4	9.2	80.6	8.9	68.2	4.8	71.4	9.9	67.8	10.2	58.9
2001	7.9	67.9	11.0	63.2	6.0	38.5	10.2	75.0	9.2	68.6	10.1	62.6
2002	8.7	76.7	9.3	63.6	7.8	81.3	9.3	57.1	8.5	71.7	9.3	54.3
2003	10.0	61.8	7.2	69.6	9.2	44.4	7.8	72.7	11.0	64.8	8.4	59.9
2004	12.2	78.1	5.2	55.6	6.0	83.3	11.4	47.1	8.9	61.7	8.6	60.5
2005	7.2	91.7	6.1	65.0	6.8	76.9	8.0	75.0	10.7	64.8	8.8	60.8
2006	6.4	47.6	8.4	60.7	10.9	50.0	2.6	100.0	7.7	63.2	8.3	64.5
2007	9.0	60.7	9.8	44.8	8.5	69.2	3.3	60.0	8.5	70.7	7.8	56.1
2008	11.6	70.6	9.0	75.0	13.0	57.9	2.0	100.0	7.8	78.9	7.8	70.3
2009	4.1	91.7	11.0	61.8	8.0	84.6	7.2	77.8	8.2	69.2	7.0	67.2
2010	9.8	82.8	8.1	75.0	8.7	78.6	3.5	75.0	5.0	83.3	6.3	73.9
2011	6.8	90.9	7.6	82.6	5.1	100.0	1.7	100.0	9.8	66.7	5.8	69.7
2012	8.1	80.8	12.5	83.3	5.8	81.8	9.0	54.5	4.8	64.0	6.4	65.3
2013	6.0	73.7	5.2	81.3	8.4	75.0	8.0	88.9	6.2	87.9	6.3	68.0
2014	5.9	78.9	5.9	66.7	7.5	73.3	9.3	100.0	7.1	65.8	6.4	79.5
2015	6.9	66.7	9.7	83.3	5.8	66.7	6.5	87.5	7.3	70.0	5.8	79.1
2016	6.3	90.0	9.4	81.5	6.3	91.7	12.0	76.9	6.7	65.7	5.5	69.9
2017	9.3	83.3	7.7	69.6	6.6	75.0	9.0	100.0	4.4	63.6	6.2	74.6
2018	4.1	92.3	8.0	78.3	4.6	25.0	3.5	75.0	7.3	75.0	4.9	77.9
2019	5.5	76.5	8.5	78.3	10.3	93.8	5.7	83.3	6.0	75.9	5.9	70.1
2020	6.2	83.3	5.4	100.0	6.1	100.0	1.0	100.0	4.7	81.0	4.8	73.3
2021	4.0	72.7	10.0	85.2	6.1	77.8	4.5	100.0	4.9	76.2	6.0	78.8
Média	8.3	74.7	9.0	72.2	8.4	71.9	6.9	78.9	8.4	69.3	7.9	66.3

PIM: Infant Mortality Rate due to preventable causes per 1.000 inhabitants; PNM: percentage of preventable neonatal mortality.

Table 3. Trends in infant mortality and preventable infant mortality rates in municipalities in the metropolitan region of Porto Alegre from 1996 to 2021.

	Infant Mortality				Preventable Infant Mortality			
	b	95% CI		p-valor	b	95% CI		p-valor
Novo Hamburgo	-0.291	-0.376	-0.207	<0.001	-0.253	-0.342	-0.163	<0.001
São Leopoldo	-0.133	-0237	-0.029	0.014	-0.116	-0.225	-0.006	0.040
Sapucaia do Sul	-0.209	-0.327	-0.091	0.001	-0.186	-0.305	-0.067	0.004
Esteio	-0.204	-0.393	-0.015	0.035	-0.153	-0.363	0.057	0.147
Canoas	-0.380	-0.468	-0.292	<0.001	-0.309	-0.384	-0.234	<0.001
Porto Alegre	-0.338	-0.400	-0.276	<0.001	-0.293	-0.363	-0.224	<0.001

b: regression coefficient; 95% CI: 95% confidence interval; p-value for Prais-Winsten regression.

Table 4. Trends in per capita public spending on health and population coverage of the Family Health Strategy in municipalities in the metropolitan region of Porto Alegre.

	Per capita public spending on health*				Population coverage of FHS**			
	b	95% CI		p-valor	b	95% CI		p-valor
Novo Hamburgo	48.357	28.940	67.775	<0.001	2.781	1.095	4.467	0.003
São Leopoldo	37.803	17.422	58.183	0.001	0.908	0.582	1.234	<0.001
Sapucaia do Sul	21.491	-8.438	51.419	0.149	2.690	1.979	3.401	<0.001
Esteio	70.634	35.446	105.823	<0.001	2.690	1.431	3.948	<0.001
Canoas	74.388	55.463	93.312	<0.001	2.695	1.350	4.040	<0.001
Porto Alegre	20.657	3.654	37.660	0.020	2.193	1.670	2.716	<0.001

* values in Reais from 2000 to 2020 corrected by the IPCA; ** average of annual percentages from 1998 to 2020. b: regression coefficient; 95% CI: 95% confidence interval; p-value for Prais-Winsten regression.

Table 5. Association between infant mortality rates and preventable infant mortality with per capita public spending on health and the Family Health Strategy in municipalities in the metropolitan region of Porto Alegre from 2000 to 2020.

	Per capita public spending on Health							
	Infant Mortality				Preventable Infant Mortality			
	b	95% CI		p-value	b	95% CI		p-value
Novo Hamburgo	-4.60	-7.45	-1.75	0.004	-3.04	-5.76	-0.32	0.031
São Leopoldo	1.02	-2.65	4.69	0.560	1.39	-3.52	6.31	0.553
Sapucaia do Sul	0.20	-7.76	8.16	0.957	-0.34	-8.66	1.88	0.189
Esteio	-0.60	-9.90	8.70	0.893	1.49	-7.12	10.10	0.717
Canoas	-4.59	-6.61	-2.58	<0.001	-3.13	-4.46	-1.79	<0.001
Porto Alegre	-7.61	-12.07	-3.14	0.003	-4.61	-8.12	-1.10	0.014
	Family Health Strategy							
	Infant Mortality				Preventable Infant Mortality			
	b	95% CI		p-value	b	95% CI		p-value
Novo Hamburgo	-0.063	-0.091	-0.035	<0.001	-0.047	-0.073	-0.020	0.001
São Leopoldo	-0.061	-0.210	0.088	0.406	-0.041	-0.179	0.097	0.541
Sapucaia do Sul	-0.059	-0.108	-0.010	0.021	-0.041	-0.088	0.006	0.086
Esteio	-0.049	-0.136	0.038	0.253	-0.029	-0.115	0.057	0.488
Canoas	-0.074	-0.118	-0.030	0.002	-0.060	-0.089	-0.031	<0.001
Porto Alegre	-0.129	-0.174	-0.084	<0.001	-0.109	-0.144	-0.073	<0.001

b: regression coefficient; 95% CI: 95% confidence interval; p-value for Prais-Winsten regression.

Discussion

This study showed a decrease in IM and PIM in all analyzed municipalities. It was observed that the persistence of IM was proportionally more concentrated in the neonatal period. The analysis showed that per capita public spending on health was more relevant in reducing mortality than in FHS coverage.

The reduction in mortality rates followed the trends found in other studies conducted in Brazil. A publication by the Ministry of Health showed a drop in IM rates between 1990 and 2019. The average for the final three-year period (2017-19) in Brazil was 13.3 deaths for every thousand live births, while in the South Region it reached 10.1 deaths for every thousand live births[2].

Other studies have shown a decreasing trend. In Rio Branco. from 1999 to 2015, there was a decrease in IM coefficients, with values falling from 27.0 to 14.5 deaths per thousand live births[27].

In Aracajú. between 2001 and 2010. IM coefficients decreased from 29.5 to 17.7 deaths per thousand live births[28]. Consequently, it can be seen that the coefficients observed in our analysis were lower than those cited, but they were still above those verified in Florianópolis, 5.34 per thousand live births in 2016, considered to be the Brazilian capital with the lowest IM[29].

In 2020 and 2021, no major changes were observed in mortality rates, except in São Leopoldo. An ecological study covering all of Brazil revealed a small impact of the pandemic on IM[30].

As for PIM, Esteio was the only municipality in which the trend did not decrease significantly. However, this municipality had the lowest IM rates in the period, a fact that may have contributed to the lack of statistical association in this outcome. Studies conducted in other locations throughout Brazil also found a decrease in PIM. In Minas Gerais, a reduction in PIM was found, although it was more severe in highly vulnerable areas of the Jequitinhonha Valley[31]. A time series study in eastern Minas Gerais also showed a decrease in IM, showing that 68% of all deaths among children under one year of age were preventable by actions linked to the SUS[32]. A time series study in Mato Grosso showed a decline in PIM between 2007 and 2020 in children under one year of age[33].

The results also showed the predominance of neonatal mortality, both in IM and PIM. This result points to the need to improve prenatal care, both in primary care and in support for high-risk situations, at the time of delivery, which specifically requires the provision and qualification of hospital services[29.-34-35-36].

This finding is in line with other studies carried out in the country. The highest IM coefficients were also concentrated in the early neonatal period, reaching an average proportion of 52%[27].

Regarding neonatal mortality in Brazil, an average rate of 9.46 per thousand live births was found from 2007 to 2017, with a reduction of 2.2% per year, with a greater decline in early neonatal mortality when compared to late mortality[37]. PNM in Brazil, between 2000 and 2018, decreased from 10.98 per thousand live births in 2000 to 6.76 in 2018[38].

An increase in per capita public spending on health was observed in all municipalities. The World Health Organization (WHO) has recommended that universal health coverage require a minimum expenditure of US$112 per capita and 7.5% of GDP applied to health[39], a figure exceeded by all municipalities in the last year of the analysis. Nevertheless, studies on health expenditures are still limited in Brazil. One study conducted in São Paulo, including seven municipalities of Rota dos Bandeirantes, between 2009 and 2012, showed per capita public spending on health ranging from R$291 to R$1.354, with an average of R$624, that is, values at the time similar to those achieved in the present study[40].

The increase observed in the analyzed period, as compared to more than 20 years ago, can be explained by the numerous changes in the financing of SUS, such as the expansion of management levels, the increase in the complexity of health actions under municipal responsibility and, primarily. the constitutional definition of sectoral spending by federated entities. A study carried out between 2000 and 2010 had already shown an 81.4% growth in per capita public spending on health in the Southern region of Brazil, showing, at the time, a restriction in federal spending but an increase in contributions made by states (from 16% to 22%) and municipalities (from 25% to 36%)[41]. Although it should be noted that per capita spending on public health actions and services by the federal government in 2019 was R$560 (13.8% of the federal government's net current revenue), this amount was the lowest invested since 2014, when it was R$600, corresponding to 14.3% of

net current revenue[42]. What is clear is the lack of definition of criteria and restrictions on federal spending on health throughout the period.

The present study pointed out the relationship between IM and PIM and the increase in per capita public spending on health in at least three municipalities. This relationship has been shown by other studies[15-43-44-45].

The FHS coverage found in this study was lower than necessary. The emblematic study conducted by Aquino *et al.*[46] considered that effective FHS coverage should reach at least 70% of the population within four years of implementation. No municipality included in the study achieved this coverage. Although FHS coverage is associated with a reduction in IM, the analysis demonstrated a low impact on this drop in indicators. The analysis of the association showed that the reduction in mortality was more impacted by public spending on health than by FHS population coverage. Ecological studies have a weak design to establish causal inferences, and it is worth noting that the data collection was carried out in different time periods. The present study did not analyze aspects that are known to determine IM, such as the structure. Organization, and quality of health services; socioeconomic factors; and individual characteristics of the children. However, the objective of the study was to monitor mortality trends in relation to public spending and FHS population coverage. The analytical treatment given to per capita public spending on health followed the rigor of economic studies, which was updated through the appropriate index, and FHS coverage considered a long observation period.

Changes in IN and PIM were observed in relation to per capita public spending on health in the years investigated in this study, even under a scenario of cost containment since 2016. It is important to note that, despite the positive results observed in the municipalities, the increase in health costs and the aging of the population require that financial contributions be adjusted, accompanying these changes for more promising results.

In this context, it is important to highlight the change in the PHC model with the strengthening of the FHS through the expansion and consolidation of coverage that should be priorities in management planning. Adequate prenatal care for pregnant women. qualified care at the time of birth, monitoring of newborns, and care during the postpartum period are essential to reduce mortality among children under one year of age.

Collaborators

All authors contributed equally to all stages of the article's preparation.

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