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Infant mortality in Brazil during recent periods of economic crisis

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ABSTRACT

Objective

To analyze time trends in infant mortality in Brazil during a recent period of economic crisis (1980-1998).

Methods

Time-series study based on Ministry of Health Mortality Information System, IBGE Foundation, and *Fundação Nacional de Saúde* (National Health Foundation) databases. Serial parameters were described using Autoregressive Integrated Moving Average (ARIMA) models, and the association between infant mortality rates and a number of determinants was evaluated using Spearman correlation coefficients.

Results

Infant mortality showed a declining trend (-59.3%) and a strong correlation with most of the indicators analyzed. However, only correlations between infant mortality rate and total fertility and birth rates presented a significant difference between the two decades.

Conclusions

Variations in fertility rate were the main cause for the persistent decline in infant mortality in the 1980's. In the subsequent period, causes related to living conditions, especially healthcare, may have been more important.

Keywords

Infant mortality. Mortality rate. Fertility rate. Birth rate. Information systems. Socioeconomic factors. Time series.

INTRODUCTION

Until the 1960's, infant mortality was understood as a problem related to economic underdevelopment,[1] due to its almost exclusive inverse association with indicators such as Gross Internal Product (GIP),[18] unemployment rates[11], and Gini's index.[25] This relationship was explained by the role these indicators played in setting income, education, and sanitation profiles, and in determining the accessibility of health programs and services[16], which promoted improvements in population-wide living conditions.

However, from the end of that decade onwards, persistently declining infant mortality trends in developing countries coexisted with severe economic crises, characterized by reductions in GIP and in the real value of minimum wage, and increasing unemployment rates. This apparent paradox served as a stimulus for conducting studies aimed at identifying the reasons behind such a sustained decline in mortality rates.[6,20] In addition, subsequent reductions in pace, stagnation, or reversions in this trend observed throughout the 1990's in a number of countries[19] revived the interest in expanding the amount of knowledge currently available on the role played by different infant mortality determinants in developing countries. Several investigations along these lines have suggested that healthcare interventions are a major determinant of the variations observed in infant mortality levels.[20]

In Brazil, where a sustained decrease in infant mortality was observed in a scenario of economic recession, certain authors have indicated, as possible explanations for this trend, the adoption of public policies, such as medical-sanitary interventions, expansion of the water supply network, and increases in schooling,[14] with the subjacent aid of the reduction in fertility rates also observed during this period.[13,17]

However, attempts to implement healthcare-related interventions in the 1980's were not always successful.[15] On the other hand, certain programs and initiatives capable of reducing infant mortality – including *Programas de Atenção Integral à Saúde da Mulher* (Integral Women's Healthcare Programs – PAISM), oral rehydration therapy (ORT), *Programa Nacional de Imunização* (National Immunization

Program – PNI), and social interventions, such as the expansion of the water supply network and reductions in illiteracy – began to be implemented in the Brazil only in the second half of the 1980's. It is thus reasonable to assume that such policies began to yield more substantial effects on the maintenance of the declining trend in infant mortality only from the 1990's onwards.

From this perspective, it is of fundamental importance to clarify what factors could have had such a marked variation as to contribute to the persistent declining trend in infant mortality, in a period in which economic, social, and healthcare indicators in Brazil suggested such an unfavorable scenario. With this in mind, we analyzed time trends of infant mortality in Brazil between 1980 and 1998, in order to identify potential factors which may have influenced the course of infant mortality evolution.

METHODS

An ecological time series study of infant mortality in Brazil between 1980 and 1998 was carried out using mortality data relative to all state capitals nationwide. The single exception was Palmas, in the state of Tocantins, excluded due to the absence of information for the entire period.

Infant mortality rate (IMR) and its neonatal (NMR) and post-neonatal (PNMR) components, as well as proportional infant mortality (PIM) were calculated. The number of deaths among infants (age <1 year) was obtained through the Brazilian Mortality Information System (MIS).[4] The entire population in this age group was used as a denominator for the above mentioned rates due to the lack of reliable estimates of the number of live births for the entire series. For the years 1980, 1991, and 1996, data from Demographic Censuses and Population Counts[4] were used; for the remainder, estimates were made using the geometric growth method.[21]

Values for total fertility rate (TFR), birth rate (BR), unemployment rate (UR), illiteracy rate (IR), annual per capita GIP variations, Gini's Index, proportion of households connected to main water supply network, and proportion of households connected to sanitary sewage network or with septic tank were obtained from publications and from the *Fundação Instituto Brasileiro de Geografia e Estatística* (Brazilian Institute for Geography and Statistics Foundation – IBGE Foundation) web page*.

*Data from the IBGE Foundation web page: http//www.ibge.gov.br [January, 2001]

Annual per capita GIP was used as a percentage rather than an absolute value. We considered the former as an easier means for the reader to understand GIP dynamics. It may also increase the chances of capturing any possible influence this actor may have had on the evolution of infant mortality.

Due to the lack of infant healthcare indicators for the whole series, a proxy was built based on the number of health facilities per 10,000 population, in spite of its lack of discriminatory power. Anti-measles immunization coverage among infants was used as a marker for children's general access to healthcare,[13] due to its ability to express improvements in health facility prevention activities, in addition to greater impact of this vaccine on infant mortality. Both indicators were obtained from the IBGE Foundation* and from the Ministry of Health's *Centro Nacional de Epidemiologia* (CENEPI) of the *Fundação Nacional de Saúde* (FNS) internet pages.[4]

Infant mortality trend analysis was done through graphic representation and through a description of movements observed through visual inspection of time trend curves. IMR curve variations were smoothened using third order moving average techniques.

Time series structure description was carried out by applying Autoregressive Integrated Moving Averages (ARIMA) models to the number of deaths occurred among infants resident in the set of state capitals between 1980 and 1998, clustered by trimester. This technique allows for a description of the degree of auto-explanation between observations based on parameters "p" and "P_s", associated to autoregression, which provide information concerning the order of structural dependence existent between adjacent observations, indicating the existence of autocorrelation. In the equation, ϕ stands for serial correlation coefficient; ϕ_s, "d", and "D_s" specify the number of times the series must be differentiated in order to become stationary; and "q" and "Q_s" indicate the number of moving average terms. In each parameter, the first notation refers to serial trend, and the second to seasonal trend.[3]

Coefficients of variation were also calculated, and annual percentage variations in IMR and its components were examined both for the entire period and for the 1980-1989 and 1990-1998 periods separately.

Statistical associations between IMR and analyzed indicators were verified based on Spearman partial correlation coefficients and their respective 95% confidence intervals for the 1980-1998 period, year by year; and for the 1980 and 1990 decades separately. A test of equality between two correlations[10] was applied in order to identify the occurrence of possible temporal changes in these rates. Statistical software used include Stata 7.0 (2001) and Statistica for Windows 4.3 (1993);[23] a 5% significance level was adopted.

RESULTS

Between 1980 and 1998, IMR in state capitals declined from 67.1‰ to 27.3‰, a 59.3% decrease. The great variability in IMR during this period deserves special attention, especially the periods of stagnation, between 1983 and 1984; and of increase, in 1988, 1992, and 1993 (Table 1 and Figure 1). The 15.0% reduction observed between 1990 and 1991was ascribed mostly to the Northeastern capitals. IMR variation rate in the 1980's (17.7%) was greater than that observed in the 1990-98 period (9.5%). PIM had a more uniform decline – approximately 70% between 1980 and 1989 – when it fell from values above 20% to approximately 7% (Table 1).

Table 1 – Selected indicators of infant mortality for Brazilian state capitals by year. Brazil, 1980-1998.

YEAR	PIM	Infant mortality		Neonatal mortality		Post-neonatal mortality	
		Rate**	Variation (%)	Rate**	Variation (%)	% Rate**	Variation (%)
1980	22.7	67.1	...	29.2	...	43.6	37.3 ...
1981	22.3	65.1	-3.0	29.9	2.3	46.0	34.9 -6.4
1982	21.4	62.5	-4.0	28.7	-4.0	45.8	33.7 -3.4
1983	19.2	57.9	-7.4	27.0	-5.9	46.7	30.5 -9.5
1984	18.5	57.9	0.0	25.5	-5.6	44.1	32.2 5.7
1985	15.9	49.5	-14.5	24.1	-5.5	48.8	25.3 -21.4
1986	14.8	47.8	-3.4	23.3	-3.3	48.8	24.3 -4.0
1987	13.8	44.5	-6.9	23.3	0.0	52.3	21.0 -13.6
1988	13.3	45.2	1.6	23.7	1.7	52.5	21.4 1.9
1989	11.8	40.2	-11.1	21.4	-9.7	53.2	18.6 -13.1
1990	10.8	36.7	-8.7	19.1	-10.8	52.2	17.4 -0.7
1991	9.4	31.2	-15.0	17.7	-7.3	56.9	12.8 -26.4
1992	9.7	33.2	6.4	18.2	2.8	54.8	14.1 10.2
1993	9.4	34.2	3.0	18.9	3.9	55.5	14.3 1.4
1994	9.0	34.1	-0.3	19.6	3.7	57.5	14.2 -0.7
1995	8.5	32.8	-3.8	20.6	5.1	62.9	12.1 -14.8
1996	7.8	30.3	-7.6	19.5	-5.3	64.4	10.8 -15.7

1997	7.3	28.0	-7.6	18.7	-4.1	66.69.3	-13.9
1998	7.0	27.3	-2.5	18.0	-3.7	66.09.2	-1.1

Source: Ministry of Health/DATASUS; IBGE. *Instituto Brasileiro de Geografia e Estatística*PIM- Proportional Infant Mortality

* Except Palmas/ State of Tocantins

**per 1.000<1 year

... Data not available informação omitida

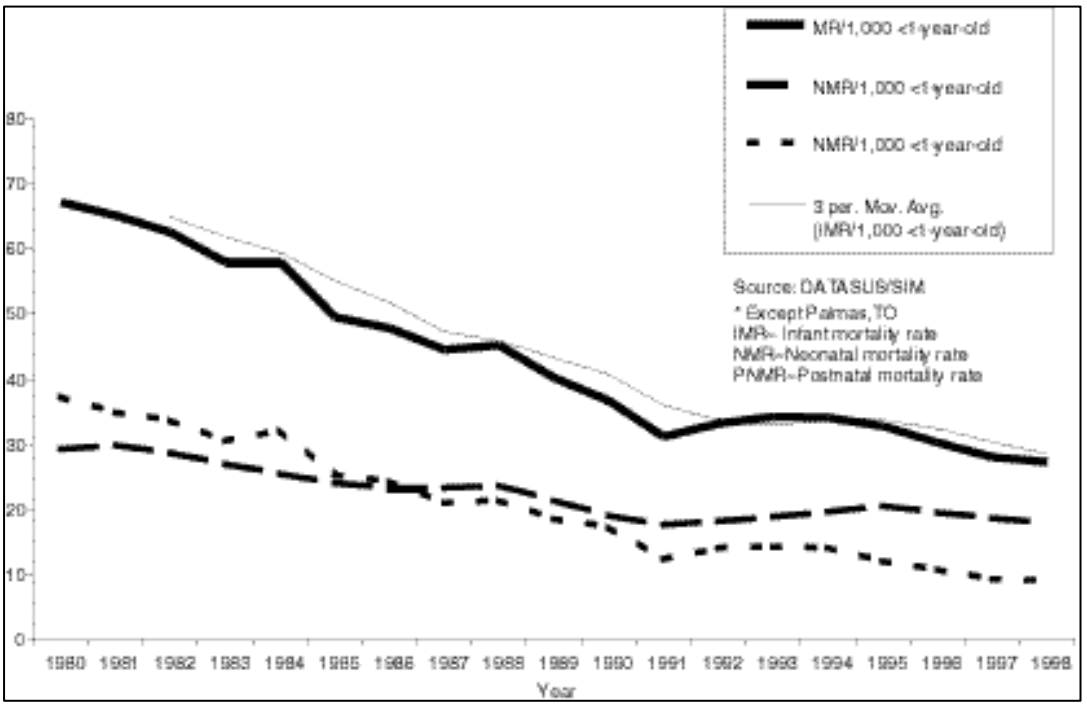

Figure 1 – Infant, neonatal and postnatal mortality rates in Brazilian capitals* according to year of occurrence. Brazil, 1980–1998.

The 29.2‰ neonatal mortality rate observed in 1980 fell to 21.4‰ in 1989, a 26.7% decline. In the 1990-98 period this variation was only 5.7% (from 19.1‰ to 18.0‰) and between 1992 and 1995 there was a slight increase, more pronounced in 1995 (+5.1%). NMR only surpassed post-neonatal infant morality in 1987. The latter suffered a 50.1% reduction in the 1980-89 period (from 37.3‰ to 18.6‰), despite an increase in 1984 and a stagnation period in 1987-88. The 1990-98 period saw a 47.1% reduction, in spite of an increase in 1992 and stagnation in the two following years (Table 1). PNMR variation rate was 23.6% in the 1980-98 period and 21.0% in the 1998-98 period. For NMR these numbers were 11.5% and 4.8% for the two decades, respectively.

ARIMA models applied to quarterly distributions of the number of infant deaths between 1980 and 1998 yielded a final model $(1,1,1)\ (1,1,0)_4$ and ϕ and ϕ_s values of 0.58 (p=0.001) and –0.49 (p=0.0001). This means that the infant mortality curve had serial and seasonal trends with first-

degree autoregression (p=1; P_s=1) and serial and seasonal correlation coefficients of ϕ=0.58 (p=0.001) and $\phi_{s=}$-0.49 (p<0.0001), respectively. Hence the first number of the series was positively correlated (58.0%) with the second one, which, in terms of serial trend, means that if the first observation is large, so will be the second one; if it is small, so will be the second one as well. However, in the case of seasonal trends, an inverse correlation was verified between seasonally adjacent observations, that is, a large first observation was followed by a small second one. Figure 2 clearly shows such trends; one can also see that both the amplitude of seasonal variation and the decline in the number of infant deaths decreased from the last years of the 1980's onwards.

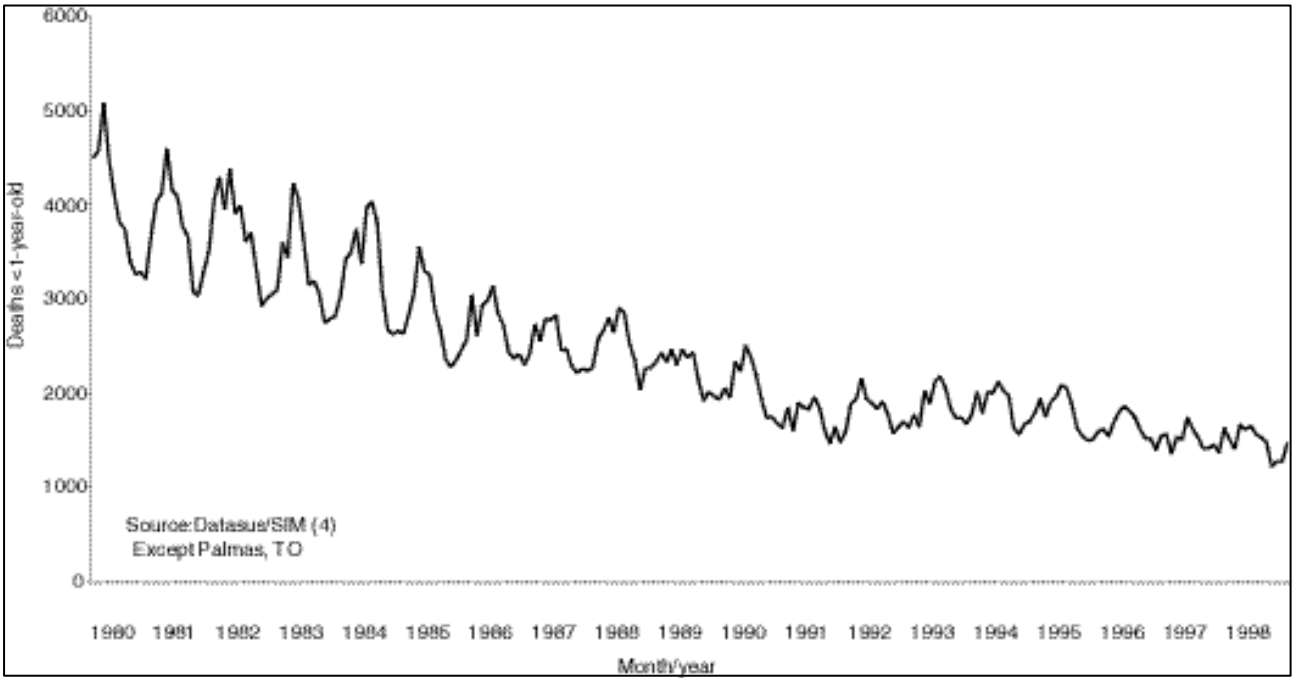

Figure 2 – Death for children under 1-year-old in Brazilian capitals according to year and month of occurrence. Brazil*, 1980–1998.

Tables 2 and 3 show that the illiteracy rate fell from 25.5% in 1981 to 9.0% in 1998, being strongly correlated with IMR (r=0.929; p=0.00) in the 1990-1998 period, for which a larger number of observations were available for this indicator. Both anti-measles immunization coverage among infants and the proportion of households connected to sewage networks or with septic tank were higher and had greater variation in the 1990's; their correlation with infant mortality during this period was also higher.

Table 2 – Infant mortality rate and some socio-economic indicators, Brazil, 1980-1998.

Year	IMR	Illiteracy Rate	Unempl. rate.	Birth rate.	Total Ferti- lity rate	Var/GIP per capita	Gini's index	Health fac. /10.000 hab	AM immuniz. Cov.<1year(%)	Water**	Sewage***
1980	67.1	...	...	31.23	4.02	6.7	0.597	1.6	56.0	...	53.0
1981	65.1	25.5	...	30.70	3.91	-6.6	0.584	1.8	72.0	60.1	56.2
1982	62.5	...	...	30.09	3.72	-1.7	0.587	1.9	66.0	64.6	57.2
1983	57.9	...	6.3	29.49	3.61	-5.5	0.589	2.0	68.8	66.2	56.0
1984	57.9	...	7.5	28.89	3.43	3.0	0.588	2.1	73.0	67.9	58.7
1985	49.5	...	6.3	28.20	3.30	5.6	0.592	2.2	67.0	69.9	...

1986 47.8...	4.2	27.24 3.18	5.2	0.586 2.3	62.0	70.0	…	
1987 44.5...	3.2	26.30 3.04	1.4	0.597 2.4	64.0	70.9	…	
1988 45.2...	3.8	25.39 2.95	-2.2	0.606 2.4	59.0	72.2	…	
1989 40.2 14.8	3.9	24.53 2.82	1.2	0.647 2.5	60.0	...	…	
1990 36.7 14.6	3.3	23.54 2.72	-6.0	0.620 2.5	78.0	...	…	
1991 31.2...	5.2	22.89 2.73	-1.4	0.636 ...	85.0	...	…	
1992 33.2 12.4	6.5	22.09 2.66	-0.6	0.575 3.3	91.0	73.6	56.7	
1993 34.2 11.3	6.2	21.37 2.60	-2.1	0.603 ...	85.0	75.0	58.8	
1994 34.1...	…	20.75 2.54	3.4	... ...	78.2	...	…	
1995 32.8 9.9	6.1	20.14 2.49	4.3	0.592 ...	89.6	76.3	60.0	
1996 30.3 8.3	7.0	19.69 2.44	2.8	0.590 ...	79.9	77.7	63.7	
1997 28.0 8.7	7.8	19.25 2.40	1.3	0.588 ...	90.1	77.7	62.5	
1998 27.3 6.9	9.0	18.81 2.36	2.2	0.584 ...	…	78.8	63.9	

Source: Ministry of Health/DATASUS. IBGE.*Instituyo Brasileiro de Geografia e Estatística*

* State capitals, except for Palmas/To – rate per 1000 < 1 year

**Percentage of households connected to water supply network

***Percentage of households connected to sewage network or with septic tank

... Data not available

Table 3 – Spearman correlation coefficient (r) for the association between infant mortality coefficient and some socio-economic, demographic and healthcare indicators, Brazil, 1980-1998.

Indicator	1980-1989			1990-1998			1980-1998		
	N	r	p-value	N	r	p-value	n	r	p-value
Total fertility rate**	10	0,985	0,00	9	0,700	0,04	190,998		0,00
Birth rate/1000 population**	10	0,985	0,00	9	0,783	0,01	190,975		0,00
Variation(%) in *per capita* GIP	10	0,000	1,00	9	-0,433	0,24	19	-0,059	0,81
Gini's index	10	-0,561	0,09	8	0,452	0,26	18	-0,073	0,77
Unemployment rate	7	0,864	0,01	8	-0,786	0,02	15	-0,341	0,21
Number of health facilities/10.000 population	10	-0,982	0,00	…..		…	……		…
Anti-measles immunization coverage among infants	10	0,286	0,42	8	-0,479	0,22	18	-0,737	0,00
Illiteracy rate	…	...	…	7	0,929	0,00	……		…
% households connected to water supply network	8	-0,970	0,00	6	-0,923	0,00	14	-0,989	0.00
% households connected to sewage network/septic tank	5	-0,564	0,32	6	-0,943	0,00	11	-0,884	0,00

Source:Ministry of Health/DATASUS. eIBGE.*Instituto Brasileiro de Geografia e Estatística*

* Rate per 1000 <1 year for all Brazilian state capitals except for Palmas/To

** Statistically significant differences between 80-89 and 90-98 correlation coefficients

N = number of years in the series

... Data not available

Tables 2 and 3 also show that the greatest levels of unemployment occurred during the first five years of the 1980's decade. In this period these rates had a strong positive correlation with IMR (r=0.864; p=0.01). The number of children per woman in reproductive age varied between 4.0 and 2.8 between 1980 and 1989, with a 3.4 average. This number fell to 2.5 in the following decade, ranging from 4.0 to 2.4. There was a very strong correlation between TFR and IMC values, especially between 1980 and 1989 (r=0.985'p,0.001). The greatest negative variations in per capita GIP were registered in 1981 and 1983, but this indicator was not correlated with IMR. The remaining indicators provided no further statistically significant correlations. Statistical tests for equality of correlations were performed in order to compare correlation coefficients from the 1980-89 and 1990-98 periods. Only the correlation coefficients related to the association between TFR/BR (collinear variables) and IMR yielded statistically significant differences.

DISCUSSION

The interpretation of study results based on secondary data requires caution, especially if dealing with studies based on Brazilian Information Systems, which experienced different stages of development and organization during the period studied, including variations in coverage and availability that most certainly affect the quality of historical series. Furthermore, one must consider the lack of a number of live births for the entire period, the arguable limitations of the independent variables employed in order to reflect population-wide living conditions, and the fact that the annual fertility rates used refer to estimates obtained through indirect techniques, not always based on a full set of the necessary data for such calculations. Result interpretation in the present study also faces difficulties posed by the recognition, to any degree of certainty, of the impact exerted by economic crises. This may be ascribed to the adoption of compensatory interventions, intended to counteract the effects of crisis. The lack of knowledge concerning the time period necessary for such effects to become perceptible poses further problems.

However, despite all these limitations, the declining trend observed for infant mortality in the present study can be considered perfectly valid, since more trustworthy data were used, provided by state capitals. Data obtained directly from the Mortality Information System (MIS) have greater sensitivity in order to express variations possibly produced by economic crises or demographic alterations, as long as one assumes their quality to be constant. In this sense, it is important to note that the most marked reduction, observed in 1991 in the time-trend infant mortality curve, may be a result of specific operational problems due to the beginning of the MIS decentralization process, in 1993 (there was, at that time, a two-year lag in data processing in this system).

Therefore, despite the great variability observed in infant mortality levels in Brazil between 1980 and 1998, their declining trend is evident, as demonstrated by previous studies.[2,4] It is hence pertinent to consider the fluctuations observed in the infant mortality curve as a result of the impact of economic crises occurred in the period,[1,3] despite the attenuation provided by the adoption of public compensatory policies.

The greater pace of the decrease in infant mortality observed during the 1980's may be explained by the its higher levels at the beginning of the period. On the other hand, the intensive implementation of oral rehydration therapy from 1988 on may account for the substantial decline in post-neonatal deaths due to infectious intestinal disease. Reductions in the amplitude of seasonal infant mortality variation observed in the present investigation may be considered as an evidence in favor of this hypothesis.

As expected, demographic, socioeconomic, and healthcare indicators were in general strongly associated with infant mortality. The absence of a statistically significant negative association between infant mortality and "percentage of households connected to sewage network or with septic tank" in 1980-89 and "anti-measles immunization coverage" in both 1980-89 and 1990-98 may be due to the little variability observed in these two indicators during both periods. It is thus possible that reductions in illiteracy, increases in anti-measles immunization coverage, and the expansion of the water supply network registered in the 1990's may have contributed to the decrease in the number of avoidable deaths among live births.

Nevertheless, there was a reduction in the absolute number of infant deaths due to all causes except for congenital anomalies and external causes. In addition, it was only from the 1990's onwards that the restructuring of the healthcare sector in Brazil began, after the implementation of the *Sistema Único de Saúde* (Unified Healthcare System) in 1988. In the preceding decade, the inflationary process experienced by the country – along with increases in medical/hospital/outpatient care complexity and costs – contributed to a further hampering of service accessibility and to reductions in efficiency and efficacy in the public healthcare sector.[5] It can thus be argued whether the interventions implemented in order to minimize the effects of crisis – most of which were adopted from the end of the 1980's onwards – were able, by themselves, to sustain the decline in infant mortality during that period.

In order to consider a factor as explicative of any given trend, it needs to have some degree of temporal variation. Of the variables analyzed, this was the case only with birth and total fertility rates, since these were the only variables whose correlation coefficients with infant mortality differed significantly from one decade to the next.

The rapid reduction in fertility rates was recognized as an actuality in the 1980's, especially during the first half of the decade, when it was as high as 19.0% (in the entire previous decade these rates declined 25%; this occurred especially among poorer women and in regions where living conditions were precarious).[7] In the 1990's, a 14.8% reduction in fertility rates (from 2.7 to 2.3 children per woman) was observed between 1992 and 1999. The difference in mean number of children per woman between the Northeast and Southeast Regions fell from 1.0 to 0.5.[8] In light of this evidence, it is reasonable to propose the hypothesis that fertility rate variations were the main cause for the sustained decline in infant mortality in the 1980's.

Among the mechanisms by which fertility rates may influence the persistence of the decline in infant mortality rates in Brazil, we must mention the relative reduction, in the 1980's, of the number of children born from mothers living in precarious conditions – hence at greater risk of dying during their first year of life. Other mechanisms include: the mediation provided by factors such as the reduction in the number of preterm and shortly spaced births and the number of high parity and older mothers, as occurred in Brazil; increases in economic efficiency due to reductions in inter-familiar dependence and in the demand for healthcare services, and to an increase in the amount of time available for mothers to care for their children.[13]

The hypothetical contribution of a reduction in illiteracy rates contributing towards the maintenance of the decline in infant mortality via a decrease in fertility rates seems improbable, since, according to data from the 1980 and 1991 Demographic Censuses, the proportion of illiterate women between ages 15 and 49 years in this period in Brazil was 17.5% and 29.4%, respectively. Furthermore, it has been demonstrated that, in that occasion, the reduction observed in fertility rates was due to economic causes,[2] reaching especially poorer women living in regions with more precarious living conditions, of whom a large proportion used permanent contraceptive methods (sterilization).[7]

As to the 1990's, it is likely that increases in service availability and other social advances be the factors that most contributed to the maintenance of the declining trend in infant mortality[8,13] This is especially the case in the North and Northeast, the less economically and socially developed regions. Thus, when analyzing factors associated with infant mortality trends in underdeveloped countries from the 1990's onwards, no single factor or small group of factors may be considered as most relevant for the reduction of infant mortality levels, since the behaviors observed in relation to some of these factors, such as fertility rate, breastfeeding, and infant nutrition were of little significance in this period. They may have therefore played a minor role in infant mortality trends.[19]

The decentralization of healthcare services and interventions registered in the 1990's in Brazil, especially after the implementation of *the Normas Operacionais Básicas* (basic operational norms - NOB) in 1993,[12] may have contributed towards the development of healthcare strategies directed towards the more vulnerable groups. Such decentralization resulted in increased immunization, antenatal care, and medical appointment coverage,[9] positively affecting infant mortality rates. Although such social accumulation may constitute compensatory policies or short-term stores of protective factors, the question remains as to whether they will be sufficient to guarantee the pace of the decline in infant mortality in case economic crises persist, increasing social exclusion and intensifying inequities in access to healthcare and consumer goods that assure better living conditions.

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