SPATIO-TEMPORAL TRENDS OF INFANT MORTALITY IN BRAZIL

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Extended Abstract:

Infant mortality in Brazil has declined appreciably in the past decades, with most significant gains observed since the 1970s [1,2]. Between 1930 and 1970, the infant mortality rate (IMR) for the country declined by 29.2%, but still remained above 100 per 1,000 live births. Between 1970 and 2005, however, IMR was reduced by 79.7%. These gains significantly contributed to increases in the country's life expectancy at birth [3], and put Brazil in a favorable position to achieve internationally set goals to reduce mortality among infants. In 1990, the World Summit for Children adopted a target to reduce the 1990 IMR by one third, or to 70 per 1,000, whichever was the greater reduction, by the year 2000 [4]. Brazil registered a 42% decline in IMR between 1990 and 2000, surpassing the set target, and achieving an IMR of 27.6 per 1,000 in 2000. Also, Brazil had the second best performance in reducing mortality among children younger than five years during 1990-2006 [5]. These results place Brazil among the 16 countries on track to meet the Millennium Development Goal 4 (MDG): reduce child mortality by two thirds between 1990 and 2015 [5,6].

Nonetheless, with an IMR of 23.5 per 1,000 in 2005, Brazil still lags behind other countries in South America, such as Uruguay (13.1 per 1,000) and Chile (7.2 per 1,000). Most importantly, the overall decline in IMR does not necessarily indicate that inequalities in infant mortality within the country were equally reduced. This is a critical issue for Brazil, since the country has historically ranked high in terms of income concentration worldwide – Brazil ranked 2nd in 1998 [7], and in 1999 it was the country with the highest ratio between the average income of the 20% richer and the 20% poorer, above 30 [8]. Despite recent improvements [9], the Gini Index in 2007 was at 57, placing Brazil as the 11th most unequal country in the world [10].

Regional inequality in Brazil regarding access to services, as well as social and health outcomes has been widely recognized: while the South and Southeast regions regularly report higher income and better socio-economic indicators, the North and Northeast regions often lag behind [11-13]. As a result, IMRs present a distinct clustering pattern across micro-regions, with high rates often concentrated in the Northeast, and low rates in the Southern portion of the country. Despite this pattern, declines in IMR have occurred countrywide. In an ideal scenario, these declines should be accompanied by reductions in inequalities between rich and poor areas. However, the "inverse equity hypothesis" [14] postulates that inequalities may temporarily increase or remain unchanged after the introduction of interventions targeted to reduce infant mortality. The increase is expected to hold until richer areas have reached low levels of IMR (with further improvements harder to achieve), and poorer areas achieve wider access to means for promoting policies toward IMR decline [14]. Also, considering a coverage gap index, which measures the gap between ideal and actual coverage of varied interventions focused on maternal, newborn, and child health, Brazil had a small coverage gap in 1995-99, but presented one of the largest ratios of differences between the two poorest and the two wealthiest quintiles [15].

In this paper we address the issues discussed above, and aim to investigate spatio-temporal trends in infant mortality in Brazil between 1980 and 2005, utilizing a time series of indirectly estimated IMRs for micro-regions [16]. First, we appraise the declines in IMR and in inequalities in infant mortality, in light of the "inverse equity hypothesis". Second, we evaluate the presence of clusters of high and low infant mortality in micro-regions, and assess if/how the clustering pattern changed over time and across space. We also investigate the clustering pattern of the relative change in IMR for 5-year periods of time in an effort to examine whether or not the gains were primarily concentrated in specific areas of the country.

All data gathered for this study are detailed by micro-region, which is an areal aggregation of several municipalities (Lima et al. 2002). Brazil is currently divided into 5,565 municipalities, 557 micro-regions, and 5 regions. Information on deaths can be obtained through varied data sources in Brazil, but the under-registration of deaths, especially those of children younger than 1 year in rural areas of the North and Northeast regions, is still an impediment to calculating IMR directly. Therefore, indirect techniques of estimation are needed, which demand the use of data only available in Demographic Census and special surveys. In this study we used the Demographic Census data (1980-2000) for the estimation of IMR by micro-regions. We also utilized the National Sampling Household Survey (PNAD) collected in 2004, 2005 and 2006, combined with Census data (1940-2000), to produce IMR estimates by regions. From each source we extracted information on: (i) number of women aged between 15-49 years by 5-year age groups; (ii) number of children ever born classified by age group of mother; and (iii) number of children surviving classified by age group of mother.

Indirect estimations of infant mortality were obtained from information on child survivorship [17-20]. The indirect method allows the conversion of proportions dead among children ever born to women in each five-year age group of the reproductive period into estimates of the probability of death, conventionally reported in life tables as ${}_nq_x$, through the application of multipliers that account for non-mortality factors impacting the proportions dead [17]. These multipliers were estimated based on the West mortality model [21] of Trussell's variant of the original model [22].

The estimates for ${}_0q_1$ were allocated in time [23], resulting in a time series of estimated IMRs from each data source utilized. That series was subjected to small fluctuations due to problems in reporting the exact number of children ever born and children surviving. We addressed this issue by smoothing the series of estimates using a 3-year or 5-year moving average, depending on the degree of fluctuations. The smoothed series was adjusted by a logistic function to estimate and project IMRs. The estimation exercise for regions utilized both Census and PNAD data. The use of PNAD information for 2004-2006 provided recent mortality estimates that facilitated the adjustment by the logistic (while the Census 2000 allowed us to obtain indirect estimates allocated until 1998, PNAD data generated estimates until 2004). In the case of micro-regions, we used only Census data, since the sample design of PNADs does not allow the disaggregation at the micro-region level [16].

Inequality in infant mortality was assessed through the use of two indicators. First, we adapted the concept of inequity ratios proposed by Victora and colleagues [14] to compute ratios that compare the extremes in infant mortality, providing a measure of the relative gap in the regional distribution of IMRs. In other words, we computed the ratio between the smallest and the largest IMR estimated for each year to evaluate whether or not inequality in infant mortality was decreasing. Second, we calculated the concentration index [24-26], considering the micro-region as the unit of analysis, the municipal GDP aggregated to the micro-region as an income-related indicator, and the infant mortality as the health variable. For each decile of the GDP distribution we obtained the total number of children aged 0-1 and the average IMR, from which we estimated the number of deaths. Negative numbers of the index indicate that infant deaths are concentrated among poor micro-regions, or those with the lowest GDP.

The presence of spatial clusters of high and low IMR were assessed through the use of a local indicator of spatial association (LISA), specifically the local Moran's I_i statistic [27,28]. Standard normal variates for the statistic, Z(I_i), were computed and the assessment of significance was based on a normal distribution: significant high values of Z(I_i) indicate positive spatial autocorrelation – cluster of similar values (either high or low), while significant low values of Z(I_i) indicate negative spatial autocorrelation – areas of dissimilarity [27]. The weight matrix was defined based on a first-order queen neighborhood definition. All results were corrected for multiple testing utilizing the False Discovery Rate control procedure [29,30]. We calculated local Moran's I_i for each year of available IMR estimates. In addition, we applied the LISA statistic to the percentage change of IMR observed during each 5-year period from 1980 to 2005, in order to assess if relative reductions in IMR were spatially randomly distributed or concentrated in particular areas.

Our spatio-temporal analysis of infant mortality by micro-regions in Brazil demonstrates that significant reductions have been observed, particularly since the 1970s, although the changes did not alter significantly the clustering pattern of high and low IMRs in the country (Fig 1). Better outcomes remained concentrated in the Southern regions, while higher infant mortality was, for the most part, restricted to the Northeast region. Of special note is the fact that the spatial pattern of rates of change of infant mortality was dramatically transformed during the 2000-2005 period, when significant reductions in IMR were clustered in the Northeast (Fig 2). Equally important is the fact that these declines were not accompanied by significant reductions in inequality of infant mortality. The relative gap between the better off and the worse off micro-regions remained unaltered, and therefore infant deaths remained disproportionally concentrated among the poorest areas (Fig 3).

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Figure 1 – Summary of clustering pattern of infant mortality by micro-region and based on estimated IMR for 1980, 1985, 1990, 1995, 2000 and 2005

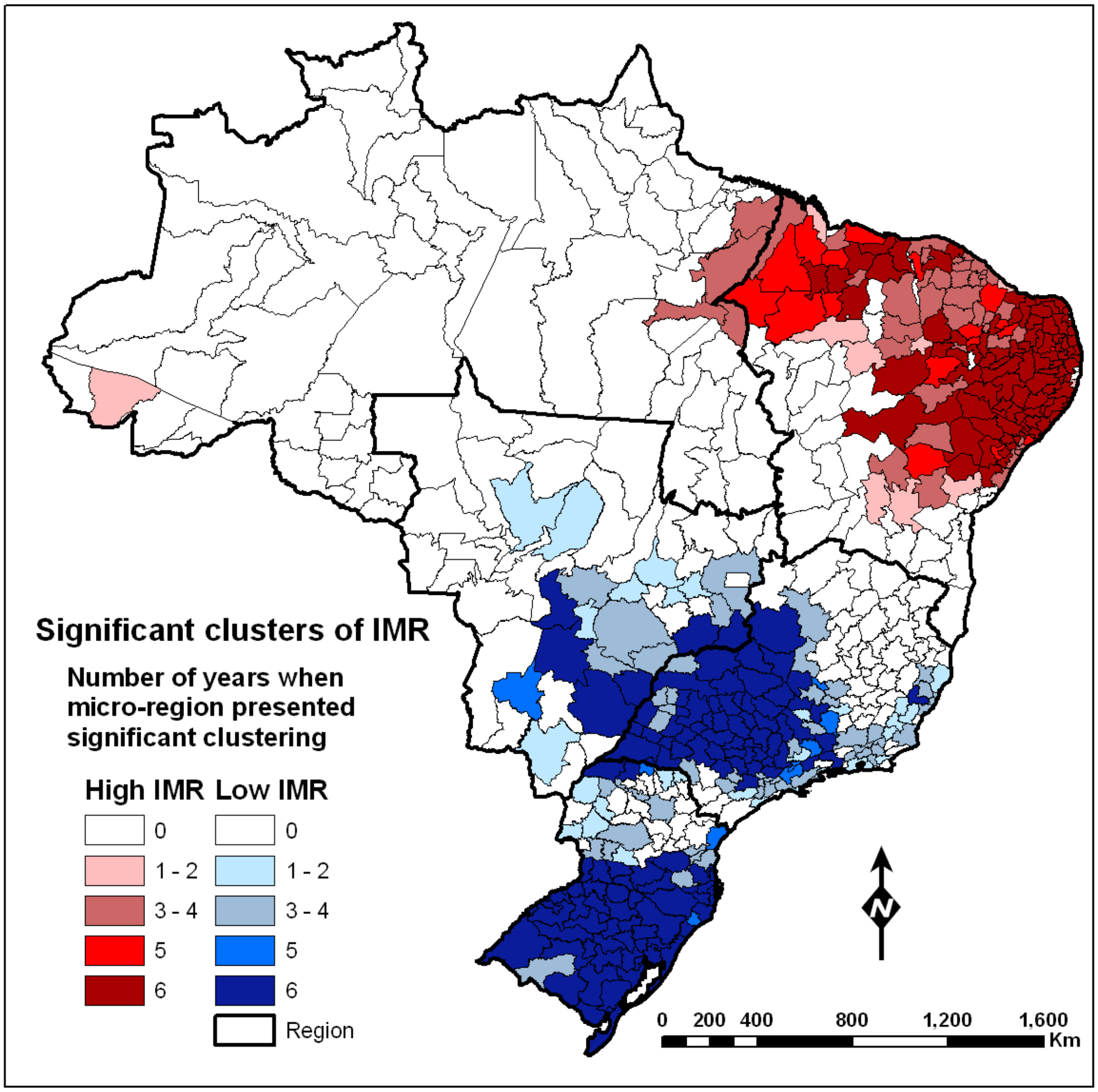


Figure 2 – Clustering pattern of percentage changes in infant mortality by micro-region for each 5-year period between 1980 and 2005

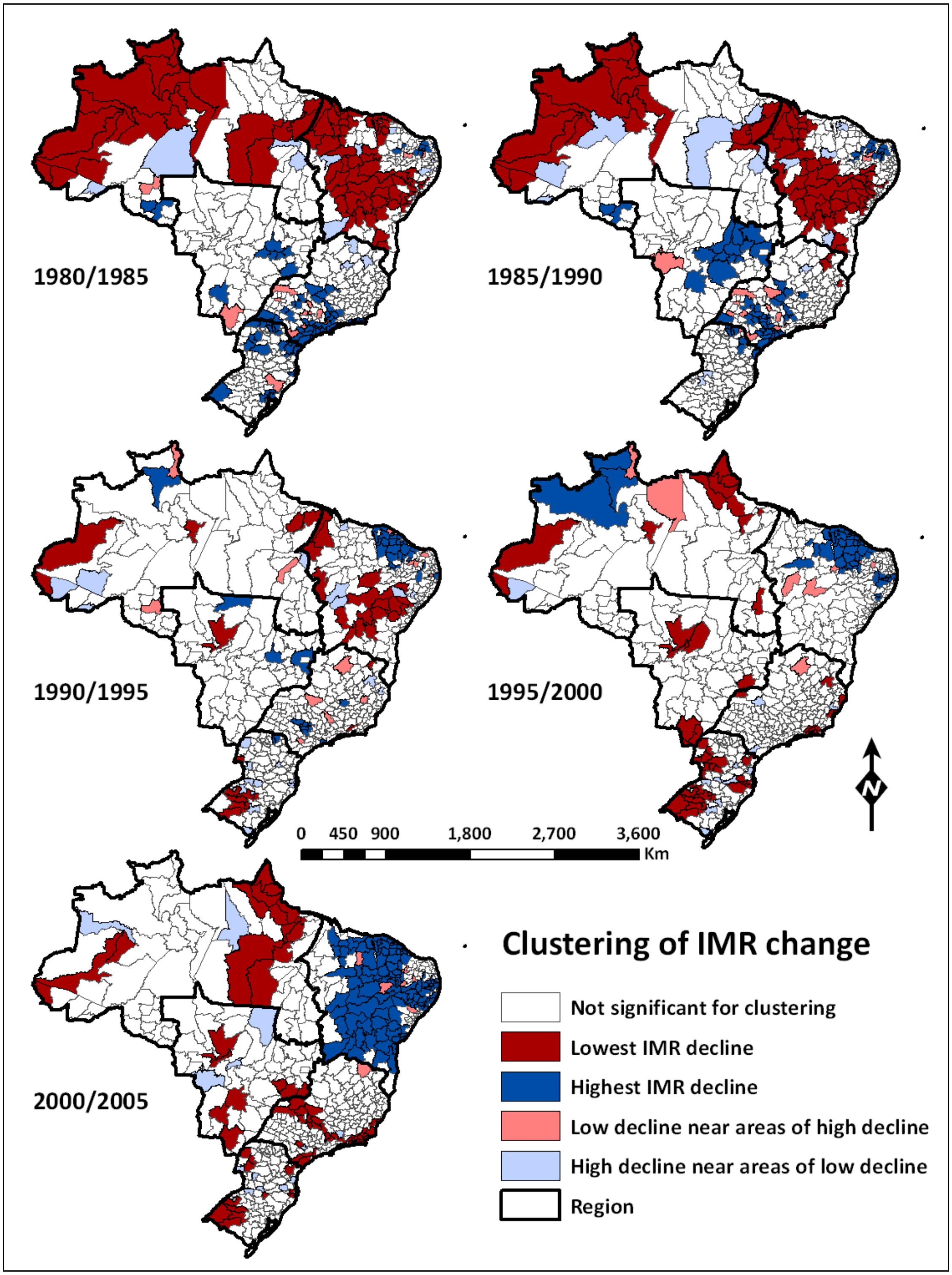
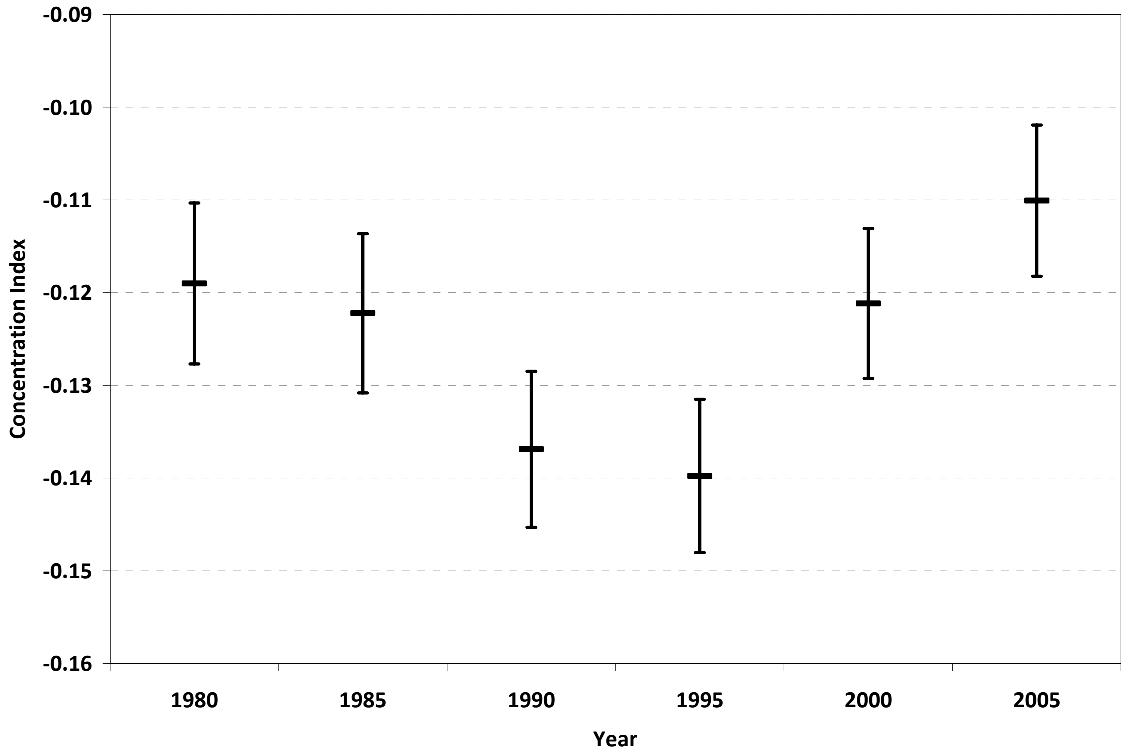


Figure 3 – Concentration Index of infant deaths by micro-region GDP – 1980-2005



Concentration index
Range: -1 to 1
-1 (all infant deaths concentrated amongst poor micro-regions (low GDP)
1 (all infant deaths concentrated amongst rich micro-regions (high GDP)