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Correcting vital information: estimating infant mortality, Brazil, 2000-2009

ABSTRACT

OBJECTIVE: To propose a simplified method of correcting vital information and estimating the coefficient of infant mortality in Brazil.

METHODS: Vital data in the information systems on mortality and live births were corrected using correction factors, estimated based on events not reported to the Brazilian Ministry of Health and obtained by active search. This simplified method for correcting vital information for the period 2000-2009 for Brazil and its federal units establishes the level of adequacy of information on deaths and live births by calculating the overall coefficient of mortality standardized by age and the ratio between reported and expected live births, respectively, in each Brazilian municipality. By applying correction factors to the number of deaths and live births reported in each county, the vital statistics were corrected, making it possible to estimate the coefficient of infant mortality.

RESULTS: The highest correction factors were related to infant deaths, reaching values higher than 7 for municipalities with very precarious mortality information. For deaths and live births, the correction factors exhibit a decreasing gradient as indicators of adequacy of the vital information improve. For the year 2008, the vital information corrected by the simplified method per state were similar to those obtained in the research of active search. Both the birth rate and the infant mortality rate decreased in the period in all Brazilian regions. In the Northeast, the annual rate of decline was 6.0%, the highest in Brazil (4.7%).

CONCLUSIONS: The active search of deaths and births allowed correction factors to be calculated by level of adequacy of mortality information and live births. The simplified method proposed here allowed vital information to be corrected per state for the period 2000-2009 and the progress of the coefficient of infant mortality in Brazil, its regions and states to be assessed.

DESCRIPTORS: Infant Mortality. Vital Statistics. Birth Registration. Mortality Registries. Underregistration. Information Systems.

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INTRODUCTION

The Brazilian Institute of Geography and Statistics (IBGE) is responsible for processing the data from civil records in Brazil, including births and deaths.¹⁵ Limitations related to coverage of information on deaths and the lack of variables relevant to tracking epidemiological profiles of mortality gave rise to the establishment of the Brazilian Ministry of Health (MH) Mortality Information Reporting System (SIM) in 1976. Years later, in 1992, the MH developed a system of registering live births (SINASC), due to the need for data on birth and delivery conditions, until then inexistent at a national level.¹²

The MH and the state and municipal health departments developed strategies for consolidating vital information through coordinated initiatives that involved producing, distributing and controlling recording forms, as well as collecting, processing and disseminating the data.¹⁷ Actions were adopted to broaden the capture of vital information and to reduce the percentage of deaths from undetermined underlying causes, including goals related to coverage of information on mortality in the Agreed and Implemented Program.⁹

A committee to monitor mortality data^a has been recently created to improve and regulate the flow of information. Commissions were also set up to investigate infant deaths in various municipalities,¹⁴ contributing to improvements in data recording.

Advances in the decentralization process of health care actions and establishing health care agreements between the three managerial spheres (federal, state and municipal) encourage the increased demand for data that could evaluate programs aimed at reducing infant mortality.⁹ Systems of vital information have become more relevant, and diverse assessments of the SIM and SINASC^{5,8} have taken place, highlighting aspects to prioritize in interventions aiming to improve quantitative and qualitative data.^{1,10}

Among the research methods adopted to assess the coverage of vital information systems, actively searching for events proved to be a promising strategy for identifying cases not captured by the systems. There were two principle aims for which this took place: to understand the process involved in producing information in locations with precarious data;^{4,6} and due to the incoherence of trends in infant mortality and SIM coverage. These trends are obtained using indirect

demographic techniques,^{13,19} incompatible with investments made in reducing infant mortality and improving vital information systems.¹⁶

Research on the active search for infant deaths took place in clusters of municipalities located in states in 2000, with a great deficit of vital information. In addition to identifying deaths not reported in the system, it was also possible to map SIM operational problems in the local area.⁷ SIM coverage had increased in the majority of clusters studied, years after the research took place.⁷

The need to assess the criteria used in analyzing coverage and regulation of MH vital statistics¹ and to investigate temporal evolution of infant mortality in regions with precarious vital information resulted in a wider study being developed. This research involved actively searching for births and deaths in a probabilistic sample of municipalities, stratified by population size, adequacy of vital information and region.^b

The study, called the Active Search for Births and Deaths in the Northeast and Amazonia, took place between 2009 and 2010, and aimed to assess the coverage of vital information systems in 2008, as well as to estimate correction factors for mortality indicators through using MH vital information.^{b,c} SIM coverage in Brazil was estimated to be 93.0%, and SINASC coverage to be 95.6%. The coverage for infant deaths was lower (81.6%) and showed notable inequalities between regions, varying from 61.6% to 83.0% in states in the Amazon and the Northeast and reaching almost 100.0% in the South and Southeast.^b

The consistency of the results obtained in estimating coverage of the information systems, with coverage decreasing as levels of adequate vital information worsened,^c raised the possibility of using correction factors obtained in the active search to correct vital information for recent years. This work aimed to propose a simplified method for correcting MH vital information and estimating the coefficient of infant mortality in Brazil.

METHODS

Based on the results found in the active search for births and deaths in the Northeast and the Amazon region,^a a method was proposed for correcting SIM

^a Ministério da Saúde. Secretaria de Vigilância em Saúde. Painel de monitoramento da mortalidade infantil e fetal. Brasília (DF); 2013 [cited 2013 Nov 22]. Available from: <http://svs.aids.gov.br/dashboard/mortalidade/infantil.show.mtw>

^b Szwarcwald CL, Morais Neto OL, Frias PG, Souza Jr PRB, Escalante JJC, Lima RB, et al. Busca ativa de óbitos e nascimentos no Nordeste e na Amazônia Legal: estimação das coberturas do SIM e do Sinasc nos municípios brasileiros. In: Ministério da Saúde. Saúde Brasil 2011: Uma análise da situação de saúde (DF); 2011. p. 79-97.

^c Szwarcwald CL, Morais Neto OL, Frias PG, Souza Jr PRB, Escalante JJC, Lima RB, et al. Busca ativa de óbitos e nascimentos no Nordeste e na Amazônia Legal: estimação da mortalidade infantil nos municípios brasileiros. In: Ministério da Saúde. Saúde Brasil 2011: uma análise da situação de saúde. Brasília (DF); 2011. p. 99-116.

and SINASC data in order to estimate the coefficient of infant mortality (CIM) per state for 2000 to 2009.

The research took place between September 2009 and June 2010. A probabilistic sample of 133 municipalities was selected, stratified by region (Amazon region; Northeast), by population (one to 20,000 inhabitants; 20,001 to 50,000 inhabitants; 50,001 to 200,000 inhabitants; more than 200,000 inhabitants) and by adequacy of vital information (non-consolidated information; in the process of consolidation; consolidated), making 24 strata. Four or five municipalities were randomly selected from each strata. All state capitals were included.

An active search for births and deaths in 2008 took place in the selected municipalities in order to identify birth (BC) and death certificates (DC) that had been issued but not reported to SINASC or SIM, respectively, and live births (LB) and deaths for which BCs and DCs were not issued. The MH/Department of Health Monitoring provided a nominal list of all LB and deaths that occurred in the selected municipalities in 2008. This nominal list was drawn up based on births and deaths reported to SINASC, SIM and the Hospital Information Systems (SIH). The data collected during the active search process were used to complete the original nominal lists of deaths and live births.

The following sources of data were used: notaries, secretaries from social action programs (Register of Federal Government Social Programs – *Programa Bolsa Família*; burial support; clothing support); hospitals, health care centers; the Coroners service and the Forensic Institute; patient transport services (ambulances, mobile emergency care service (SAMU) and the fire brigade); official and non-official cemeteries (burial places); funeral homes; police stations; traditional midwives; churches and pharmacies. In each municipality of the sample and in neighboring municipalities, notaries and hospitals where births and deaths from the municipality in question had been registered were investigated. Births and deaths found in the active search with no record in the notaries or primary health care units were confirmed by the household.

The overall standardized mortality rate (OSMR) per age was calculated for the population of Brazil, for the same year, as a standard characterizing the adequacy of data on deaths. The OSMR were grouped into categories (≥ 1 and < 2 ; ≥ 2 and < 3 ; ≥ 3 and < 4 ; ≥ 4 and < 5 ; ≥ 5 and < 5.5 ; ≥ 5.5 per 1,000 inhabitants), in each state.

Correction factors were estimated for each state according to category of OSMR, calculated using the ratio between the sum of deaths corrected for the active search process^{b,c} and the sum of deaths reported. Deaths

in those aged under and those aged over one year were considered separately.

The OSMR was estimated for all Brazilian municipalities by generalizing the process of correcting deaths reported to the SIM per state from 2000 to 2009. The populations of the municipalities were estimated by age group (in years: < 1 ; 1 to 4; 5 to 9; 10 to 14; 15 to 19; 20 to 29; 30 to 39; 40 to 39; 50 to 59; 60 to 69; 70 and over) and by year of the period in question. Total populations and age distributions of the municipalities, per year, were obtained by interpolating between census populations from 2000 and 2010 and the respective proportions per age group.

Deaths reported in the three-year-period corresponding to each year were considered to provide the estimates with more stability, i.e., the means of reported deaths per age group were calculated for the three-year-periods 1999 to 2001, 2000 to 2002, 2001 to 2003, 2002 to 2004, 2003 to 2005, 2004 to 2006, 2005 to 2007, 2006 to 2008, 2007 to 2009 and 2008 to 2010. Deaths for which the municipality was unknown were redistributed proportionally between the municipalities in the same state, and those for which the age was unknown were redistributed proportionally between those for which the ages were known, per three-year-period.

The Brazilian municipalities were classified by level of adequacy of mortality data, according to OSMR category in order to generalize the correction procedures for infant deaths between 2000 and 2009 in each three-year-period. Reported deaths in those aged under one year in all Brazilian municipalities in the period, were corrected by the corresponding correction factors estimated in each state. The correction factors were kept constant per OSMR category, but not per municipality. In other words, if there was better coverage of mortality information in a specific municipality throughout the period, the lowest correction factor would be applied as it passed into another OSMR category. The corrected number of deaths per state, per year of the period, were obtained by summing corrected deaths for the municipalities in that state.

Similarly, in order to estimate correction factors for live births (LB), the municipalities were grouped per state and level of adequacy in LB data, shown by the ratio (LBR) between reported and expected LB, calculated using the estimated population aged under one year.^d When calculating the indicator, the mean of LB reported per three-year-period (1999-2001 to 2008-2010). For the three-year-period corresponding to 2008, the sampled municipalities in the active search project were grouped into categories (< 0.5 ; ≥ 0.5 and < 0.6 ; ≥ 0.6 and < 0.7 ; ≥ 0.7 and < 0.8 ; ≥ 0.8 and < 0.9 ; ≥ 0.9). The LB correction

^d United Nations. Model life tables for developing countries. Geneva; 1982 [cited 2013 Nov 22]. (United Nations publication, E.81.XIII.7). Available from: http://www.un.org/esa/population/techcoop/DemMod/model_lifetabs/model_lifetabs.html

Table 1. Synthesis of procedures for estimating the Coefficient of Infant Mortality per state. Brazil, 2000 to 2009.

Correction of reported infant deaths

1. Estimate OSMR in all Brazilian municipalities for the three-year-period 2007-2009;
2. Calculate correction factors for state and categorize the OSMR (≥ 1 and < 2 ; ≥ 2 and < 3 ; ≥ 3 and < 4 ; ≥ 4 and < 5 ; ≥ 5 and < 5.5 ; ≥ 5.5 per 1,000 inhabitants) using death data corrected by active search and reported to the SIM;
3. Estimate the OSMR for all Brazilian municipalities, for each three-year-period between 2000-2009;
4. Classify all Brazilian municipalities per state and categorize the OSMR, for each three-year-period 2000-2009;
5. Apply the corresponding correction factors to infant deaths in all Brazilian municipalities, according to the state and OSMR category;
6. Obtain the corrected number of infant deaths per state and three-year-period for 2000-2009 by summing the corrected infant deaths in the state municipalities.

Correction of reported live births

1. Estimate LBR in all Brazilian municipalities for the three-year-period 2007-2009;
2. Calculate correction factors for state and categorize the LBR (< 0.5 ; ≥ 0.5 and < 0.6 ; ≥ 0.6 and < 0.7 ; ≥ 0.7 and < 0.8 ; ≥ 0.8 and < 0.9 ; ≥ 0.9) using LB data corrected by active search and reported to SINASC;
3. Estimate the LBR for all Brazilian municipalities, for each three-year-period between 2000-2009;
4. Classify all Brazilian municipalities per state and categorize the LBR, for each three-year-period 2000-2009;
5. Apply the corresponding correction factors to LB in all Brazilian municipalities, according to the state and LBR category;
6. Obtain the corrected number of LB per state and three-year-period for 2000-2009 by summing the corrected LB in the state municipalities.

Estimating CIM

1. Estimate CIM using the corrected number of infant deaths and live births obtained per municipality for each three-year-period, in all municipalities in which the reported number of infant deaths was greater than zero;
2. Obtain the minimum limits of the CIM for each region considered in the study, per year of analysis, based on the corrected log-normal distribution of the CIM for the municipalities of the region;
3. For those municipalities in which the corrected number of infant deaths remains below the expected minimum in at least one unit, and the vital information for the municipality are deemed inadequate ($OSMR < 5.5$ or $LBR < 0.9$), the corrected number of infant deaths was estimated using the mean CIM for the state, multiplied by the corrected number of LB in the municipality.

CIM: Coefficient of Infant Mortality by age; OSMR: Overall Standardized Mortality Rate ; SIM: Mortality Information System; LBR: Ratio between reported and expected live births; SINASC: Live Births Information System

factors per level of adequate LB data were estimated using corrected LB data from the active search process of vital events.

The LB corrections factors per state and level of adequate LB data in 2008 were estimated using the ratio between the sum of LB corrected using the active search process and the sum of LB reported in each category.

LB reported to SINASC (in the corresponding three-year-period) were corrected using the corresponding correction factors of each state and the level of adequacy of LB data for each year of the 2000 to 2009 period. The correction factors for LB were estimated per LBR category. Therefore, if there was an improvement in LB information coverage in a specific municipality during that period, the lower correction factor would be applied as it would pass into another LBR category. The corrected number of LB per state and per year was obtained by summing corrected LB for the municipalities of that state.

The corrected numbers for infant deaths and live births obtained for each municipality in each three-year-period were used to estimate the CIM per state between 2000

and 2010. Additional adjustments were necessary at the municipal level. When no infant deaths were reported to the SIM, the corrected number of infant deaths should remain at zero, regardless of the correction factor, which could lead to underestimating the CIM.

Minimum limits for the CIM were estimated for each region for each year analyzed, based on log-normal distribution corrected for the municipalities of the region. The expected number of infant deaths in each municipality was obtained, multiplying the minimum limit of the CIM by the number of corrected LB. When the corrected number of infant deaths was equal to or greater than the minimum number, no additional corrections were performed. When the corrected number was below the minimum number in at least one unit, the municipalities were classified according to the adequacy of vital information. For the adequate vital information ($OSMR \geq 5.5$ and $LBR \geq 0.9$), no complementary corrections were performed. Of those municipalities with inadequate vital information, the corrected number of infant deaths were estimated by the mean CIM for the state multiplied by the corrected number of LB in the municipality.

Table 2. Correction factors for deaths according to category of Overall Standardized Mortality Rate and for live births according to category of the ratio between live births. States with incomplete vital information. Brazil, 2008.

| State | Correction factor for deaths in those aged under 1 year old | | | | | | | Correction factor for deaths in those aged 1 year old and over | | | | | | | Correction factor for live births | | | | |
|---------------------|---|--------|--------|--------|----------|--------------|--------|--|--------|--------|----------|--------------|------------|------------|-----------------------------------|------------|--------------|--|--|
| | OSMR category | | | | | | | OSMR category | | | | | | | LBR category | | | | |
| | 1 to 2 | 2 to 3 | 3 to 4 | 4 to 5 | 5 to 5.5 | 5.5 and over | 1 to 2 | 2 to 3 | 3 to 4 | 4 to 5 | 5 to 5.5 | 5.5 and over | 0.5 to 0.6 | 0.6 to 0.7 | 0.7 to 0.8 | 0.8 to 0.9 | 0.9 and over | | |
| Rondônia | 7.36 | 3.88 | 3.16 | 1.55 | 1.31 | 1.02 | 2.71 | 1.79 | 1.40 | 1.23 | 1.20 | 1.03 | 1.64 | 1.31 | 1.22 | 1.17 | 1.06 | | |
| Acre | 7.45 | 3.07 | 2.54 | 1.46 | 1.32 | 1.06 | 2.78 | 2.30 | 1.14 | 1.15 | 1.18 | 1.05 | 1.79 | 1.62 | 1.20 | 1.15 | 1.12 | | |
| Amazonas | 7.31 | 2.95 | 2.28 | 1.40 | 1.20 | 1.05 | 3.21 | 2.08 | 1.52 | 1.28 | 1.09 | 1.06 | 1.60 | 1.36 | 1.18 | 1.11 | 1.05 | | |
| Roraima | 7.23 | 3.43 | 2.08 | 1.60 | 1.49 | 1.07 | 2.84 | 1.94 | 1.57 | 1.27 | 1.11 | 1.06 | 1.76 | 1.40 | 1.22 | 1.15 | 1.09 | | |
| Pará | 7.00 | 2.58 | 1.94 | 1.41 | 1.09 | 1.05 | 2.10 | 2.31 | 1.63 | 1.27 | 1.14 | 1.07 | 1.78 | 1.42 | 1.21 | 1.06 | 1.04 | | |
| Amapá | 7.09 | 3.37 | 2.17 | 1.59 | 1.25 | 1.03 | 2.99 | 1.80 | 1.43 | 1.27 | 1.10 | 1.08 | 1.70 | 1.36 | 1.29 | 1.07 | 1.06 | | |
| Tocantins | 7.40 | 4.32 | 2.75 | 1.86 | 1.25 | 1.14 | 2.78 | 1.84 | 1.39 | 1.14 | 1.17 | 1.09 | 1.43 | 1.21 | 1.17 | 1.12 | 1.07 | | |
| Maranhão | 7.28 | 3.43 | 2.06 | 1.49 | 1.27 | 1.05 | 3.13 | 2.07 | 1.59 | 1.29 | 1.12 | 1.06 | 1.86 | 1.57 | 1.19 | 1.16 | 1.06 | | |
| Piauí | 7.25 | 3.59 | 2.03 | 1.40 | 1.18 | 1.14 | 2.73 | 1.70 | 1.33 | 1.17 | 1.12 | 1.08 | 1.76 | 1.33 | 1.13 | 1.08 | 1.06 | | |
| Ceará | 7.28 | 3.63 | 2.03 | 1.48 | 1.27 | 1.11 | 2.72 | 1.96 | 1.37 | 1.20 | 1.11 | 1.07 | 1.78 | 1.34 | 1.20 | 1.08 | 1.05 | | |
| Rio Grande do Norte | 7.07 | 2.91 | 2.48 | 1.78 | 1.25 | 1.06 | 2.70 | 2.05 | 1.42 | 1.21 | 1.11 | 1.09 | 1.78 | 1.26 | 1.13 | 1.07 | 1.05 | | |
| Paraíba | 7.07 | 3.50 | 2.58 | 1.62 | 1.24 | 1.14 | 2.72 | 1.75 | 1.38 | 1.17 | 1.11 | 1.06 | 1.66 | 1.38 | 1.13 | 1.09 | 1.04 | | |
| Pernambuco | 7.33 | 3.62 | 2.32 | 1.35 | 1.19 | 1.14 | 2.77 | 1.88 | 1.45 | 1.17 | 1.10 | 1.06 | 1.91 | 1.33 | 1.18 | 1.07 | 1.04 | | |
| Alagoas | 7.22 | 3.66 | 2.56 | 1.38 | 1.26 | 1.09 | 2.80 | 2.06 | 1.45 | 1.24 | 1.13 | 1.06 | 1.70 | 1.50 | 1.16 | 1.09 | 1.06 | | |
| Sergipe | 7.17 | 3.59 | 2.30 | 1.36 | 1.30 | 1.16 | 2.76 | 1.88 | 1.49 | 1.16 | 1.11 | 1.07 | 1.66 | 1.43 | 1.12 | 1.05 | 1.04 | | |
| Bahia | 7.20 | 3.59 | 1.81 | 1.42 | 1.24 | 1.08 | 2.73 | 2.03 | 1.51 | 1.26 | 1.11 | 1.07 | 1.54 | 1.35 | 1.17 | 1.07 | 1.06 | | |
| Minas Gerais | 7.59 | 4.56 | 2.16 | 1.53 | 1.20 | 1.16 | 2.97 | 1.99 | 1.45 | 1.17 | 1.11 | 1.08 | 1.71 | 1.33 | 1.14 | 1.06 | 1.01 | | |
| Mato Grosso | 8.08 | 3.86 | 2.56 | 1.80 | 1.48 | 1.18 | 2.59 | 1.75 | 1.29 | 1.16 | 1.03 | 1.06 | 1.39 | 1.22 | 1.11 | 1.09 | 1.00 | | |
| Goiás | 8.11 | 3.69 | 2.48 | 1.90 | 1.24 | 1.17 | 2.18 | 1.94 | 1.34 | 1.19 | 1.13 | 1.07 | 1.69 | 1.49 | 1.23 | 1.12 | 1.01 | | |

OSMR: Overall Standardized Mortality Rate; LBR: Ratio between reported and expected live births (not shown)

Table 3. Number of deaths in those aged under one year, of live births and the coefficient of infant mortality (/1,000 LB) corrected in the active search and using the simplified method. States with complete and incomplete vital information. Brazil, 2008.

| Regions and states | Deaths of those aged under one year old | | Live births | | CIM (/1,000 LB) | |
|---------------------|---|--------------------------------|----------------------------|--------------------------------|----------------------------|--------------------------------|
| | Corrected by Active Search | Corrected by Correction Factor | Corrected by Active Search | Corrected by Correction Factor | Corrected by Active Search | Corrected by Correction Factor |
| Rondônia | 628 | 619 | 29,105 | 28,554 | 21.6 | 21.7 |
| Acre | 441 | 441 | 18,870 | 18,832 | 23.4 | 23.4 |
| Amazonas | 1,829 | 1,831 | 83,435 | 83,402 | 21.9 | 22.0 |
| Roraima | 223 | 221 | 10,766 | 10,764 | 20.7 | 20.5 |
| Pará | 3,968 | 3,827 | 167,879 | 161,904 | 23.6 | 23.6 |
| Amapá | 469 | 462 | 16,216 | 15,957 | 28.9 | 29.0 |
| Tocantins | 600 | 614 | 27,465 | 27,582 | 21.8 | 22.3 |
| North | 8,158 | 8,016 | 353,737 | 346,995 | 23.1 | 23.1 |
| Maranhão | 3,427 | 3,412 | 142,621 | 140,472 | 24.0 | 24.3 |
| Piauí | 1,317 | 1,312 | 55,767 | 55,781 | 23.6 | 23.5 |
| Ceará | 2,748 | 2,728 | 143,679 | 142,734 | 19.1 | 19.1 |
| Rio Grande do Norte | 1,131 | 1,120 | 53,645 | 52,714 | 21.1 | 21.2 |
| Paraíba | 1,395 | 1,380 | 65,840 | 64,243 | 21.2 | 21.5 |
| Pernambuco | 2,961 | 2,945 | 153,391 | 151,455 | 19.3 | 19.4 |
| Alagoas | 1,327 | 1,331 | 61,644 | 61,750 | 21.5 | 21.6 |
| Sergipe | 783 | 763 | 38,376 | 37,553 | 20.4 | 20.3 |
| Bahia | 5,556 | 5,636 | 238,489 | 238,840 | 23.3 | 23.6 |
| Northeast | 20,644 | 20,627 | 953,453 | 945,542 | 21.7 | 21.8 |
| Minas Gerais | 4,812 | 4,797 | 276,788 | 273,253 | 17.4 | 17.6 |
| Mato Grosso | 1,158 | 1,122 | 53,213 | 52,307 | 21.8 | 21.4 |
| Goiás | 1,602 | 1,571 | 94,872 | 94,071 | 16.9 | 16.7 |

CIM: Coefficient of Infant Mortality; LB: Live Births

Values in bold: Highlighting two macro-regions of Brazil

After correcting the data for the municipalities, the CIM per state was calculated by the ratio between the sum of corrected infant deaths and the sum of corrected LB in the municipalities of the state (Table 1). The birth rate was estimated using the ratio between the corrected number of LB and the estimated population per year of the period.

The project was approved by the Committee of Ethics and Research in Human Beings of the Pernambucan Society for Combatting Cancer (Record no. 15/2011 on 14/6/2011).

RESULTS

The correction factors for LB and deaths of those aged under and over one year varied according to the level of adequacy of the vital information in the state in 2008 and showed a gradient which increased as the completeness of the vital data systems worsened. No significant differences were found between the correction factors for LB and deaths in the state. However, they were

systematically lower for births and higher for deaths, especially for infant deaths. The correction factors for deaths in those aged under one year old exceeded 7.0 in all states when the OSMR was < 2 , i.e., worse levels of adequacy of mortality information (Table 2).

The Active Search of 2008 and the simplified method showed similar results for corrected LB and deaths with inexpressive fluctuations in estimates of CIM per state (Table 3).

The behavior of the birth rate was presented by region and by state, from 2000 to 2009. There was a marked decrease in the birth rate for the country and in the regions over the ten years. The rate for Brazil went from 20.3/1,000 inhabitants in 2000 to 16.0 in 2009. Greater decreases occurred in the North and lower in the South (from 27.8 to 22.3/1,000 inhabitants), but in the North, the values remained above those found at the beginning of the decade in the South (17.7), Southeast (18.3) and Midwest (20.3) (Table 4).

Table 4. Birth rates (/1,000 inhabitants) estimated after correcting live births. Brazilian states and regions. Brazil, 2000 to 2009.

| Regions and states | Birth rate | | | | | | | | | |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | 1999-2001 | 2000-2002 | 2001-2003 | 2002-2004 | 2003-2005 | 2004-2006 | 2005-2007 | 2006-2008 | 2007-2009 | 2008-2010 |
| Rondônia | 24.9 | 24.0 | 23.0 | 22.3 | 21.8 | 21.0 | 20.1 | 19.5 | 19.0 | 19.1 |
| Acre | 35.1 | 33.7 | 31.8 | 31.4 | 30.8 | 29.5 | 28.0 | 27.4 | 27.5 | 26.9 |
| Amazonas | 29.9 | 28.9 | 28.0 | 27.2 | 26.6 | 26.3 | 25.7 | 25.3 | 24.8 | 24.4 |
| Roraima | 32.6 | 30.8 | 30.3 | 29.6 | 29.5 | 28.3 | 27.5 | 26.8 | 25.9 | 25.5 |
| Pará | 26.5 | 25.8 | 25.2 | 24.4 | 23.9 | 23.5 | 23.0 | 22.6 | 22.0 | 21.2 |
| Amapá | 33.5 | 31.6 | 30.6 | 29.1 | 27.9 | 26.5 | 25.9 | 25.6 | 25.9 | 25.5 |
| Tocantins | 26.1 | 25.3 | 24.6 | 23.7 | 23.3 | 22.7 | 21.8 | 21.2 | 21.4 | 21.0 |
| North | 27.8 | 26.9 | 26.2 | 25.4 | 24.8 | 24.3 | 23.7 | 23.2 | 22.8 | 22.3 |
| Maranhão | 27.2 | 26.6 | 25.9 | 25.3 | 24.7 | 24.1 | 23.6 | 23.1 | 22.8 | 21.9 |
| Piauí | 22.9 | 22.2 | 21.4 | 20.6 | 20.3 | 20.0 | 19.6 | 19.0 | 18.3 | 17.7 |
| Ceará | 21.8 | 21.2 | 20.5 | 19.8 | 19.4 | 18.8 | 18.2 | 17.7 | 17.3 | 16.8 |
| Rio Grande do Norte | 22.0 | 21.0 | 20.3 | 19.7 | 19.2 | 18.6 | 18.0 | 17.6 | 17.3 | 16.9 |
| Paraíba | 19.8 | 19.7 | 19.8 | 19.4 | 19.1 | 18.7 | 18.3 | 18.0 | 17.5 | 17.3 |
| Pernambuco | 22.1 | 21.4 | 20.6 | 19.8 | 19.5 | 19.0 | 18.6 | 18.1 | 17.7 | 17.3 |
| Alagoas | 25.8 | 25.2 | 24.5 | 23.4 | 22.6 | 21.7 | 21.2 | 20.7 | 20.2 | 19.6 |
| Sergipe | 24.3 | 23.0 | 22.0 | 21.0 | 20.5 | 20.0 | 19.7 | 19.3 | 19.2 | 18.6 |
| Bahia | 21.3 | 20.7 | 20.1 | 19.6 | 19.1 | 18.4 | 17.9 | 17.4 | 16.8 | 16.4 |
| Northeast | 22.6 | 22.0 | 21.3 | 20.7 | 20.2 | 19.6 | 19.1 | 18.7 | 18.2 | 17.7 |
| Minas Gerais | 18.5 | 17.6 | 17.0 | 16.4 | 15.9 | 15.5 | 15.0 | 14.6 | 14.0 | 13.7 |
| Espírito Santo | 19.0 | 18.1 | 17.4 | 16.7 | 16.3 | 15.8 | 15.4 | 15.1 | 15.2 | 15.1 |
| Rio de Janeiro | 17.8 | 16.9 | 16.1 | 15.7 | 15.4 | 15.0 | 14.6 | 14.3 | 13.9 | 13.7 |
| Sao Paulo | 18.3 | 17.3 | 16.4 | 16.1 | 15.9 | 15.6 | 15.2 | 14.9 | 14.9 | 14.8 |
| Southeast | 18.3 | 17.3 | 16.5 | 16.1 | 15.8 | 15.5 | 15.1 | 14.7 | 14.5 | 14.3 |
| Paraná | 18.6 | 17.7 | 16.8 | 16.4 | 16.1 | 15.8 | 15.3 | 14.9 | 14.4 | 14.4 |
| Santa Catarina | 17.5 | 16.5 | 15.6 | 15.3 | 15.0 | 14.9 | 14.5 | 14.3 | 14.1 | 14.1 |
| Rio Grande do Sul | 17.1 | 16.0 | 15.0 | 14.6 | 14.3 | 14.0 | 13.2 | 12.8 | 12.6 | 12.5 |
| South | 17.7 | 16.8 | 15.8 | 15.4 | 15.1 | 14.9 | 14.3 | 13.9 | 13.6 | 13.6 |
| Mato Grosso do Sul | 19.6 | 19.1 | 18.6 | 18.6 | 18.5 | 18.4 | 17.7 | 17.4 | 17.3 | 17.3 |
| Mato Grosso | 20.9 | 20.4 | 19.8 | 19.5 | 19.5 | 19.1 | 18.6 | 18.0 | 17.9 | 17.5 |
| Goiás | 20.5 | 19.9 | 19.3 | 18.8 | 18.4 | 18.0 | 17.5 | 16.9 | 16.3 | 16.0 |
| Distrito Federal | 23.4 | 22.4 | 21.6 | 20.9 | 20.5 | 19.9 | 19.2 | 18.6 | 17.4 | 17.0 |
| Central-West | 20.9 | 20.3 | 19.7 | 19.3 | 19.0 | 18.7 | 18.1 | 17.5 | 17.0 | 16.8 |
| Brazil | 20.3 | 19.5 | 18.7 | 18.2 | 17.9 | 17.5 | 17.0 | 16.6 | 16.3 | 16.0 |

Values in bold: macro-regions of Brazil

There was a marked reduction in the CIM in all states and regions in the period. The rate of annual percentage decrease in the period was 4.7% for Brazil, being most significant in the Northeast (6.0%) and least in the Midwest (3.2%). The South kept the lowest CIM values throughout the decade.

The unequal rates of annual reductions between the Brazilian regions were observed among the states in the same region. In the North, whereas Amapá and Roraima had annual reductions in CIM of less than 1.0%,

Amazonas and Tocantins exceeded the mean national reduction. In the Northeast, the state of Maranhão showed a trend to decrease that was below the national mean, whereas the decrease was above 6.0% in Ceará, Sergipe, Paraíba, Alagoas, Pernambuco and Rio Grande do Norte, contributing to the better performance of the Northeast among the regions. The Southeast had rates of decrease similar to that of the North (4.1%), although differences between the states were considerable less (varying between 3.4% in Espírito Santo and 4.6% in Minas Gerais) (Table 5).

Table 5. Coefficients of Infant Mortality (/1,000 LB) estimated after correction of vital statistics. Brazilian macro-regions and states. Brazil, 2000 to 2009.

| Macro-regions and states | Coefficient of Infant Mortality | | | | | | | | | | Annual decrease (%) |
|--------------------------|---------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------------|
| | 1999-2001 | 2000-2002 | 2001-2003 | 2002-2004 | 2003-2005 | 2004-2006 | 2005-2007 | 2006-2008 | 2007-2009 | 2008-2010 | |
| Rondônia | 31.9 | 31.2 | 27.4 | 26.7 | 25.9 | 24.9 | 25.4 | 23.5 | 21.7 | 20.2 | 4.5 |
| Acre | 29.2 | 29.9 | 26.9 | 24.8 | 25.2 | 24.9 | 25.6 | 25.0 | 23.4 | 22.0 | 2.7 |
| Amazonas | 34.8 | 33.8 | 30.1 | 28.9 | 27.3 | 25.7 | 26.4 | 24.8 | 22.0 | 21.4 | 5.1 |
| Roraima | 22.2 | 21.2 | 20.4 | 22.0 | 22.1 | 22.3 | 22.4 | 22.2 | 20.5 | 19.1 | 0.7 |
| Pará | 32.3 | 31.9 | 30.6 | 30.9 | 29.0 | 28.6 | 27.5 | 25.8 | 23.6 | 22.9 | 3.8 |
| Amapá | 32.9 | 29.1 | 27.4 | 28.8 | 27.3 | 27.8 | 27.5 | 30.2 | 29.0 | 28.7 | 0.5 |
| Tocantins | 36.9 | 35.8 | 32.9 | 30.3 | 29.5 | 28.2 | 27.8 | 24.7 | 22.3 | 21.3 | 5.9 |
| North | 32.8 | 32.1 | 29.7 | 29.3 | 27.8 | 27.1 | 26.8 | 25.3 | 23.1 | 22.3 | 4.1 |
| Maranhão | 36.8 | 32.5 | 30.2 | 27.9 | 27.7 | 26.5 | 26.8 | 25.7 | 24.3 | 23.0 | 4.3 |
| Piauí | 37.8 | 35.3 | 31.5 | 30.0 | 28.3 | 27.3 | 26.6 | 24.7 | 23.5 | 22.0 | 5.5 |
| Ceará | 36.8 | 32.1 | 30.4 | 29.4 | 26.8 | 24.2 | 22.1 | 21.1 | 19.1 | 17.6 | 7.6 |
| Rio Grande do Norte | 34.5 | 31.9 | 30.3 | 29.1 | 27.2 | 25.3 | 24.5 | 22.0 | 21.2 | 19.1 | 6.1 |
| Paraíba | 39.2 | 36.7 | 30.9 | 29.4 | 26.9 | 25.3 | 24.1 | 22.7 | 21.5 | 19.3 | 7.2 |
| Pernambuco | 34.0 | 30.9 | 29.2 | 27.9 | 26.7 | 23.4 | 22.1 | 20.1 | 19.4 | 18.1 | 6.8 |
| Alagoas | 37.7 | 36.5 | 34.4 | 31.7 | 29.2 | 27.8 | 25.9 | 23.3 | 21.6 | 20.1 | 7.0 |
| Sergipe | 37.7 | 35.5 | 33.8 | 30.4 | 28.7 | 27.2 | 25.5 | 22.8 | 20.3 | 18.8 | 7.4 |
| Bahia | 34.6 | 34.2 | 31.0 | 29.9 | 29.0 | 27.5 | 26.2 | 24.9 | 23.6 | 22.1 | 4.8 |
| Northeast | 35.9 | 33.4 | 30.8 | 29.3 | 27.8 | 25.9 | 24.8 | 23.2 | 21.8 | 20.3 | 6.0 |
| Minas Gerais | 25.7 | 24.7 | 23.3 | 22.1 | 21.2 | 20.3 | 19.2 | 18.3 | 17.6 | 17.0 | 4.6 |
| Espírito Santo | 18.1 | 17.6 | 16.8 | 15.8 | 15.7 | 15.4 | 15.1 | 14.7 | 13.6 | 12.9 | 3.4 |
| Rio de Janeiro | 20.5 | 19.3 | 18.8 | 18.4 | 17.7 | 16.8 | 15.8 | 15.2 | 14.8 | 14.5 | 3.9 |
| Sao Paulo | 17.4 | 16.5 | 15.7 | 15.0 | 14.4 | 13.8 | 13.3 | 13.1 | 12.8 | 12.4 | 3.7 |
| Southeast | 20.1 | 19.1 | 18.3 | 17.5 | 16.8 | 16.0 | 15.3 | 14.8 | 14.3 | 13.9 | 4.1 |
| Paraná | 19.0 | 18.1 | 17.0 | 16.3 | 15.6 | 14.7 | 14.0 | 13.4 | 13.0 | 12.6 | 4.6 |
| Santa Catarina | 15.9 | 15.5 | 15.0 | 14.3 | 13.4 | 12.9 | 12.6 | 12.3 | 11.9 | 11.2 | 3.8 |
| Rio Grande do Sul | 15.3 | 15.5 | 15.8 | 15.6 | 15.0 | 14.0 | 13.2 | 12.9 | 12.4 | 11.9 | 3.3 |
| South | 16.9 | 16.5 | 16.1 | 15.6 | 14.9 | 14.1 | 13.4 | 13.0 | 12.5 | 12.0 | 3.9 |
| Mato Grosso do Sul | 24.4 | 22.8 | 21.5 | 20.6 | 20.3 | 19.8 | 19.1 | 18.2 | 18.0 | 16.9 | 3.6 |
| Mato Grosso | 29.4 | 27.6 | 25.6 | 25.0 | 24.3 | 24.0 | 23.3 | 22.1 | 21.4 | 20.8 | 3.5 |
| Goiás | 21.2 | 20.8 | 20.6 | 20.7 | 19.9 | 19.1 | 18.5 | 17.8 | 16.7 | 15.8 | 3.2 |
| Distrito Federal | 15.3 | 14.5 | 14.2 | 13.7 | 13.7 | 13.6 | 12.6 | 12.0 | 11.7 | 12.3 | 2.7 |
| Central-West | 22.3 | 21.4 | 20.6 | 20.3 | 19.7 | 19.3 | 18.5 | 17.7 | 17.1 | 16.4 | 3.2 |
| Brazil | 26.1 | 24.9 | 23.4 | 22.5 | 21.5 | 20.4 | 19.6 | 18.6 | 17.7 | 16.8 | 4.7 |

Values in bold: Macro-regions of Brazil

DISCUSSION

The findings are coherent when compared with the results obtained in the active search research in 2008.

After correcting the LB, the birth rate showed a trend to decrease in all states and regions, although at different intensities. Studies on fecundity in Brazil indicate marked changes in the country,³ although indirect estimates indicate lower reductions.

There was a rate of decrease of 4.7%/year in the CIM, with greater intensity in the region that has recognizably the most precarious living conditions. The annual rate of decrease in the Northeast was 6.0% per year, probably due to public interventions focused on the most vulnerable population groups and on socioeconomic development in the region, prompted by inclusive public policies.¹⁸ The different intensities of reduced CIM in Brazil and the regions shows the success in the decline of regional inequalities.

Large groups of the vulnerable population benefitted from SUS actions and programs, in particular those focusing on care for mothers and babies as well as those of the state and municipal programs. The benefits from interventions such as antenatal care and hospitalization for births, immunization programs, promoting breastfeeding, among others¹⁸ are indisputable. The Family Health Care Program, which groups together all programs with activities in primary care, was one of the protagonists in the success in the decreasing infant mortality rate, when high coverage was achieved.^{2,11}

The advances made in Brazil in reducing infant mortality² are indisputable. The country is one the way to reaching the fourth millennium goal if the trends seen in 2000 to 2009 are maintained. However, inequalities remain between regions and states, with a significant social debt and serious problems in delivering care.¹⁸ Infant mortality in the North and Northeast in the last year of the time series in question (2009) were greater than the rates shown in the states in the South in 2000.

The method proposed here are easy to apply: it is sufficient to classify the municipality according to the level of adequacy of the vital information in each state. Variations in the correction factors as the municipalities have improving or worsening coverage of vital information enables the methodology to be used in the long term, without need for complementary research to update the estimates. Correcting the mean data per three-year-period guarantees more stability in indicators

of adequacy of vital information and in estimating birth rates and infant mortality.

Although it is desirable to correct the data, it is not recommended that this simplified method is used for all levels of grouping. It should be limited to states, region and Brazil in the current stage of development, as the categories of municipalities according to level of adequacy of the information establishes corrections that are the same for municipalities located at the extremes of the same category. A municipality with CGMP of 3.1 would be corrected using the same factor as a municipality in the same state with a CGMP of 3.9. However, the positive and negative effects are eliminated in the state mean.

Another limitation to using the simplified method in time series analysis is the assumption that the relationship between the correction factors of infant deaths and the estimates for total deaths remain constant throughout the period of the study. The method does not propose to correct mortality data for the different age groups shown here, nor for groups of specific causes of death. Additional research would be needed for this.

It is essential that assessments of vital information and active search procedures are carried out regularly to improve the corrections, until such time as the systems can be considered complete for full use of the data. Improvements in vital statistics is a fundamental step in tracking epidemiological profiles and in deciding, planning, monitoring and assessing interventions aimed at reducing infant mortality.

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