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Adequacy of mortality data and correction of reported deaths from the Proactive Search of Deaths

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Abstract *The aim of this paper is to propose indicators of adequacy and to estimate correction factors for deaths reported to SIM. In 2014, we carried out a Proactive Search to capture deaths that occurred in 2012 in a sample of municipalities in the regions North and Northeast, and the states of Minas Gerais, Mato Grosso and Goiás. To characterize the coverage of deaths information, we proposed indicators of adequacy by municipality. Correction factors were estimated for individuals one year of age or older and younger than 1 year old. Among the deaths of people aged one year or more, the coverage was above 90% in 12 states. As for infant deaths, the coverage was less than 80% in 7 states. The results of the regression models showed association between the correction factors estimated and the proposed indicators of adequacy. We found very poor death information in 227 municipalities, for which the reported number of infant deaths even after correction, could not reach the minimum expected. Although the progress made in information of vital data in Brazil is recognized, the results show that our greatest challenge is to reach rural and remote municipalities, which do not yet have adequate vital information.*
Key words *Mortality registries, Vital statistics, Mortality, Estimation techniques, Brazil*

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Introduction

The commitment to reach the Millennium Development Goals (MDG) established in 1990 revealed the need for reliable data to monitor health indicators[1]. Particularly among vulnerable groups such as women and children, MDGs are seen as fundamental measures of human development[2].

Several countries have accepted the challenge to broadly improvematernal and child health conditions. This movement uncovered issues around the development of health indicators used to assess the achievement of MDGs. An adequate assessment of the progress achieved ensured accountability among country members and strengthened their commitment to the United Nations[3].

Few developing countries have adequate vital information systems to calculate reliable indicators[4]. Further, population surveys are not useful to assess the progress towards goals[1]. Instead, the maintenance of continuous recording systems that provide good coverage of births and deaths is the best way to monitor temporal trends for health indicators[3].

Brazil has two vital information systems: Mortality Information System (SIM), created in 1976 after the implementation of the standardized death certificate (DO) throughout the country, and Live Birth Information System (SINASC), implemented in 1994, and based on the declaration of live birth (DNV). Hospitals are required to issue a DNV for all hospital births. The two systems are managed by the Ministry of Health (MS) – the objective of these systems is to provide subsidies to characterize the profile of deaths and birth in the country. The information is available online for all Brazilian municipalities up to 2014[5].

Recognizing the importance of vital information systems, the Ministry of Health in partnership with states and municipalities invested in data quality improvement and coverage expansion of the SIM and SINASC, and prioritized strategies toreach the poorest regions of the country as well as those with large gaps in quality and coverage of data[6].

The country invested in technological improvements, implementation of standard forms (DO and DNV), development of data processing routines, and publicizing ofdata online by municipality allowing for rapid identification of inconsistencies[6]. Particularly in the last 15 years, significant improvement in vital information was directly linked to the establishment of goals to increase coverage of mortality information in states and municipalities, the development of monitoring dashboards, the establishment of infant and maternal death review committees as well as committee to review deaths due to ill-defined causes, and the expansion of the surveillance of infant deaths and deaths among women of childbearing age[5,7].

In parallel to these improvements, there was the development of methods to assess the coverage and regularity of vital statistics[8,9]. Data linkage using other national information systems was used to identify deaths not reported to the SIM[10,11]. In addition, since 2000, three Proctive Search surveys were carried outto identify unreported vital statistics events. The aims of the first two surveys were to validate the criteria for adequacy of vital information and to estimate the coverage of the SIM and SINASC in Brazilian states and the Federal District (hereafter referred to as Unidades Federativas or UFs)[8,12,13]. The third Proactive Search survey only searched for unreported deaths.

The second Proactive Searchsurvey, which collected data on deaths and live births occurred in 2008, was carried out in a probabilistic sample of municipalities in the Northeast and Legal Amazon. Data from this survey was critical to develop maternal and infant indicators in the UFs using vital statistics data. By using correction factors estimated according to the level of adequacy of information on deaths and live births, it was possible to generalize the methodology to other years[13,14]. This represented a large shift in the way mortality indicators were calculated in Brazil – previously indirect demographic methods were used to estimate mortality for all states of the North and Northeast regions as well as for the states of Minas Gerais, Mato Grosso and Goiás[15]. Now, with this new methodology based on data from proactive search of deaths, indicators such as infant mortality rate and maternal mortality ratiocould be calculated annually and used to assess temporal changes[14,16].

Despite of the enormous advancesin coverage and quality of the data, which allowed the monitoring of the Millennium Development Goals as well as national and regional targets, both systems, SIM and SINASC, still have important gaps. These gaps hinder the use of information on mortality and live births in several Brazilian municipalities[11-13,16,17]. Based on the findings of the Proactive Search of Deaths carried out in 2014, related to events occurred in 2012, the

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present study aims to create adequacy indicators of the coverage of mortality data, calculate correction factors for indicators produced with data from the SIM by sex and age group, and estimate the Infant Mortality Ratio (IMR) in 19 Brazilian states and in municipalities where the correction was insufficient, seeking to establish priorities for intervention in places where deficiency in the data registry still persist.

Methods

Vital information adequacy criteria and correction factors were estimated based on the Proactive Search survey that was carried out between May and October 2014 and collected data on deaths (fetal and non-fetal) occurred between January 1st and December 31st, 2012.

The survey occurred in a probabilistic sample of 79 small and medium-sized municipalities (all but one with fewer than 100,000 inhabitants) in 19 states, including all states in the North and Northeast regions and the states of Minas Gerais, Mato Grosso, and Goiás; these states are known to have poor data quality[13]. Sample selection was stratified by groups based on two criteria: age-standardized mortality rate for the period 2009-2011, and infant mortality rate. Age-standardized mortality rates (ASMR) were calculatedusing 2010 Brazilian population as the standard population and then split into six categories: <2 per 1,000 inhabitants, >= 2 and <3, >= 3 and <4, >= 4 and <5, >= 5 and <5.5, and >= 5.5 per 1000 inhabitants[14]. Infant mortality rate was classified as adequate or inadequate[17]. In each stratum, 6 to 7 municipalities were randomly selected.

Among sampled municipalities, proactive search was carried out to identify deaths that were not included in the list of deaths printed from the SIM – those that had a death certificated (DO) issued but were not reported to the SIM, and deaths that did not had a DO issued. The search involved neighboring municipalities that might have received patients transferred from the sampled municipality.

The following sources of information were used: databases managed by the state and municipal health secretariats, civil registries,cemeteries including unofficial ones, funeral homes, health clinics, hospitals and other health facilities (clinics, emergency units) located in the sampled municipality and neighboring municipalities,forensic pathology and autopsy offices, police stations, social program registries, and other sources suggested by the municipal team. In each source, a team of field workers searched and recorded the names of the deceasedpeople or the mother's name of the deceased children under one year of age who were not included in the municipality's nominal list. Data was entered in an online panel prepared by the Health Surveillance Secretariat (SVS/MS) to monitor the field work in real time.

The proactive search database was linked to the 2012 SIM database using the variables DO number, name, date of birth or age, date of death, mother's name, municipality of residence. Through this procedure, we identified the deaths found in the proactive search that did not appear in the SIM. The proactive search database was also linked to data from the Sistema Informatizado de Controle de Óbitos (SISOBI) to identify additional deaths not found through the proactive search.

The second stage of the project consisted of additional field work to verify the deceased's residence and the year of death, and collect missing information in variables such as address, date of birth, age, and sex. Interviews were conducted in health clinics and households. Confirmation was also required for all infant or fetal deaths found by the proactive search.

Correction of vital statistic data by sex and age range

To calculate correction factors for the sampled municipalities, we considered all deaths identified and confirmed by the proactive search plus those not confirmed – deaths identified through unofficial sources, such as cemeteries that did not have a log book. The deaths that were already in the SIM, those with proven residency in another municipality, and those that did not occur in 2012 were excluded.

For each municipality, the correction factor for deaths was estimated by adding one to the ratio between the number of deaths found in the survey and the number of deaths reported to the SIM, calculated separately for individuals aged one year orolder and for children under one year old.

In order to estimate the distribution of corrected deaths by sex and age range among individuals agedone year or older, we compared the distribution of underreported deaths (those identified by the proactive search) by age and sex to that of deaths reported to SIM in the same year.To estimate the corrected number of deaths in a given age group and sexwe used the formula:

$x_0p_0 + x_1p_1/100$ = corrected number of deaths in a given age group and sex

Where x_1 and x_0 are the total deaths among people one year or older that were present and not present in the SIM, respectively.And p_0 e p_1 are the proportions of a given age group and sex in relation to the total deaths among people aged one year or older that were present and not presentin the SIM, respectively.

The correction factor was calculated using the formula:

$$\frac{x_0p_0 + x_1p_1}{x_0p_0} = 1 + \left(\frac{x_1}{x_0} \text{ x } \frac{p_1}{p_0} \right)$$

onde as razões e são estimadas com os dados de 2012, informados e não informados ao SIM.

Correction of vital statistic data by municipality

Adequacy indicators were created to assess the coverage of live births and deaths in the SINASC and SIM. Due to a large proportion (45%) of municipalities with less than 10000 inhabitants, we calculated adequacy indicators using the average number of vital events reported in a three-year period 2011-2013, to provide greater stability to municipal estimates[16,17]. SINASC adequacy was assessed by the Live Birth Ratio (LBR), or the ratio between the recorded number of live births (LB) in the SINASC and the estimated number of LB. We calculated the estimated number of LBs using the formula below:

$$LB_{est} = \frac{\textit{2012 projected population under one year of age}}{(1 - (0.5 \text{ x IMR}_{UF}/1000)}$$

where IMR_{UF} is the Infant Mortality Rate per UF in the yearprior to the research (2011).

For each municipality we calculated the LBR using the formula:

$$LBR = \frac{min\ (LB_{rec}, LB_{est})}{LB_{est}}$$

where min (LB_{rec}, LB_{est}) represents the smallest number between the recorded and the estimated LB. The highest coverages are found when LBR approximates one.

We then used the correction factors demonstrated previously to calculate the corrected number of Live Births according to ranges of the Live Birth Ratio (ratio between recorded and estimated number of live births)[13].

SIM adequacy was assessedfor deaths among children under one year old and among individuals aged one year or older. We calculated age-standardized mortality rate among all (ASMR) and among those aged one year or older ($ASMR_{1a+}$) by Brazilian municipality. We used SIM data in the triennium 2011-2013 and the Brazilian population in 2012 as the standard population.

A $ASMR_{1a+}$ of 5.5 per 1000 was considered a satisfactory level of adequacy fordata on deaths among individuals aged one year and over. The following model was used to estimate the correction factors (CF) for deaths among people aged one year or older by municipality:

$$CF_{1a+} = \frac{5{,}5}{min\ (5{,}5\ ;\ ASMR_{1a+})}$$

where the denominatorrepresents the smallest number between 5.5 and the $ASMR_{1a+}$.

We then calculated the corrected number of deaths among individuals aged one year or more per municipality by multiplying the mean number of deaths reported to SIM in the period 2011-2013 by the correction factor CF_{1a+}.

For infant deaths, we used linear regression; the outcome was the infant death correction factors estimated in the sample of municipalities for which there was proactive search and the SMR as the independent variable. The following model was used to estimate the correction factor (CF) for children under one year old:

$$CF_{s1a} = min\ (1;\ 3.626 - 0.418 \text{ x } ASMR),$$

The $CF_{s1a}$is smallest number between 1and the expected value of for a given ASMR in the linear model.

We then multiplied the mean number of deaths reported to SIM in the period 2011-2013 by the correction factor CF_{s1a}. In some municipalities, however, when the reported number of infant deaths in the triennium was zero or close to zero, the correction was insufficient to obtain a reliable IMR.

The correction factor was assessed as sufficient or insufficient after taking into account the population of the municipality and the probability of occurring at least one infant death in the triennium 2011-2013 in municipalities with small population counties. To assess this issue we calculated the minimum number of expected infant deaths in the triennium for each municipality using the formula:

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$$D_{minexp} = \frac{TRUNC\,(IMR_{min} \text{ x } LB_{cor})}{3}$$

Where the IMR_{min} is the minimum IMR (half of the IMR in the UF in the prior year, 2011),LB_{cor} is the corrected number of LB in the triennium 2011-2013, and *TRUNC* is a function that uses only the integer part of the number.

If the corrected number of infant deaths was greater than or equal to the expected minimum number of deaths among children under one year old (D_{minexp}), the correction factor obtained was considered sufficient. Otherwise, the correction factor was considered insufficient and the corrected number of infant deaths in the municipality was estimated based on the UF's IMR, which was calculated using only data from municipalities with sufficient correctionas proposed in previous publications[8,13-16].

The corrected number of infant deaths by UF in the triennium was obtained by the sum of corrected infant deaths in the municipalities of that UF. Lastly, we obtained the total corrected number of deaths by adding the corrected number of infant deaths to the corrected number of deaths among individuals aged one year or older per UF.

Results

Table 1 shows the correction factors among individuals aged one year or older for all 19 states by sex and age group. The distribution of deaths identified by proactive search varied according to sex and age groups resulting in varying correction factors. Larger correction factors were observed amongmales and females in the age groups 1-4, 5-14, and 15- 29 years old compared to other age groups.The greatest correction factors were found in the group between 1 and 4 yearsold, with values higher than 1.3 in some states of the North region and in the state of Maranhão (MA), in the Northeast region. Among males and females, the correction factor declined with an increase in age.

Figure 1 (a and b) shows linear regression models adjusted for correction factorsthat were estimated using deaths identified by the proactive search and the correction factors based on the coverage of the SIM. For individuals aged one year or more, the multiple regression coefficient was 0.892, showing a statistically significant association between the correction factors based on the deaths obtained in the proactive search and the correction factors calculated with the data reported to the SIM ($R^2 = 0.795$, $p < 0.001$). Regarding the model for infant deaths, there was also a significant association with a similar multiple correlation coefficient of 0.894 ($R^2 = 0.8$, $p < 0.001$).

Table 2 shows the data on the number of deaths, reported and corrected, and the corresponding coverage of the SIM for deaths among children under one year old, among people aged one year or older, and among all deaths by state in the triennium 2011-2013. The coverage was high for individuals aged one year or more – above 85% in all states, with the exception of Maranhão (82.2%). Regarding infant deaths, coverage was much lower and did not reach 80% in seven of the 19 states. The lowest coverage of infant deaths was found in Maranhão (68%) and the highest in Pernambuco (93.7%). Regarding SIM coverage for all deaths, the amplitude of variation was 81.2% to 97.9%, evidencing the almost complete coverage of the SIM in the states of Pernambuco, Alagoas, Sergipe and Goiás.

Table 3 shows the IMR by state, which was estimated using the corrected number of deaths from children under one year old for all the municipalities in the state and the corrected number of live births[13]. The IMR ranged from 14.2 in Pernambuco to 22.2 per 1000 LB in Amapá; four states out of 19 had coefficients lower than 15 per 1000 LB.

A total of 227 municipalities had the correction factor classified as insufficient. In these municipalities, the reported number of infant deaths was so low that even after correction the number of deaths did not reach the minimum estimated for the triennium (Table 3). For these municipalities, the $IMR^{(1)}$, estimated using the corrected number of deaths, was very low compared to the state IMR. The $IMR^{(2)}$ is the infant mortality rate based on the state IMR among municipalities with sufficient correction, according to the level of adequacy of the municipality.

Discussion

This paper presented a new method to develop correction factors and calculate the number of deaths in municipalities with poor data quality using proactive search of deaths in a probabilistic sample of 79 Brazilian municipalities. Unlike previous methodology, which estimated correction factors by intervals constructed from the general age-standardized mortality rate (ASMR)[13,14], the

Table 1. Estimated correction factors for deaths among individuals aged one year or older by sex and age group in the 19 participating states. North and Northeast regions, and states of Minas Gerais, Mato Grosso, and Goiás. 2011-2013.

State	Age group					
	1 - 4	5 - 14	15-29	30-69	70+	1 year old or more
	Male					
RO	1.10	1.13	1.09	1.07	1.08	1.08
AC	1.18	1.16	1.13	1.07	1.07	1.08
AM	1.36	1.30	1.15	1.14	1.18	1.16
RR	1.25	1.28	1.12	1.11	1.11	1.12
PA	1.35	1.25	1.16	1.14	1.15	1.15
AP	1.33	1.30	1.22	1.13	1.10	1.14
TO	1.18	1.14	1.12	1.10	1.10	1.10
MA	1.34	1.31	1.23	1.21	1.23	1.22
PI	1.21	1.20	1.15	1.12	1.14	1.13
CE	1.11	1.10	1.07	1.06	1.07	1.07
RN	1.15	1.16	1.10	1.09	1.11	1.10
PB	1.10	1.11	1.06	1.06	1.07	1.06
PE	1.05	1.04	1.02	1.01	1.02	1.02
AL	1.07	1.06	1.03	1.03	1.03	1.03
SE	1.06	1.04	1.04	1.01	1.02	1.02
BA	1.19	1.17	1.10	1.10	1.14	1.12
MG	1.11	1.10	1.09	1.06	1.06	1.06
MT	1.17	1.13	1.07	1.05	1.05	1.06
GO	1.06	1.06	1.03	1.04	1.04	1.04
	Female					
RO	1.10	1.09	1.10	1.08	1.07	1.07
AC	1.28	1.22	1.11	1.07	1.06	1.08
AM	1.41	1.32	1.27	1.12	1.14	1.15
RR	1.28	1.16	1.14	1.11	1.08	1.11
PA	1.34	1.27	1.21	1.13	1.13	1.14
AP	1.34	1.30	1.24	1.12	1.10	1.13
TO	1.17	1.17	1.13	1.09	1.10	1.10
MA	1.32	1.32	1.29	1.21	1.20	1.21
PI	1.20	1.20	1.18	1.12	1.13	1.13
CE	1.13	1.11	1.09	1.06	1.07	1.06
RN	1.14	1.14	1.12	1.10	1.10	1.10
PB	1.11	1.07	1.09	1.05	1.07	1.06
PE	1.04	1.04	1.03	1.01	1.01	1.01
AL	1.07	1.04	1.04	1.03	1.03	1.03
SE	1.04	1.04	1.04	1.01	1.02	1.02
BA	1.22	1.19	1.14	1.10	1.12	1.12
MG	1.10	1.10	1.09	1.06	1.06	1.06
MT	1.19	1.08	1.08	1.04	1.04	1.05
GO	1.04	1.05	1.04	1.03	1.04	1.04

current methodology uses different correction factors per municipality, estimated separately among children under one year old and individuals aged one year or older.

Another innovation was to use the standardized mortality rate for individuals aged one year or older as the main indicator of adequacy for mortality data among this age group, thus

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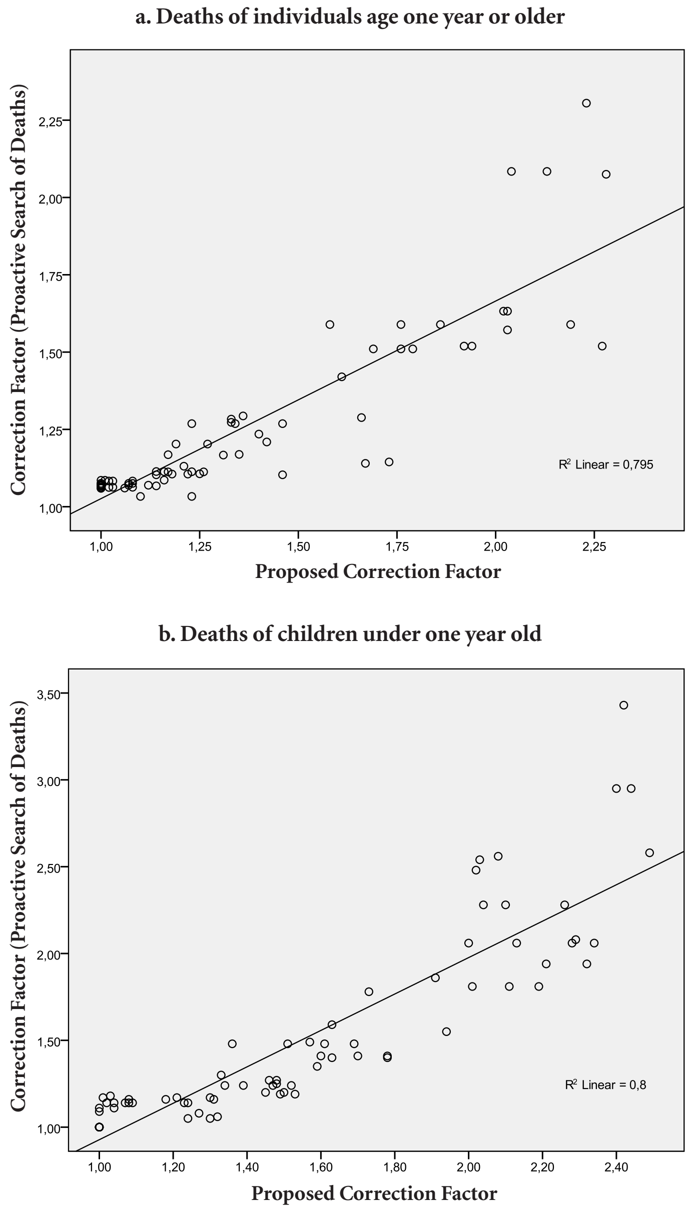

Figure 1. Linear regression models showing association between correction factors calculated using data from the Proactive Search of Deaths and correction factors calculated with data from the SIM. Brazil. 2012.

eliminating the possible influence of unreported infant deaths in the estimation of correction factor forall other deaths.The correction factors estimated in this study were calculated using data reported to the SIM by municipality. The calculation is relatively simple – multiplying the mortality rate by a factor in order to reach a value established as satisfactory (SMR of 5, 5 per 1000 inhabitants). Considering that the correction factor is based on the level of coverage, the methodology of correction by municipality can be updated annually.

The Proactive Search of Deaths survey, referring to deaths occurred in 2012 but that were not reported to the SIM, also enabled the assessment of data quality in municipalities of the North and Northeast regions and validated the adequacy criteria previously proposed, now taking into

Table 2. Informed (INF) and corrected (COR) number of deaths, and estimated coverage (%) of the SIM in the 19 participating states. North and Northeast regions, and states of Minas Gerais, Mato Grosso, and Goiás. 2011-2013.

UF	Infant deaths			Deaths of individuals aged one year or older			Total deaths		
	INF	COR	Coverage (%)	INF	COR	Coverage (%)	INF	COR	Coverage (%)
RO	370	446	82.9	6956	7537	92.3	7326	7983	91.8
AC	270	331	81.5	2980	3223	92.5	3249	3554	91.4
AM	1280	1751	73.1	13422	15463	86.8	14702	17214	85.4
RR	170	205	82.8	1598	1779	89.8	1768	1984	89.1
PA	2370	3252	72.9	30976	35620	87.0	33346	38872	85.8
AP	307	368	83.4	2284	2593	88.1	2591	2961	87.5
TO	354	474	74.6	6340	7003	90.5	6694	7477	89.5
MA	1843	2710	68.0	27668	33653	82.2	29511	36363	81.2
PI	797	1072	74.3	16649	18842	88.4	17446	19914	87.6
CE	1695	2117	80.1	47624	50540	94.2	49319	52657	93.7
RN	651	861	75.6	17539	19204	91.3	18190	20065	90.7
PB	831	997	83.4	24355	25914	94.0	25186	26911	93.6
PE	1986	2121	93.7	55207	56310	98.0	57193	58431	97.9
AL	833	913	91.2	17915	18264	98.1	18748	19177	97.8
SE	544	593	91.7	11196	11419	98.0	11740	12012	97.7
BA	3514	4420	79.5	75656	85011	89.0	79169	89431	88.5
MG	3281	4013	81.8	120936	128253	94.3	124218	132266	93.9
MT	742	878	84.5	14952	15799	94.6	15694	16677	94.1
GO	1303	1430	91.1	33959	35293	96.2	35261	36723	96.0

consideration the municipality population size[17]. In the present study, these criteria were improved to estimate infant mortality by municipality. The results showed that the correction was insufficient in 227 Brazilian municipalitiesforwhich the reported number of infant deaths is very low even after correction.

The survey also collected the deceased's date of birth. Deaths identified through unofficial sources had the age verified in a second stage of the data collection, allowing for the calculation of correction factors by age group and sex. The estimation of such correction factors permits the calculation of age and sex specific mortality rates, which can then be multiplied by proportional mortality due to specific causes of death, resulting in cause specific mortality rates[16].

Unlike in previous Proactive Search surveys, the 2012 Proactive Search of Deaths included municipalities in the states of Minas Gerais and Goiás, which allowed for the calculation of mortality indicators with greater precision in these two states. The study did not include municipalities in the states of Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina, Rio Grande do Sul, Mato Grosso do Sul or the Federal District, which historically presented high-quality mortality data[15]. Our results showed that Pernambuco and Sergipe could certainly be included in the list of states with satisfactory coverage of vital information – the states that do not need to use correction factors to calculate mortality indicators.

Quality improvement of vital statistics in Brazil intensified in the early 2000s. The movement towards high-quality data started from an understanding that vital statistics, compiled by continuous recording systems, are crucial to monitor the results of maternal and child health programs[6]. Proactive search of vital events hasgained relevance and have become an important instrument toestimatevital statistics correction factors[14]. In addition, the search for events not reported to official sources have become part of the routine in some municipalities, contributing to the data quality improvement[12].

The search for Proactive Search of Deaths also had a qualitative component. Research in re-

Table 3. Infant Mortality Rate (IMR) per por 1,000 LB estimated after applying correction factors in 19 participating states, and municipalities for which the correction fator was insufficient. North and Northeast regions, and states of Minas Gerais, Mato Grosso, and Goiás. 2011-2013.

UF	IMR (/1000 LB)	Municipalities with insufficient correction			
		n	%	IMR [(1)] /1000 LB	IMR [(2)] /1000 LB
RO	15.2	4	7.7	4.4	18.7
AC	17.4	0	0.0	-	-
AM	20.4	0	0.0	-	-
RR	17.9	0	0.0	-	-
PA	20.6	2	1.4	4.3	26.1
AP	22.2	0	0.0	-	-
TO	17.6	18	12.9	5.3	19.9
MA	19.5	10	4.6	6.9	21.8
PI	20.3	25	11.2	5.9	22.7
CE	14.9	7	3.8	6.2	15.5
RN	17.0	13	7.8	3.6	20.4
PB	16.1	26	11.7	4.5	17.2
PE	14.2	2	1.1	4.5	13.9
AL	15.8	7	6.9	4.1	16.6
SE	16.1	4	5.3	5.4	16.0
BA	19.5	16	3.8	7.2	20.2
MG	14.8	63	7.4	3.7	15.7
MT	16.3	21	14.9	3.7	17.7
GO	14.6	9	3.7	3.0	16.2

[(1)] Using number of infant deaths after applying correction factors. [(2)] Using number of infant deaths estimated from UF's IMR among municipalities with sufficient correction factors according to mortality data adequacy.

mote and very poor municipalities has described a very different situation from that in found more economically developed municipalities. In some rural municipalities surveyed, most of the burials are carried out in unofficial cemeteries, without identification of the deceased, in pits dugin the forest, without physical barriers and in a poor state of conservation, while official sources that routinely report data to the SIM, such as hospitals and civil registries,remain unaware of such deaths.

This study showed higher numbers of unreported infant deaths compared to all other deaths, a finding corroborated by studies in other countries[18]. A study conducted in 51 indigenous villages in India, found a high association between underreporting of infant deaths and lack of prenatal care, and care received during delivery and postpartum[19].Among infant deaths found in the Indian study, only 29.2% of the mother received prenatal care and 60.4% had a home birth. In addition, 39.6% of the mothers did not breastfeed their baby. The Proactive Search of Deaths found cases of infant that were buried in the forest of rural Amazon, with a baby bottle and a can of infant formula next to the grave. One of the municipalities in this region had only 41% coverage of infant deaths for the period 2011-2013.

The advances made by Brazil in the field ofvital statistics are widely recognized[5,7], but the results of this research showed that our greatest challenge is to reach rural and remote municipalities that do not yet have reliable vital information. Lack of access to health care, related not only to geographic barriers but also to cultural aspects of local communities, is one of the mainimpediments to continuousquality improvement of vital statistics data[20,21]. Data from the Proactive Search of Deaths, gathered during the household interview phase, revealed that the main reason families gave for not report an infant death to a hospital or a vital statistic registrar was that they "felt no need to register the death of the child".

To reach those in need of care, we need to improved access to skilled birth attendance and community-based interventions including universal primary care.One of the strategies implemented by the federal government in 2011 was the ProgramaRedeCegonha. This program offers a new model of care that integrates high-quality prenatal care and pre-identification of referral hospitals for each mother to ensure safe delivery including safe transportation to the hospital[21,22]. The lack of accurate information about infant mortality is one of the greatest obstacles to its reduction. Inaccurate information restricts planning and adoption of adequate measures by policy makers and managers of the health care system[23]. Reliable information on the health status of newborns is essential to discuss progress at the local level.

Collaborations

WS Almeida and CL Szwarcwald contributed in all stages of the design and development of this manuscript.

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