Estimation of maternal mortality rates in Brazil, 2008-2011

Estimação da razão de mortalidade materna no Brasil, 2008-2011

Estimación de la tasa de mortalidad materna en Brasil, 2008-2011

Celia Landmann Szwarcwald [1]
Juan José Cortez Escalante [2]
Dácio de Lyra Rabello Neto [2]
Paulo Roberto Borges de Souza Junior [1]
César Gomes Victora [3]

Abstract

[1] Instituto de Comunicação e Informação Científica e Tecnológica em Saúde, Fundação Oswaldo Cruz, Rio de Janeiro, Brasil.
[2] Secretaria de Vigilância em Saúde, Ministério da Saúde, Brasília, Brasil.
[3] Faculdade de Medicina, Universidade Federal de Pelotas, Rio Grande do Sul, Brasil.

Correspondence
C. L. Szwarcwald
Departamento de Informações em Saúde, Instituto de Comunicação e Informação Científica e Tecnológica em Saúde, Fundação Oswaldo Cruz.
Av. Brasil 4365, sala 225, Biblioteca de Manguinhos, Rio de Janeiro, RJ 21040-360, Brasil.
celials@icict.fiocruz.br

This study proposes a methodology for estimating maternal mortality rates (MMR) in Brazil between 2008 and 2011 using data obtained from Ministry of Health information systems. The method assesses underreporting of maternal deaths, the investigation rates of deaths among women of reproductive age, as well as the proportion of maternal deaths that were misclassified as other causes before investigation. MMR was estimated for each state in Brazil in the 2009 to 2011 triennium. Overall MMR in Brazil was lower in 2011 (60.8 per 100,000 live births) and higher in 2009 (73.1 per 100.000 live births) probably due to the H1N1 influenza epidemic that occurred in the same year. MMR was highest in the States of Maranhão and Piauí (over 100 per 100,000 live births) and lowest in the State of Santa Catarina, the only state with a MMR of less than 40 per 100,000 live births. The results show that rates are higher than the target rate of the fifth Millennium Development Goal, but indicated a significant decrease in MMR during the period 1990 to 2011.

Maternal Mortality; Underregistration; Cause of Death

Resumo

Neste trabalho, propõe-se uma metodologia de estimação da razão de mortalidade materna (RMM), no Brasil, de 2008 a 2011, por meio das informações do Ministério da Saúde. O método proposto leva, em consideração, o sub-registro geral de óbitos, as proporções de investigação de mortes de mulheres em idade fértil, bem como as proporções de óbitos maternos que foram atribuídos, indevidamente, a outras causas antes da investigação. A RMM foi estimada por Unidade de Federação no triênio de 2009-2011. No Brasil, a RMM atinge o valor mínimo em 2011 (60,8/100 mil nascidos vivo) e o máximo em 2009 (73,1/100 mil nascidos vivos), explicado, provavelmente, pela epidemia de influenza A (H1N1). Os maiores valores da RMM foram encontrados no Maranhão e no Piauí, ultrapassando 100/100 mil nascidos vivos, e o menor foi apresentado por Santa Catarina, o único estado com magnitude inferior a 40/100 mil nascidos vivos. Os resultados indicaram valores superiores aos que deveriam ter sido alcançados de acordo com a quinta meta do milênio, mas apontaram para um decréscimo significativo no período de 1990-2011, se as estimativas anteriores da RMM forem consideradas.

Mortalidade Materna; Sub-Registro; Causa de Morte

Introduction

A large number of women in developing countries experience pregnancy-related complications, a considerable proportion of which result in death [1]. A mere 1% of maternal deaths worldwide occur in developed countries [2].

Pregnancy-related deaths have long been considered fatalities. Gradually, however, these events have become understood as markers of social development, since the majority of maternal deaths could be prevented if all women had timely access to good quality care [3].

Currently, mortality due to complications during pregnancy, childbirth or the postpartum period, otherwise known as maternal mortality, is considered a highly preventable cause of death and has been the focus of national and international efforts aimed at its reduction [4,5,6]. One of the targets of the fifth *Millennium Development Goal* is to reduce the maternal mortality ratio by three-quarters by 2015. However, monitoring progress towards this target is challenging, mainly due to difficulties in obtaining reliable data [7,8]. Even in developed countries, which have comprehensive vital registration systems, maternal deaths may be underreported due to misclassification under other categories of the International Classification of Diseases, 10th Revision (ICD-10) or because of the absence of specific information on the death certificate indicating maternal death. To identify the true number of maternal deaths, it is necessary to undertake specific research into the causes of death in women of reproductive age [9].

In Brazil, studies that focus on these dimensions of maternal mortality are scarce. Estimates of maternal mortality rates in Brazil are affected by underreporting of deaths, especially in less developed areas of the country where maternal mortality tends to be higher, and the absence of specific information indicating maternal death in reported deaths of women of reproductive age [10].

A survey carried out in 2002 in the country's state capitals using the RAMOS method (*Reproductive Age Mortality Survey*) estimated a maternal mortality rate of 54.3 deaths per 100,000 live births across all capital cities [11]. The study observed that a number of maternal deaths registered by the Mortality Information System (SIM, acronym in Portuguese) had been wrongly attributed to other causes of death. Similarly, research conducted in the ABC Region in the State of São Paulo showed that the maternal mortality rate was underestimated in official data [12].

In recent years, the government has begun a number of initiatives to expand coverage and improve the quality of vital information systems including: active search procedures to capture vital events not registered by the Ministry of Health systems; strategies for reducing ill-defined causes of death; integration with other Ministry of Health information systems, such as the Hospital Information System (SIH) and Primary Health Care Information (SIAB), at local, regional and national level; and setting goals to increase the coverage of mortality data [13].

Additionally, the Brazilian government recognizes the importance of maternal death surveillance, resulting in the promotion of research into the cause of death among women of reproductive age and the creation and strengthening of maternal mortality review committees at national, regional, state, municipal and hospital level [14].

The objective of this paper is to propose a methodology for estimating maternal mortality in Brazil using data from Ministry of Health information systems from 2008, 2009, 2010 and 2011 and assess causes of death in women of reproductive age to evaluate the general degree of underreporting of maternal deaths, the proportion of investigated deaths, the proportion of maternal deaths that went unreported on the death certificate, and the proportion of deaths attributed to other causes before the investigation.

Methodology

The maternal mortality rate (MMR), defined as the number of maternal deaths per 100,000 live births, is an indicator of the magnitude of maternal mortality and temporal and spatial trends. To estimate MMR in the period 2008 to 2011, it was necessary to adjust the vital statistics data to correct for the methodology adopted by the Ministry of Health and for the lack of coverage of the birth and death registration system in Brazil (Health Informatics Department – DATASUS. The ratio between reported and estimated deaths can be found at: http://tabnet.datasus.gov.br/cgi/idb2011/a1801b.htm, and the ratio between the number of reported and estimated live births can be found at: http://tabnet.datasus.gov.br/cgi/idb2011/a17b.htm, accessed on 02/May/2013).

Active search of deaths and births in the Amazon and Northeast Region

The "Active Search of Deaths and Births in the Amazon and the Northeast Region" project was conducted between September 2009 and June 2010. The study was approved by the Research Ethics Committee of the Oswaldo Cruz Foundation (Fiocruz).

A random sample of 133 municipalities in 17 states in the Amazon and the Northeast Region was selected and stratified by population size (1 to 20,000; 20,001 to 50,000; 50,001 to 200,000 inhabitants, and over 200 thousand inhabitants) and the level of adequacy of vital statistics data (poor, unsatisfactory, satisfactory) based on criteria proposed by Andrade & Szwarcwald [15]. All the state capitals of the regions studied were also included in the survey.

In the selected municipalities, an active search of vital events in 2008 was conducted to identify birth and death certificates registered in the SINASC (Information System on Live Births) and the SIM and live births and deaths which were not registered. The sampling process and correction method are described in detail by the Ministry of Health [16].

Correction of the number of reported deaths

To determine the level of coverage of data on maternal mortality we calculated the overall standardized mortality rate by age for all Brazilian municipalities based on the population of Brazil in the year under review. Due to the large proportion (45%) of municipalities with less than 10,000 inhabitants, the overall standardized mortality rate was calculated based on the average mortality rate of the reference year and the two years immediately preceding and immediately following the reference year (1999 to 2001 for the reference year 2000, 2000 to 2002 for the reference year 2001, through to 2009 to 2011 for the reference year 2010) to provide greater reliability.

For the 2007 to 2009 triennium (reference year 2008), the municipalities were categorized according to overall standardized mortality rate (< 2; ≥ 2 and < 3; ≥ 3 and < 4; ≥ 4 and < 5; ≥ 5 and < 5.5; ≥ 5.5 per 1,000 inhabitants). Correction factors were then calculated for each standardized mortality rate category, based on the ratio between the total number of deaths corrected in the active search process and the total number of reported deaths. Deaths among children under the age of one and among individuals aged one year or over were considered separately.

To generalize the correction procedure for the period 2000 to 2010, municipalities were ranked according to the level of coverage of mortality data and standardized mortality rate category in each triennium and all deaths reported in the municipalities during the period 2000 to 2010 were adjusted using the corresponding correction factors. The correction factors were held constant for the standardized mortality rate, but not for municipality. Therefore, any improvement

in coverage of mortality data in a particular municipality over the period is reflected by a lower correction factor in the following standardized mortality rate category [17].

Distribution by gender and age-adjusted death

Distribution by gender and age-adjusted death among individuals aged one year or older was estimated based on a comparison between deaths not reported to the SIM and deaths identified by the active search carried out in 2008.

The corrected number of deaths in a particular age group and by gender was calculated using a mathematical equation where the number of reported and unreported deaths at one year of age or older are represented by x_0 and x_1, respectively:

$x_1 + x_0$ = number of deaths at one year of age or older.

The proportion of reported and unreported deaths in a particular age group and sex is represented by p_0 and p_1, respectively:

$x_0p_0 + x_1p_1$ = corrected number of deaths in a particular age group and sex.

Hence, the correction factor for a given age group and gender is given by:

$$\frac{x_0p_0 + x_1p_1}{x_0p_0} = 1 + \frac{x_1}{x_0}\frac{p_1}{p_0}$$

where the ratios x_1/x_0 and p_1/p_0 are estimated using data obtained from the active search.

Correction of live births

The level of adequacy of live birth data was expressed by the ratio between reported and estimated live births in all Brazilian municipalities, based on the average reported live births for each triennium, and the projected population of infants under the age of one year.

For the 2007 to 2009 triennium, municipalities were categorized into live birth ratio groups (< 0.5; ≥ 0.5 e < 0.6; ≥ 0.6 e < 0.7; ≥ 0.7 e < 0.8; ≥ 0.8 e < 0.9; ≥ 0.9). Correction factors for live births by level of coverage of data were estimated using the adjusted live births data obtained from the active search process.

All municipalities were categorized according to the ratio between reported and estimated live births in each triennium during the period 2000 to 2010 and live births were adjusted using the corresponding correction factors [17]. Any improvement in the level of coverage of live births data in a given municipality over the period

is reflected by a lower correction factor in the following ratio of reported and estimated live births category [17].

Correction of maternal deaths attributed to other causes

For the 2009 to 2011 triennium, the study used individual SIM data on deaths among women of reproductive age (10-49 years old), together with combined SIM and SINASC data. Individual SIM data shows the underlying cause of death initially registered in the system and the final underlying cause of death after investigation.

To calculate the proportion of maternal deaths not indicated on the death certificate and causes of death classified in other categories of ICD-10, deaths were categorized according to the presence/absence of investigation using the SIM variable TPPOS, and period in which death occurred (during pregnancy; during childbirth; 43 days to one year postpartum; undefined period outside pregnancy, childbirth and postpartum; ignored period) composed of two variables contained in the SIM (OBGRAV and OBPUERP).

The investigated deaths of women of reproductive age were aggregated according to the original cause of death (CAUSABAS_O): presumed maternal death (A400-A403; A408-A419; A542; D65; G400-G409; G932; I10; I210-I214; I219; I269; I429; I469; I500; I509; I64; I740-I749; J100-J101; J108; J110-J111; J118; J120-J122; J128-J129; J13-J14; J150-J160; J180- J182; J188-J189; J81; K650; K658-K659; K720; N170-N172; N178-N179; N710-N711; N719; N733-N739; R568; R571; R578; R58; R98; R99; Y480-485; Y579); maternal death; late maternal death; other cause. The investigated deaths of women of reproductive age were also ranked by the final cause of death (CAUSABAS) as maternal death or non-maternal death. The study adopted definitions of maternal death and presumed cause of maternal death established by the Ministry of Health [18].

By crosschecking the original and final causes of death it was possible to ascertain the proportion of deaths not originally classified as maternal deaths, but considered maternal deaths after investigation and the proportion of deaths no longer considered maternal deaths after investigation.

These proportions were calculated based on the assumption that the percentage of reclassified and uninvestigated deaths is equal and adjusted according to the corresponding misclassification correction factors. Table 1, 2 and 3 shows the estimated additional number of maternal deaths that would have been identified if all deaths of women of reproductive age had been investigated, by underlying cause (presumed; maternal death; late maternal death, other) and the period in which death occurred.

With respect to state MMR estimates for the 2009 to 2011 triennium, the misclassification correction factor was not used to adjust the number of investigated maternal deaths by cause of death and period in which death occurred.

Based on the assumption that the rate of underreporting of maternal deaths is the same as that of non-maternal deaths among women aged between 10 and 49 years, maternal deaths were further adjusted using a correction factor to reflect underreporting in the SIM (CI95%: 1.068±0.047) [16]. The number of live births was also adjusted using a correction factor to reflect underreporting in the SINASC (CI95%: 1.043±0.015) (http://tabnet.datasus.gov.br/cgi/idb2011/a17b. htm, accessed in 02/May/2013) [16]. State maternal mortality rates were calculated by dividing the corrected number of maternal deaths by the corrected number of live births.

Trends in the maternal mortality rate during the period 1990 to 2011

The proposed method was used to estimate the MMR from 2008, the year in which the investigation of deaths among women of reproductive age became widespread.

Trends in MMR during the period 1990 to 2011 were assessed using official estimates of MMR in 1990 and 1996 and estimates of MMR in the 2008 to 2011 triennium [18]. The 2005 estimate was adjusted using correction factors for misclassification of maternal deaths (1.4) [11] and for underreporting of deaths of women of reproductive age (1.08 -http://tabnet.datasus.gov.br/cgi/idb2011/a1801b.htm, assessed in 02/May/2013) and underreporting of live births (1.09 – http://tabnet.datasus.gov.br/cgi/idb2011/a17b.htm, accessed on 02/May/2013).

Results

A total of 200,619 deaths among women of reproductive age were registered in the SIM during the period 2009 to 2011, of which 112,007 (55.8%) were investigated. The investigation rate ranged from 2.9% in the State of Amapá to 83.7% in State of Mato Grosso. The rate of investigated deaths was above 50% in all regions, except the North Region. The rate of investigated deaths in municipalities with an average of at least 10 deaths among women of reproductive age over three years varied considerably by state: the rate was over 30% in all municipalities in 10 States, while

Table 1

Proportion of investigated deaths among women of reproductive age and percentage of municipalities * with investigation rate under 30% by state and region. Brazil 2009-2011.

States and Region	Uninvestigated	Investigated	Total number of deaths among WRA	Proportion (%)	% municipalities * with investigation rate < 30%
RO	712	910	1,622	56.1	25.0
AC	306	449	755	59.5	33.3
AM	1,598	1,621	3,219	50.4	60.0
RR	128	311	439	70.8	0.0
PA	4,174	2,933	7,107	41.3	47.3
AP	537	16	553	2.9	100.0
TO	464	968	1,432	67.6	0.0
Total North Region	7,919	7,208	15,127	47.6	42.9
MA	3,990	1,981	5,971	33.2	69.0
PI	590	2,336	2,926	79.8	0.0
CE	1,125	6,403	7,528	85.1	0.0
RN	1,122	1,575	2,697	58.4	23.1
PB	1,835	1,869	3,704	50.5	20.0
PE	2,973	6,822	9,795	69.6	5.0
AL	2,412	1,166	3,578	32.6	54.5
SE	415	1,736	2,151	80.7	0.0
BA	9,162	5,917	15,079	39.2	46.9
Total Northeast Region	23,624	29,805	53,429	55.8	29.1
MG	7,444	13,851	21,295	65.0	14.2
ES	1,419	2,655	4,074	65.2	0.0
RJ	6,860	14,017	20,877	67,1	19.3
SP	21,879	19,905	41,784	47,6	19.4
Total Southeast Region	37,602	50,428	88,030	57,3	16.6
PR	2,744	8,516	11,260	75.6	0.0
SC	2,966	3,158	6,124	51.6	25.6
RS	6,515	4,929	11,444	43.1	50.7
Total South Region	12,225	16,603	28,828	57.6	25.7
MS	734	2,018	2,752	73.3	0.0
MT	537	2,758	3,295	83.7	0.0
GO	4,922	1,746	6,668	26.2	65.9
DF	1,049	1,441	2,490	57.9	0.0
Total Central Region	7,242	7,963	15,205	52.4	34.6
Brazil	88,612	112,007	200,619	55.8	25.6

AC: Acre; AL: Alagoas; AM: Amazonas; AP: Amapá; BA: Bahia; CE: Ceará; DF: Distrito Federal; ES: Espírito Santo; GO: Goiás; MA: Maranhão; MG: Minas Gerais; MS: Mato Grosso do Sul; MT: Mato Grosso; PA: Pará; PB: Paraíba, PE: Pernambuco; PI: Piauí; PR: Paraná; RJ: Rio de Janeiro; RN: Rio Grande do Norte; RO: Rondônia; RR: Roraima; RS: Rio Grande do Sul; SC: Santa Catarina; SE: Sergipe; SP: São Paulo, TO: Tocantins.
* Municipalities with an average of 10 or more deaths among women of reproductive age (WRA) in the 2009-2011 triennium.

in seven States 50% of municipalities had an investigation rate of under 30% (Table 1).

Table 2 shows the investigated deaths of women of reproductive age classified according to the period in which death occurred and original underlying cause, and whether the death was reclassified as a maternal death after investiga-tion. It is interesting to note that the number of deaths occurring outside pregnancy and child-birth reclassified after investigation as maternal deaths was insignificant, while 40% of deaths outside pregnancy, childbirth and postpartum originally classified as maternal (n = 120), were classified into other categories. With respect to

Table 2

Proportion of deaths among women of reproductive age reclassified as maternal deaths after second investigation according to type of original cause (before the investigation) and period in which death occurred. Brazil 2009-2011.

Period in which death occurred/original underlying cause before the investigation	Reclassified as maternal deaths after investigation		Total investigated deaths among women of reproductive age	Proportion (%) of deaths reclassified as maternal
	No	Yes		
Outside pregnancy, childbirth and postpartum period				
Not presumed	74,744	23	74,767	0.03
Presumed	20,199	20	20,219	0.10
Maternal death	48	72	120	60.00
Late maternal death	5	0	5	0.00
During pregnancy, childbirth and 43 days to one year postpartum or undefined				
Not presumed	2,033	539	2,572	20.96
Presumed	739	482	1,221	39.48
Maternal death	80	2,224	2,304	96.53
Late maternal death	55	7	62	11.29
Ignored				
Not presumed	7,930	7	7,937	0.09
Presumed	2,758	14	2,772	0.51
Maternal death	1	27	28	96.43
Late maternal death	-	-	-	-
Total	108,592	3,415	112,007	3.05

the category related to pregnancy (pregnancy, childbirth and postnatal, late postnatal, or undefined period), 39.48% of deaths with presumed cause of maternal death, 20.96% of deaths without any apparent cause, and 11.29% of late maternal deaths were reclassified after investigation, while only 3.57% of deaths originally classified as maternal deaths were reclassified as non-maternal deaths. In cases where the period in which death occurred was ignored, the reclassification rate was less than 1%.

Table 3 shows the expected number of maternal deaths in Brazil in 2010 based on uninvestigated deaths among women of reproductive age by period in which death occurred and type of cause (maternal death presumed or not presumed). The reclassification rate was calculated based on the total number of corrected maternal deaths (812) and number of uninvestigated deaths among women of reproductive age.

The expected number of maternal deaths if all deaths had been investigated (1,902) is obtained from the sum of investigated maternal deaths (1,090) and corrected number of uninvestigated maternal deaths (812). Since the number of originally reported maternal deaths was 1,430,

the misclassification correction factor was calculated as 1.33 (1,902/1,430). If the correction factor for underreporting of deaths of women of reproductive age (1.068 ± 0.047) is also taken into account, the resulting adjustment factor is 1.421 ± 0.063 and the estimated number of maternal deaths is 2,031 (± 90). The ratio between the corrected number of maternal deaths (2,031) and the corrected number of live births (3,009,345 ± 44,133) results in an estimated MMR of 67.5 per 100,000 live births in 2010, in a range between 63.6 to 71.5 per 100,000 live births, if the standard errors of the correction factors relating to the underreporting of deaths and births are taken into account [16].

Table 4 presents estimates of MMR in 2005, 2008 to 2011, and official national estimates in 1990 and 1996 [18]. The annual rate of decline in MMR over the period 1990-2011 was 3.72%, with a multiple correlation coefficient of 0.988 (p < 0.01). It is interesting to note that MMR in 2011 was significantly lower than the 2010 estimate.

Table 5 shows MMR estimates by state for the 2009 to 2011 triennium. The highest rates were found in the States of Maranhão and Piauí, surpassing 100 per 100,000 live births, followed by

Table 3

Number of uninvestigated deaths among women of reproductive age that would have been reclassified as maternal deaths by type of cause of death and period in which death occurred. Brazil 2010.

Period in which death occurred/ type of cause	Uninvestigated deaths among women of reproductive age	Proportion (%) of deaths that would have been reclassified as maternal	Deaths among women of reproductive age who would have been reclassified as maternal	Expected number of maternal deaths
Outside pregnancy, childbirth and postpartum period				
Not presumed	12,718	0.03	3.8	
Presumed	2,889	0.10	2.9	
Maternal death	**21**	60.00	12.6	**19**
Late maternal death	2	0.00	0.0	
During pregnancy, childbirth and 43 days to one year postpartum or undefined				
Not presumed	536	20.96	112.3	
Presumed	194	39.48	76.6	
Maternal death	**526**	96.53	507.7	**698**
Late maternal death	11	11.29	1.2	
Ignored				
Not presumed	8,559	0.09	7.7	
Presumed	2,849	0.51	14.5	
Maternal death	75	96.43	72.3	**95**
Late maternal death	1	0.00	0.0	
Total				
Not presumed	21,813			
Presumed	5,932			
Maternal death	622			812
Late maternal death	14			

Table 4

Estimates of maternal mortality rate (MMR) in Brazil for selected years.

Year	MMR (per 100 thousand live births)
1990 *	143.2
1996 *	103.2
2005	78.2
2008	66.9
2009	73.1
2010	67.5
2011	60.8
Annual rate of decline (%)	3.72 **

* Official MMR [18].

** Statistically significant at 1% ($p < 0.001$).

Tocantins, Amazonas, Sergipe, Bahia and Rio de Janeiro, where rates were over 80 per 100,000 live births. The lowest MMR was observed in Santa Catarina, the only state with an MMR of less than 40 per 100,000 live births.

Discussion

Interest in health indicator estimates has grown considerably with the looming 2015 deadline for achieving the *Millennium Development Goals*. However, estimating reductions in maternal mortality is more complex than other health indicators such as infant and child mortality. First, confusion exists between maternal deaths and mortalities during pregnancy caused by infectious diseases and external causes which are considered non-maternal deaths [19,20]. Thus, household surveys conducted using verbal autopsy

Table 5

Estimates of Maternal Mortality Rate by state and region.
Brazil 2009-2011.

States and region	MMR (per 100 thousand live births)
RO	71.3
AC	41.4
AM	93.9
RR	64.6
PA	74.3
AP	59.5
TO	96.1
Total North Region	**77.8**
MA	114.0
PI	101.8
CE	73.4
RN	61.4
PB	56.6
PE	63.3
AL	55.1
SE	90.1
BA	87.9
Total Northeast Region	**80.8**
MG	55.5
ES	72.3
RJ	85.7
SP	52.3
Total Southeast Region	**60.4**
PR	63.3
SC	36.9
RS	55.7
Total South Region	**54.5**
MS	76.4
MT	76.7
GO	61.0
DF	48.7
Total Central Region	**65.0**
Brazil	**68.2**

AC: Acre; AL: Alagoas; AM: Amazonas; AP: Amapá;
BA: Bahia; CE: Ceará; DF: Distrito Federal; ES: Espírito
Santo; GO: Goiás; MA: Maranhão; MG: Minas Gerais;
MS: Mato Grosso do Sul; MT: Mato Grosso; PA: Pará;
PB: Paraíba, PE: Pernambuco; PI: Piauí; PR: Paraná;
RJ: Rio de Janeiro; RN: Rio Grande do Norte; RO: Rondônia;
RR: Roraima; RS: Rio Grande do Sul; SC: Santa Catarina;
SE: Sergipe; SP: São Paulo, TO: Tocantins.

may lead to an overestimation of maternal mortality [23], adding to the limitations of sample surveys for monitoring mortality indicators [21,22].

Another important issue is induced abortion in countries where abortion is illegal [24] and where maternal deaths due to unsafe practices are not always included in the maternal mortality statistics [25].

Another difficulty in estimating maternal mortality stemming from the general underreporting of deaths common to developing countries, is the notification of maternal deaths due to other causes. This requires specific investigation procedures to obtain reliable statistics and studies conducted in different countries to identify maternal deaths wrongly attributed to other causes observed an average correction factor of 1.5. This variation can be attributed to the data sources (death certificates, hospital records, verbal autopsies) and the research procedures used [2].

Scientific literature on maternal mortality in Brazil is scarce, despite its relevance to the nation's health scenario. Due to the difficulties of measuring this indicator, the Interagency Health Information Network (RIPSA, acronym in Portuguese) provides non-adjusted estimates of national MMR and separate estimates for only eight states (DATASUS. Maternal mortality rate by region and state. http://www.tabnet.datasus.gov.ve/cgi/idb2011/c03b.htm, accessed on 2/May/2013).

With respect to the period 2000 to 2007, we adopted a constant correction factor of 1.4 based on a survey of state capitals carried out in 2002 [11]. Without taking into account the decrease in underreporting and increase in the investigation of deaths of women of reproductive age, the MMR in Brazil plateaued in the 2000s after experiencing a 50% decrease in the 1990s [18].

However, the *Brazilian Millennium Development Goals* monitoring report [27] indicates the need to revise the use of a constant correction factor during a whole decade and widen the investigation of deaths among women of reproductive age. The official estimate of maternal mortality in Brazil in 2010 was 68.2 per 100,000 live births. Considering that about 20% of deaths among women of reproductive age were wrongly attributed to other causes, this rate is very similar to that estimated by the present study.

The method used by this study allowed us to estimate MMR at a national level and in all states in the years 2008 to 2011. The revision of the correction factor for 2005 allowed us to observe the trend in MMR during the period 1990 to 2011 which, unlike the RIPSA estimate (http://www.tabnet.datasus.gov.ve/cgi/idb2011/c03b.htm, accessed on 2/May/2013), showed a further annual decline of 3.72%.

It should be noted, however, that 2009 was an atypical year and the MMR increased to over 70 per 100,000 live births, probably due to the H1N1

influenza epidemic which hit Brazil and other countries that year [18,28].

Despite the downward trend during the period 1990 to 2011, the results presented by this study indicate that MMR in Brazil is still unacceptably high, since it is between three and four times higher than rates in developed countries in early 2010 [2,29]. These high rates seem to be inconsistent with progress in health care, such as an increase in coverage of antenatal and childbirth care, and the social transformations experienced by Brazilian society, including improved socioeconomic status and a sharp drop in fertility [30].

In fact, according to the World Health Organization model, based on gross domestic product per capita, fertility rate and quality of childbirth care, Brazil's MMR was estimated at 56 per 100,000 live births in 2010, approximately 20% less than the estimate presented here. However, the annual rate of decline for the period 1990 to 2010 was estimated at 3.5%, similar to the findings of this study [2].

Brazil has seen a significant increase in the use of contraceptive methods and the total fertility rate declined from 2.7 children in 1991 to 1.8 children in 2010 (DATASUS. Total fertility rate. http://tabnet.datasus.gov.br/cgi/idb2011/a05b.htm, accessed on 2/May/2013). Data from the National Demographic Health Survey (DHS) conducted in 2006, showed that the proportion of women of reproductive age using modern contraceptives was 65% and over 75% among women between 30 and 49 years of age [32]. The impact of family planning on the reduction in maternal mortality is increasingly recognized, decreasing the chance of conception and thus the number of maternal deaths [33]. With regard to access to antenatal care and hospital delivery, data from the SINASC shows that coverage is high and indicates an increasing trend: in 2010, 91% of Brazilian mothers attended more than four antenatal visits, and this proportion ranged from 80% in the North Region to 94% in the Southeast and South Regions. The proportion of hospital deliveries was also very high (98%). The percentage of home births in the North Region was the highest among the regions, but was under 5% (DATASUS. http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sinasc/cnv/nvuf.def, accessed on 2/May/2013).

In light of general improvements in indicators of maternal and child health, the high maternal mortality rates observed by this study are cause for concern. Based on the Millennium Development Goals, MMR in Brazil in 2010 was expected to be 47 per 100,000 live births, equivalent to 70% of the rate estimated by this study. The poor quality of existing health services, lack of integration between antenatal care and childbirth care, as well as the increase in unnecessary caesarean sections are possible factors that explain the high maternal mortality rates in Brazil which are at odds with the distinctly favorable evolution of access to antenatal care and hospital delivery [30].

Unlike the decline in the rate of post-neonatal mortality, which surpassed the expectations of the fourth *Millennium Development Goal*, the slow decrease in neonatal mortality [34] and a persistently high MMR draw attention to performance problems in the SUS. Improvements must be made to the health system to ensure timely and quality maternity care [35].

Thorsen et al. [36] conducted a review of the conceptual framework for the analysis of maternal mortality related to delays in care during the three stages of labor and child birth: delay in the decision to seek skilled attendance; delay in access to a health care facility that is able to provide emergency obstetric care services; and delay in receiving adequate care on entering the health care facility [3]. As discussed by the authors, these three delays are not independent, and a delay in one can affect the other, resulting in complications or even death. Although all Brazilian women have a guaranteed right to receive free care during labor and childbirth, many still experience difficulty in being admitted to hospital during childbirth due to lack of beds, causing a delay in receiving care [37].

The estimates of MMR by state during the 2009 to 2011 triennium are even more alarming. MMR was over 100 per 100,000 live births in two states, and in Rio de Janeiro, one of the richest states in the country, MMR was over 80 per 100,000 live births.

It is important to note, however, that the quality of subnational data varies substantially depending on the proportion of investigated deaths and sampling criteria. Although it is recommended that all deaths of women of reproductive age are investigated, in practice the states establish prioritization criteria which tend be very heterogeneous. To overcome this limitation, correction factors for underreporting of maternal deaths among women of reproductive age were calculated to adjust national MMR for the 2009 to 2011 triennium, and also applied to data for all states, considering only differences in the proportion of deaths investigated.

Another limitation is that maternal death is a rare event, and for some states with smaller populations, such as those in the Northern Region, a small undercount of maternal deaths may substantially affect the state MMR: for example, although the data used to estimate state

MMR was taken from the 2009 to 2011 triennium to provide greater reliability, it is likely that the MMR for certain states such as Acre remains underestimated.

Another relevant aspect of this study is the definition of the set of suspected causes of maternal death [20]. Although a discussion about the criteria adopted by the Ministry of Health to establish the set of suspected causes used by this study are beyond the scope of this study, the definition of causes may have affected the reclassification rates observed in this analysis. Additionally, it should be noted that the point estimates for MMR are subject to uncertainties due to sampling errors related to the correction factors for vital statistics, such as uncertainties in the rate of reclassification of uninvestigated deaths, which can only be overcome by widening the investigation and ensuring that changes in the original underlying cause of death are properly registered in the SIM.

In conclusion, the method used by this study allowed us to estimate MMR in recent years. Although the maternal mortality rates observed by this study do not meet the targets of the fifth Millennium Development Goal, the findings point to an overall decline in MMR during the period 1990 to 2011, with an average annual reduction rate of 3.7%, higher than rates in other developing countries [2]. However, despite the improvements, these results must not lead to complacency. To the contrary, each maternal death needs to be understood as a failure of the health system and a violation of reproductive rights.

Resumen

En este trabajo se propone una metodología de estimación de la razón de mortalidad materna (RMM), en Brasil, de 2008-2011, mediante la información proporcionada por el Ministerio de Salud. El método propuesto tiene en consideración el sub-registro general de óbitos, las proporciones de investigación en muertes de mujeres en edad fértil, así como las de óbitos maternos que fueron atribuidos, indebidamente, a otras causas antes de esta investigación. La RMM fue estimada por estados durante el trienio de 2009-2011. En Brasil, la RMM alcanza el valor mínimo en 2011 (60,8 por 100.000 nacidos vivos) y el máximo en 2009 (73,1 por 100.000 nacidos vivos), explicado, probablemente, por la epidemia de gripe A (H1N1). Los mayores valores de la RMM se encontraron en los estados de Maranhão y en Piauí, sobrepasando 100 por 100.000 nacidos vivos, y el menor se presentó en Santa Catarina, el único estado con magnitud inferior a 40 por 100.000 nacidos vivos. Los resultados indicaron valores superiores a los que deberían haber sido alcanzados, de acuerdo con el quinto objetivo del milenio, pero apuntaron un decremento significativo durante el período de 1990-2011, si se consideraran las estimaciones anteriores de la RMM.

Mortalidad Materna; Omisiones de Registro; Causa de Muerte

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