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Correction for reported cervical cancer mortality data in Brazil, 1996–2005

ABSTRACT

OBJECTIVE: To develop a methodology for correction of reported cervical cancer deaths in Brazil.

METHODS: Data on 9,607,177 cancer deaths were obtained from the Brazilian National Mortality Database for the period between 1996 and 2005. For correction of underreporting of deaths, factors generated by the Global Burden of Disease Study in Brazil-1998 were used. Proportional distribution was used in order to correct the categories of unknown, incomplete or ill-defined death diagnosis. The corrections were applied to each Brazilian state and the results were presented for Brazil nationwide, macroregions, and geographical areas (capital, other cities of metropolitan areas and interior cities) as percent variability of cervical mortality rates before and after correction. Corrections were analyzed by multivariate linear regression with interaction terms between macroregion and geographical area.

RESULTS: After correction, cervical cancer mortality rates showed an increment of 103% nationwide, ranging between 35% (Southern region capitals) and 339% (Northeastern region interior cities). The reallocation of cervical cancer deaths not otherwise specified resulted in greater mortality rate increments. The percent correction by year of death revealed steady trends nationwide.

CONCLUSIONS: The study results showed that the proposed methodology was appropriate for the correction of cervical cancer mortality rates in Brazil. It evidenced that cervical cancer mortality is even higher than that reported.

DESCRIPTORS: Uterine Cervical Neoplasms, mortality. Mortality Registries. Underregistration. Information Systems. Brazil.

INTRODUCTION

Cervical cancer is characteristically a preventable disease that can be detected in early, non-invasive forms. Yet cervical cancer is still an ongoing serious challenge for public health authorities, especially in developing countries accounting for 83% of all cases and 86% of all deaths from cervical cancer.[10]

According to the Brazilian Ministry of Health,[a] age-adjusted cervical cancer mortality rates increased from 4.97 to 5.29 per 100,000 women-years for the period 1979 to 2005, a 6.4% increment in 26 years. However, these rates are low compared to other Latin American countries such as Venezuela (15.2), Ecuador (18.6), Bolivia (22.2), Nicaragua (26.1), and Haiti (53.5).[3]

[a] Ministério da Saúde. Departamento de informática do Sistema Único de Saúde. Sistema de Informação de Mortalidade. Brasília; 2006[cited 2009 Dec 30]. Available from: http://tabnet.datasus.gov.br/cgi/idb2006/matriz.htm

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The Brazilian National Mortality Database (SIM) faces many challenges, mainly related to underreporting of deaths and deaths from ill-defined causes.[12] They vary across Brazilian regions but are mostly serious in the North and Northeast regions. It can be thus assumed that reported rates have been underestimated, making it necessary to assess the actual impact of cervical cancer in Brazil.

In addition to SIM-related general issues, there is a particular obstacle specific to cervical cancer. A significant proportion of deaths from cervical cancer is reported as neoplasm of "uterus, not otherwise specified (NOS)," which hinders the assessment of the actual impact of this disease. In an attempt to address this issue and generate more realistic statistics, researchers[7,9,19] have included in their analysis total cases of uterine cancer not otherwise specified, in addition to cervical cancer cases. In fact, Wünsch & Moncau (2002)[19] claim that this inclusion has allowed to reset trends based on socioeconomic profile of populations and Brazilian macroregions.

The literature describes several approaches that aim to correct issues related to mortality databases and death certificates reporting as primary cancer site "uterus, NOS."[1,2,4,14,16,17] The objective of the present study was to develop a methodology for correction of reported cervical cancer deaths in Brazil by combining two approaches: correction of SIM-related issues and those specifically related to death certificates reporting as primary cancer site "uterus, NOS."

METHODS

All 9,607,177 deaths reported by SIM for the period between 1996 and 2005 were included in the correction of reported cervical cancer deaths. Of them, 39,618 deaths were from cervical cancer. Data prior to 1996 were excluded because factors generated by the Global Burden of Disease Study in Brazil for the year 1998 were used for correction of underreporting of deaths.[b] The application of these factors would not be suitable for data prior to 1996 because issues related to underreporting and quality of death certificates were more significant in the early years after SIM implementation.[12]

Underreporting of deaths was corrected using factors indirectly generated by the Global Burden of Disease Study in Brazil for the year 1998.[b] Underreporting of deaths in those under one[6] and those one year old and older[15] was thus separately corrected by gender and macroregion. These factors were recalculated[c] since in that study the corrections were made by macroregion as a whole, disregarding capital cities, other cities in metropolitan areas and interior cities. These aspects were taken into consideration in the present study, but only data from interior cities was corrected assuming that reporting of deaths was close to 100% in capital cities and other cities in metropolitan areas nationwide. For the states of Rio de Janeiro, São Paulo, Mato Grosso do Sul and Rio Grande do Sul reported deaths in interior cities were not corrected assuming that reporting of deaths was also close to 100%. Based on the reference study correction factors were recalculated for so-called "natural" causes of death assuming that reporting of deaths from external causes was close to 100%.

Deaths with unknown (missing), incomplete or ill-defined data in SIM (variables such as gender; macroregion; primary cause of death "uterus, NOS;" incomplete diagnoses; and ill-defined signs and symptoms) were corrected applying proportional distribution of deaths coded in each chapter of the International Statistical Classification of Diseases and Related Health Problems – 10th revision (ICD-10) among deaths from specified causes, by age groups and excluding external causes.[17] For example, all deaths from cancer of the uterus, NOS were redistributed by age, macroregion, geographic area and year among deaths from cervical and uterine body cancer following its original proportion. To estimate missing data on age, single imputation was applied and missing data were replaced by median age, taking into account macroregion, gender and cause of death (three digits).

Since deaths from cancer are most often better reported than other causes of death,[12] the representation of cancers among ill-defined causes would be smaller, making a proportional reallocation of all deaths from ill-defined causes incorrect. Thus, in an attempt to avoid overestimating deaths from cervical cancer, and because there was no other consensus for reallocation of deaths from ill-defined causes, 50% of the estimated weight was attributed to neoplasms by gender, age, geographic area and type of cancer.

Overall, the correction process comprised eight steps:

1. correction of underreporting;
2. imputation of unknown age;
3. reallocation of deaths with unknown gender;
4. reallocation of deaths with unknown macroregion;
5. reallocation of cancer deaths with incomplete diagnosis coded ICD-10 C578 and C579, corresponding to cancer of female genital organs, among cancers of female genital organs;

[b] Gadelha AMJ, Leite IC, Valente JG, Schramm JMA, Portela, MC, Campos MR. Relatório final do Projeto estimativa da carga de doença do Brasil–1998. Rio de Janeiro: Fiocruz; 2002.

[c] Gamarra CJ. Magnitude da mortalidade por câncer do colo do útero no Brasil, 1996-2005 [doctoral thesis]. Rio de Janeiro: Instituto de Medicina Social da UERJ; 2009.

6. reallocation of cancer deaths with an incomplete diagnosis coded ICD-10 C76 to C80 and C97, corresponding to different organs, among all cancers;
7. reallocation of deaths from cancer of the uterus, NOS (ICD C55) among cancers of the uterus and cervix, and
8. reallocation of deaths with ill-defined causes (ICD R00 to R99) among all causes of death except external causes.

There were included all deaths identified as from cervical cancer after correction, coded ICD-10 C53.

Non-corrected cervical cancer mortality rates were estimated based on deaths obtained from SIM whereas corrected rates were estimated from deaths identified as from cervical cancer after the final process of correction and based on their estimated populations. Rates were also estimated for each stage of correction.

Cervical cancer mortality rates were first estimated for all ages (Table 1) and for the age group 20–79 years old (Tables 2 to 5), aggregated into five-year age groups. The rates were then adjusted for age using a direct method based on world population.[8] After adjusting for all age groups, expected deaths of those under 20 years and of those 80 years and more were excluded to obtain adjusted rates for the age group 20–79 years old.

Annual mortality rates from cervical cancer and average rates for the entire period (1996–2005), by age group, as well as crude rates and standardized by age were estimated for Brazil nationwide, for each macroregion and geographic division (capital, interior and other metropolitan areas). The current geographical division according to the Brazilian Institute of Geography and Statistics (IBGE)[d] was used to aggregate geographic areas into capital cities, other cities in metropolitan areas and interior cities. The category corresponding to "other cities in metropolitan areas" was created from a list of cities in nine reference metropolitan areas used in official IBGE publications, excluding capital cities. The nine metropolitan areas were distributed as follows: one in the North (metropolitan area of Belem); three in the Northeast (metropolitan area of Recife, Fortaleza, and Salvador); three in the Southeast (metropolitan area of Belo Horizonte, Rio de Janeiro and São Paulo); and two in the South (metropolitan area of Curitiba and Porto Alegre). Following this classification, the Central-west region does not have a metropolitan area.

Population-based and mortality data were collected from the Brazilian Ministry of Health Database (DATASUS) website.[e]

The variability of rates before and after correction of deaths was assessed by percent variation [(corrected rate / non-corrected rate) × 100]. Multiple regression analysis was performed to assess factors associated with variations of mortality rate corrections, where the dependent variable was the ratio between corrected and non-corrected annual cervical mortality rates (corrected rate / non-corrected rate). The independent variables included in the model were: calendar year, macroregion, and geographical area (capital, other cities in metropolitan areas and interior). The Southern region and geographical area of capital cities were considered reference categories.

For the assessment of potential interactions between Brazilian macroregions and their related geographic areas seven region-area interaction terms were first included in the multivariate regression model: (1) North region and the interior area; (2) Northeast region and the interior area; (3) Southeast region and the interior area; (4) Central-west region and the interior area; (5) North region and other cities of metropolitan areas; (6) Northeast region and other cities of metropolitan areas; and (7) Southeast region and other cities of metropolitan areas. In the final model, the terms (3) and (5) were not included, and their exclusion did not affect the estimates or the precision of confidence intervals.

The study was approved by the Research Ethics Committee of the Instituto de Medicina Social (Protocol No. FR186658, on 04/10/2008).

RESULTS

In Brazil, for the period between 1996 and 2005, the average crude and adjusted annual rates of deaths from cervical cancer based on world population were 4.6 and 5.1 deaths per 100,000 women-years, respectively. After corrections of deaths, mortality rates from cervical cancer showed an increment of 103.4% in Brazil nationwide, ranging from 35% in capital cities of the South to 339% in interior cities of the Northeast. There were wide variations across regions, within a region, across capital cities, other cities of metropolitan areas, and interior cities (Table 1).

Table 2 shows average annual mortality rates from cervical cancer, total percent variation and percent variation by step of correction. The steps of correction with higher increments in cervical cancer mortality rates were: reallocation of deaths from cancer of the uterus, NOS (55.6%), correction of underreporting (22.0%), and reallocation of deaths with ill-defined causes (21.2%). These three steps of correction accounted for a 98.8% increment in the mortality rate nationwide

[d] Instituto Brasileiro de Geografia e Estatística. Comissão Nacional de Classificação. Rio de Janeiro;1994 [cited 2009 Dec 30]. Available from: http://www.ibge.gov.br/concla

[e] Ministério da Saúde. Departamento de informática do Sistema Único de Saúde. Brasília; 2008[cited 2009 Dec 30]. Available from: http://www.datasus.gov.br

Table 1. Average mortality rates from cervical cancer (per 100,000) in women of all ages and variation after correction by macroregion. Brazil, 1996–2005.

Macroregions/ geographical areas	Crude rates			Standardized rates[a]		
	Non-corrected rate	Corrected rate	Total increment (%)	Non-corrected rate	Corrected rate	Total increment (%)
North	5.1	9.8	91.5	8.1	15.6	93.1
Capital	10.0	13.5	34.7	14.7	20.0	36.0
Other metropolitan areas[b]	8.1	11.0	35.5	12.7	17.5	38.2
Interior	2.5	7.9	215.3	4.1	13.1	218.1
Northeast	3.9	12.3	211.1	4.8	14.8	209.3
Capital	6.2	9.2	49.0	7.3	11.0	49.2
Other metropolitan areas[b]	6.7	9.2	37.4	8.6	11.9	38.3
Interior	3.0	13.4	344.0	3.7	16.3	338.7
Southeast	4.5	7.4	66.4	4.6	7.6	66.3
Capital	5.6	7.8	40.8	5.1	7.2	40.5
Other metropolitan areas[b]	5.1	7.8	51.5	6.1	9.3	52.8
Interior	3.7	7.1	93.4	3.8	7.4	93.0
South	5.7	9.1	60.7	5.8	9.4	60.7
Capital	7.3	9.9	35.0	6.9	9.3	34.9
Other metropolitan areas[b]	7.1	9.5	35.4	8.1	11.1	36.9
Interior	5.1	8.9	73.8	5.3	9.1	73.6
Central-West	5.0	8.8	77.0	6.7	12.1	79.0
Capital	5.4	7.4	35.6	7.3	10.0	36.9
Other metropolitan areas[b]	-	-	-	-	-	-
Interior	4.7	9.7	106.7	6.4	13.4	109.2
Nationwide	4.6	9.3	103.4	5.1	10.4	103.3
Capital	6.3	8.8	40.9	6.6	9.3	41.1
Other metropolitan areas[b]	5.7	8.3	45.7	6.8	10.0	47.1
Interior	3.7	9.7	162.5	4.2	11.0	161.6

[a] Adjusted based on world population
[b] Other cities of nine metropolitan areas: Belém, Recife, Fortaleza, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Curitiba, and Porto Alegre.

(17.39 deaths per 100,000 women aged 20–79). Other steps of correction, i.e., reallocation of deaths with unknown macroregion, reallocation of deaths with incomplete diagnosis (missing codes) and reallocation of deaths with unknown gender, accounted for a 4.6% increment in the annual average rate nationwide and for all the study period.

The reallocation of deaths from cancer of the uterus, NOS produced the greatest effect on mortality rates from cervical cancer in all regions and nationwide, even greater than the percent increment seen after the correction of underreporting and reallocation of deaths from ill-defined causes. However, the same was not seen in interior cities of the North and Northeast, where the correction of underreporting had a greater effect than reallocation of deaths NOS. These regions also showed the greatest percent increments after the reallocation of deaths with ill-defined causes, 57% in the Northeast and 10% in the North.

The corrections of mortality rates form cervical cancer by age group are shown in Table 3. The greatest correction percents were seen in older age groups. The curve of correction of deaths showed an increasing trend with age for Brazil nationwide and all macroregions. The correction of mortality rates ranged from 70% to 80% in the age group 20–49, up to 120% in the age group 70–79.

The corrections of mortality rates from cervical cancer by year of death are presented in Table 4. They showed a steady pattern over the time series studied, especially nationwide. This steady pattern is evident after excluding the corrections made for the year 2005, which were higher than those made for previous years, and in all regions. The South and Northeast had the lowest and the highest variation, respectively, compared to the percent increment in annual mortality rates from cervical cancer.

Table 2. Average mortality rates from cervical cancer (per 100,000) in women aged 20 to 79 years and variation after correction by macroregion. Brazil, 1996–2006.

Macroregions/ geographical areas	Non-corrected rate[a]	Corrected rate[a]	Total increment (%)	Increment in each step of correction (%)			
				Underreporting	Uterus NOS	Ill-defined	Other steps
North	13.5	26.0	93.1	28.8	49.5	10.3	4.6
Capital	24.5	33.3	36.0	0.0	29.6	4.2	2.1
Other metropolitan areas[b]	21.1	29.2	38.2	0.0	31.4	3.9	2.8
Interior	6.9	21.8	218.1	93.3	92.7	23.6	8.6
Northeast	8.0	24.6	209.3	69.4	77.6	56.6	5.6
Capital	12.2	18.2	49.2	0.0	40.2	7.0	2.0
Other metropolitan areas[b]	14.4	19.8	38.3	0.0	33.2	2.9	2.3
Interior	6.2	27.1	338.7	126.2	108.8	96.2	7.4
Southeast	7.7	12.7	66.3	2.5	50.5	9.0	4.3
Capital	8.5	12.0	40.4	0.0	33.7	4.3	2.4
Other metropolitan areas[b]	10.1	15.4	52.9	0.0	42.9	6.6	3.3
Interior	6.4	12.3	93.0	6.2	67.2	13.7	6.0
South	9.7	15.6	60.7	4.0	43.5	9.8	3.4
Capital	11.5	15.5	34.9	0.0	29.3	4.1	1.5
Other metropolitan areas[b]	13.5	18.4	36.9	0.0	30.4	3.7	2.8
Interior	8.8	15.2	73.6	6.1	50.6	12.8	4.0
Central-West	11.2	20.1	79.0	13.9	49.1	10.7	5.3
Capital	12.2	16.7	36.9	0.0	30.4	4.1	2.4
Other metropolitan areas[b]	-	-	-	-	-	-	-
Interior	10.7	22.3	109.2	25.0	62.5	15.4	6.2
Nationwide	8.6	17.4	103.3	22.0	55.6	21.2	4.6
Capital	11.0	15.5	41.1	0.0	34.0	4.9	2.2
Other metropolitan areas[b]	11.4	16.7	47.2	0.0	38.7	5.4	3.1
Interior	7.0	18.4	161.6	44.0	75.0	36.6	6.0

Uterus NOS: not otherwise specified (ICD-10, C55).
[a] Adjusted based on world population.
[b] Other cities of nine metropolitan areas: Belém, Recife, Fortaleza, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Curitiba, and Porto Alegre.

Table 5 presents the results of the multivariate regression analysis. A comparison of the two models (with and without interaction terms) illustrates the effects of the interaction between corrections in the interior and the reference region (South), especially between the North and Northeast. After the inclusion of interaction terms in the regression model, most corrections for interior cities in these two regions are associated with an increment of the estimated mortality rate from cervical cancer.

DISCUSSION

As expected the corrections of deaths from cervical cancer were more significant in regions with lower socioeconomic status, and within these regions, they were more pronounced for death rates in interior than capital cities or other cities in metropolitan areas. These results are consistent with the literature since higher death rates from cervical cancer are expected in less developed regions.[3,10,18] In addition, more corrections were expected in these Brazilian regions because they have the lowest reporting rates and the poorest quality of death certificates.[f] The percent variation of rates at each step of correction also showed a close relationship with prevalent socioeconomic conditions in the regions and their geographical areas (capital, interior and other cities of metropolitan areas).

After correction, the mortality rate from cervical cancer in Brazil had a percent increment above 100%, from 5.1 to 10.4 deaths per 100,000 women-years, adjusted

[f] Ministério da Saúde. Secretaria de Vigilância à Saúde. Saúde Brasil 2005 – uma análise da situação de saúde. Brasília; 2005.

Table 3. Average mortality rates from cervical cancer (per 100,000 women) and variation after correction by age in women aged 20–79 years. Brazil, 1996–2006.

Macroregion	Age group	Non-corrected rate[a]	Corrected rate[a]	Total increment (%)
North	20 to 29	1.2	2.2	83.3
	30 to 39	6.5	11.4	75.4
	40 to 49	15.2	28.0	84.2
	50 to 59	22.3	43.0	92.8
	60 to 69	27.7	53.5	93.1
	70 to 79	32.6	67.4	106.7
Northeast	20 to 29	0.6	1.7	183.3
	30 to 39	3.4	9.2	170.6
	40 to 49	9.3	26.1	180.6
	50 to 59	13.4	40.5	202.2
	60 to 69	16.5	53.5	224.2
	70 to 79	19.3	64.8	235.8
Southeast	20 to 29	0.5	0.7	40.0
	30 to 39	2.8	4.1	46.4
	40 to 49	8.0	12.4	55.0
	50 to 59	12.8	20.9	63.3
	60 to 69	16.5	27.9	69.1
	70 to 79	21.3	38.6	81.2
South	20 to 29	1.0	1.4	40.0
	30 to 39	4.6	6.9	50.0
	40 to 49	11.5	17.2	49.6
	50 to 59	16.8	26.1	55.4
	60 to 69	19.4	31.8	63.9
	70 to 79	21.2	38.3	80.7
Central-West	20 to 29	0.7	1.0	42.9
	30 to 39	3.9	6.4	64.1
	40 to 49	11.2	18.8	67.9
	50 to 59	18.5	32.9	77.8
	60 to 69	25.2	44.5	76.6
	70 to 79	34.5	66.7	93.3
Nationwide	20 to 29	0.7	1.2	71.4
	30 to 39	3.5	6.5	85.7
	40 to 49	9.5	17.8	87.4
	50 to 59	14.4	28.7	99.3
	60 to 69	18.0	37.3	107.2
	70 to 79	21.8	48.2	121.1

[a] Adjusted based on world population.

based on world population. This result confirms the estimated risk of death from cervical cancer by the International Agency for Research on Cancer (IARC) in Brazil in 2002, 10.2 deaths per 100,000 women-years.[g] Another study in Latin America estimated a mortality rate of 11.6 cervical cancer deaths per 100,000 women-years in Brazil in 2000.[3] Other Brazilian studies for the correction of cervical cancer rates focused only on the reallocation of deaths from cancer of the uterus, NOS in some cities. Antunes & Wünsch (2006) reallocated cancer of uterus, NOS and obtained an almost 50% increment of rates in São Paulo, southern Brazil. In another study[13] in Recife, northeastern state of Pernambuco, the authors reviewed death certificates against medical records and concluded that half of the cases previously reported in the SIM as cancer of the uterus, NOS were due to cervical cancer, increasing deaths from cervical cancer by 20%.

The results of the present study show the relative weight of deaths from uterine cancer, NOS in increasing corrected rates from cervical cancer: over 50% of total increments in the rates nationwide can be attributable to reallocation of the primary cause of death. It can be thus inferred that the Brazilian health system has low diagnostic capacity and that part of female population does not have access to or does not undergo cervical screening. These women are seen at advanced stages of disease when it is more difficult to make an accurate diagnosis. The effectiveness of a population-based screening program depends not only on the performance of Pap smears, but especially on the capacity of health services to ensure treatment and follow-up of all patients with abnormal results.[18] However, our results show inadequate diagnostic ability in addition to inadequate cervical cancer prevention.

The high proportion of death certificates with uterine cancer, NOS as primary cause of death could be explained by the difficulty in making the diagnosis of cervical cancer at advanced stages of disease.[11] However, the quality of data points to a need for training health providers in death certificate completion.[2,4,14,16,17] It is also possible that health providers do not see the value of appropriate completion of death certificates. In a study of deaths from uterine cancer, NOS the authors were able to reclassify most diagnoses by primary site using a simple approach of data recovery and retrieval.[13] Therefore it should be further explored the reasons that prevent adequate completion of death certificates.

Another example of diagnosis inaccurately completed in death certificates is "cardiac arrest," classified as a well-defined diagnosis in several ICD revisions in the chapter of diseases of the circulatory system.[h] It was eventually considered an ill-defined cause based on studies showing that, in almost all deaths, the primary cause reported by health providers as "cardiac arrest" was not a cardiac condition. Death could be due to

[g] International Agency for Research on Cancer. Cancer Mondial. The Globocan 2002 database. Lyon; 2002[cited 2009 Dec 31]. Available from: http://www-dep.iarc.fr/globocan/database.htm

[h] Laurenti R, Mello Jorge MH, Gotlieb SL. O Sistema de Informação sobre Mortalidade: passado, presente e futuro. São Paulo; Centro Colaborador da OMS para a Família de Classificações em Português; 2006. (Série divulgação, 11).

Table 4. Mortality rates from cervical cancer (per 100,000) in women aged 20–79 years and total percent variation after correction by annual series. Brazil, 1996–2006.

Macroregions	Year	Non-corrected rate[a]	Corrected rate[a]	Total increment (%)
North	1996	11.2	20.7	84.3
	1997	11.3	19.7	74.2
	1998	12.3	23.0	87.5
	1999	14.5	27.0	86.9
	2000	11.8	22.4	89.0
	2001	12.8	25.5	99.9
	2002	14.2	26.6	87.3
	2003	14.2	27.9	96.5
	2004	15.7	31.5	101.1
	2005	15.5	32.0	107.1
Northeast	1996	6.8	18.1	167.8
	1997	6.6	17.9	172.0
	1998	7.3	19.7	170.6
	1999	7.3	20.9	185.9
	2000	7.6	22.7	199.7
	2001	7.9	24.8	214.6
	2002	8.4	27.3	224.5
	2003	8.4	27.1	221.4
	2004	8.8	29.0	229.4
	2005	10.0	35.3	252.8
Southeast	1996	7.5	12.6	67.1
	1997	7.6	12.7	66.5
	1998	7.8	12.9	65.0
	1999	8.3	13.7	66.4
	2000	7.9	13.1	66.2
	2001	8.1	13.4	65.3
	2002	7.3	12.2	66.5
	2003	7.3	12.0	65.7
	2004	7.7	12.9	66.7
	2005	7.0	11.8	67.9
South	1996	9.3	14.6	57.4
	1997	10.3	16.5	59.7
	1998	11.4	18.0	58.2
	1999	11.3	18.0	59.6
	2000	9.0	14.5	61.1
	2001	10.0	16.1	60.5
	2002	9.0	14.8	63.2
	2003	9.3	14.9	61.1
	2004	9.1	14.8	62.3
	2005	9.1	14.8	63.2
Central-West	1996	10.5	18.5	77.1
	1997	11.9	21.0	77.1
	1998	11.4	20.2	77.5
	1999	14.3	26.2	83.3
	2000	10.3	18.5	80.5
	2001	10.3	18.4	78.1
	2002	9.8	17.7	81.4
	2003	11.8	20.6	75.2
	2004	11.6	20.5	77.1
	2005	10.9	19.7	80.4
Nationwide	1996	7.9	15.0	90.0
	1997	8.2	15.5	89.2
	1998	8.7	16.4	89.5
	1999	9.1	17.7	93.6
	2000	8.3	16.6	99.6
	2001	8.7	17.7	103.0
	2002	8.4	17.6	110.0
	2003	8.5	17.7	108.5
	2004	8.8	18.7	112.0
	2005	8.8	19.9	126.2

[a] Adjusted based on world population.

well-defined causes, but providers would report only "cardiac arrest" since it is a primary cause easily to be reported, or even because is a well-established cause of death.[h] It would be valuable to investigate using a combined approach of death information retrieval and providers' survey the reasons that make them report the primary cause of death as cancer of the uterus, NOS where it is possible to classify these diagnoses.

With respect to corrections of mortality rates from cervical cancer by age group, there were increasing corrections with age, which is consistent with the Brazilian[1,13] and international literature.[2] In contrast, corrections by year of death showed a steady pattern over the time series analyzed, while a declining pattern would be expected due to improvements in reporting of deaths and quality of completion of death certificates in the SIM.[f] This finding should be interpreted with caution given the intrinsic limitations of correction of underreporting based on expansion factors generated by the Global Burden of Disease Study in Brazil for the year 1998. Improvements in the reporting of deaths may have been masked in this study. However, there are still deficiencies in the SIM that need to be addressed so that information from all Brazilian regions can be available with similar rates of reporting and data quality.

Table 5. Results of multivariate linear regression models of corrected mortality rates from cervical cancer in women aged 20–79 years by geographical areas. Brazil, 1996–2005.

Variable	Multivariate regression models[a]			
	I		II	
	Regression coefficient β (significance of β)	Standard error	Regression coefficient β (significance of β)	Standard error
Constant	0.781 (0.000)	0.050	1.308 (0.000)	0.044
North	0.602 (0.000)	0.054	-0.003 (0.947)	0.051
Northeast	1.284 (0.000)	0.048	0.183 (0.000)	0.050
Southeast	0.125 (0.017)	0.052	0.096 (0.033)	0.045
Central-West	0.104 (0.084)	0.060	0.030 (0.622)	0.060
Other metropolitan areas[b]	0.177 (0.000)	0.047	0.096 (0.105)	0.059
Interior	1.819 (0.000)	0.033	0.515 (0.000)	0.045
Year	-0.001(0.836)	0.005	0.001(0.855)	0.004
Interaction terms				
North – interior	-	-	1.483 (0.000)	0.070
Northeast – interior	-	-	2.667 (0.000)	0.061
Central-West – interior	-	-	0.269 (0.001)	0.080
Northeast – other metropolitan areas	-	-	-0.278 (0.001)	0.087
Southeast – other metropolitan areas	-	-	0.024 (0.763)	0.081

[a] Adjusted by age and other variables of the table, Model I (R2 = 0.566) and II (R2 = 0.747) with and without interaction terms, respectively.
[b] Other cities of nine metropolitan areas: Belém, Recife, Fortaleza, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Curitiba, and Porto Alegre.

Regarding the correction of underreporting, although there were corrected only deaths occurring in interior cities of each macroregion, assuming that reporting of deaths was close to 100% in capital cities and other cities in metropolitan areas, we are aware that major cities were included as "interior" ones. For instance, the cities of Uberaba, Uberlandia and Juiz de Fora in the southeastern state of Minas Gerais show adequate reporting[i] and could have been excluded from the corrections of underreporting. However, the interior of each macroregion was corrected in a single block. Thus, the use of a more accurate method of correction of underreporting[5] could improve the results of this study, providing a more realistic overview of the profile of mortality from cervical cancer in Brazil by macroregions and their geographic areas.

Another limitation of the present study is regarding the approach for correction of deaths from ill-defined causes, which followed the proportional reallocation of deaths from well-defined causes by age groups.[17] This approach can be inadequate, especially when it is intended to reallocate cancer deaths since they are usually adequately reported.[12] But, since there is no consensus in the literature on this subject, we believe that by using 50% of the weight of neoplasms for reallocation of deaths from ill-defined causes we have prevented overestimation of cervical cancer mortality.

Despite its limitations, consistent corrections in terms of geographical areas and their agreement with data from literature[3,10,18] confirm that the method of correction used in this study provided a more realistic estimate of mortality rates from cervical cancer in Brazil.

Corrections of specific death estimates are significant especially for cervical cancer which is the most common cancer among low-income women. The direct use of data without taking into consideration quality and other characteristics of mortality information systems can lead to underestimations of actual mortality rates. Corrected estimates should be used to identify Brazilian regions requiring priority actions for prevention and control of cervical cancer.

In conclusion, given the magnitude of corrected mortality rates from cervical cancer in Brazil (10.4 deaths per 100,000 women-years in the period 1996–2005 among women of all ages), it is evident that cervical cancer

[i] Instituto Brasileiro de Geografi a e Estatística. Geociência: Perfil dos Municípios Brasileiros. Rio de Janeiro; 2009 [cited 2009 Dec 30]. Available from: http://www.ibge.gov.br/

mortality is actually higher than that officially reported. The correction of mortality rates is an essential strategy for planning actions for disease control. Other studies including validation and reliability testing of methods of correction of data on the primary cause of death are needed for consistently improving the SIM.

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