# Socioeconomic inequalities in breast cancer mortality in microregions of the Brazilian Northeast

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**Abstract**

*Objectives: to evaluate the relation between the corrected mortality rates on breast cancer and the indicators of elderly women's living conditions in the Northeast micro-regions of Brazil .*

*Methods: an ecological study was adopted in 2010 and 2015 for 188 micro-regions in the Northeast using structural equation modeling. The data on the population, deaths and indicators on living conditions were extracted from the IBGE, SIM/MS, and SISAP-Idoso (elderly), respectively. The under-registration of death data on breast cancer, badly defined death causes and garbage codes were corrected. The standardized mortality rates were calculated to permit time-space comparison.*

*Results: the recovery of a considerable number of deaths was made possible to obtain a greater accuracy in the mortality rates estimation in micro-regions level. An increase in the mortality rates was observed at the time. The structural equation modeling presented a robust model with significance for some indicators on living conditions. The rates were higher in the micro-regions with lower percentage of illiterate elderly women, lower percentage of elderly women living in poverty, lower dependency ratio, and higher percentage of elderly women living at home with running water.*

*Conclusions: the results showed an increased trend of elderly women dying of breast cancer in the region and with higher levels in the micro-regions with better indicators on living conditions.*

**Key words** *Mortality, Breast neoplasms, Underregistration, Social conditions, Models, structural*



http://dx.doi.org/10.1590/1806-93042019000200008

## Introduction

In Brazil, 59,700 new cases of female breast cancer were estimated for 2019, corresponding to an incidence rate of 56.3 cases per 100,000 women. In this same scale, the incidence by region showed a rate of 73.1 in the South, 69.5 in the Southeast, 52.0 in the Midwest, 40.4 in the Northeast, and 19.2 in the North. Therefore, without considering non-melanoma skin tumors, breast cancer is the most frequent tumor among women in the country. New cases of breast cancers account for 29.5% of all the malignant tumors estimated for Brazilian women.[1]

According to a world scale, breast tumors lead in the mortality rate among female neoplasms. More than 600,000 deaths of female breast cancer were estimated in 2018.[2] Setting as the main cause also in Brazil, 16,593 deaths with breast cancer were registered, which accounted for 15.9% of all women's deaths due to neoplasms in the country in 2017.[3] In addition, 53.7% of deaths due to breast cancer occurred in women 60 years and over age group in which this population group has the highest mortality burden due to the disease.

The magnitudes of breast cancer mortality rates are higher in the South and Southeast regions in Brazil, which also concentrates the best infrastructure in oncology care. There are 75% of specialized hospitals, 66% of chemotherapy rooms and 72% of radiotherapy equipment.4 However, the Northeast is the second region in the number of deaths of female breast cancer, accounting for 3,604 (21.7%) deaths in 2017, and its rates has been increasing faster than any other regions.[3] It was observed that, in the midst of a late and uneven epidemiological and demographic transition process in the Northeast region, the female population faces an increased burden of this chronic-degenerative disease in a scenario with the lowest development indicators in Brazil.[5]

When the Northeast region is disintegrated into small areas, cancer mortality became exacerbated in these different regions, making these inequalities more evident. Some studies have drawn attention in relation between living conditions and cancer mortality in various locations around the world.[6] However, in Brazil, the scarcity for researching on this subject makes it difficult to understand this relation. In addition, in the poorest regions of the country, deficiency in the quality of cancer mortality data is still a concern.[7] In this context, the objective was to evaluate the relation between the corrected mortality rates on breast cancer and the elderly women's living conditions in the Northeast micro-regions of Brazil.

## Methods

An ecological cross sectional design was adopted in 2010 and 2015. As observational analysis units, 188 micro-regions make up the nine states in the Northeast region of Brazil.

The database was formed by the standardized rates on breast cancer mortality and the indicators on the living conditions referred to the elderly women (60 years and over) in the Northeast micro-regions, disintegrated by quinquennial age groups (60 to 64, 65 to 69, 70 to 74, 75 to 79, 80 and over). To calculate the rates, the information on deaths was extracted from the *Sistema de Informações sobre Mortalidade do Ministério da Saúde* (SIM/MS) (Mortality Information System of the Health Ministry) available at www.datasus.gov.br.[3] To reduce the random fluctuations effect on the death data, the means of deaths were calculated and used the three year term from 2009 to 2011 and 2014 to 2016 as references for 2010 and 2015, respectively. The census population of elderly women from the micro-regions in 2010 and the estimated population in 2015 and onwards was necessary to calculate the mortality rates and this information was obtained from the *Instituto Brasileiro de Geografia e Estatística* (IBGE) (Brazilian Institute on Geography and Statistics), available at www.ibge.gov.br.[8]

The indicators on the living conditions were obtained from the *Sistema de Indicadores de Saúde e Acompanhamento de Políticas do Idoso* (SISAP-Idoso) (System of Health Indicators and Accompany of Elderly Policies) at *Fundação Oswaldo Cruz* (Fiocruz) (Oswaldo Cruz Foundation), available at https://sisapidoso.icict.fiocruz.br.[9] This system is formed by several indicators based on demographic census information of environmental, socioeconomic and demographic dimensions, which provide a series of useful indicators to measure the elderly women's living conditions. After scanning the database, all the indicators within these dimensions, with the available information for the women and municipal level for subsequent aggregation in the micro-regions were selected. The selected indicators were: environmental condition (elderly women living in homes with running water, elderly women living in homes with sewage system, elderly women living in homes with garbage disposal service, and elderly women living in adequate homes); socioeconomic condition (illiterate elderly women, elderly women living in poverty , economically active elderly women, elderly women with a nominal income of up to one minimum wage and elderly women living alone); demographic condition (dependency ratio, population aging index, and elderly women living in urban areas).

The indicators of the environmental and socioeconomic dimensions are expressed in percentages and the demographic indicators are the ratio type, except for elderly women living in urban areas, which is shown in percentage.

Two steps were outlined to develop this study. The first one was consisted of producing corrections on mortality rates and after analyzing the quality of death registrations. The second one used the structural equations modeling to assess a proposed model of adequacy adjustment relating to breast cancer mortality with indicators on living conditions.

First Step: Review the quality on death registrations.

*i*) Badly defined causes: Ledermann[10] method was used to redistribute the elderly women's death registrations to each micro-region classified in the group of badly defined causes (Chapter XVIII) among the neoplasms and the other chapters of the *Classificação Estatística Internacional de Doenças e Problemas Relacionados à Saúde Décima Revisão* (CID-10) (International Diseases and Problems Related to Health Statistic Classification, Tenth Review). Then, proportionality, the badly defined deaths attributed to neoplasms was redistributed to female breast cancer.

*ii*) Correction factors - To reduce the impact of death coverage deficits, correction factors were estimated by using the quotient between the number of deaths of elderly women due to neoplasms registered at SIM and corrected according to a *Pesquisa de Busca Ativa* (Active Search Research).[11] The correction factors were used to calculate the total number of deaths of elderly women due to breast cancer corrected for under-registered in each micro-region.

*iii*) Garbage codes: for each micro-region, the deaths of elderly women related to the garbage[12] codes were redistributed - malignant neoplasms from other badly defined locations (C76) and malignant neoplasms with no specific location (C80) breast cancer were redistributed for proportionality.

*iv*) Redistribution of deaths by age - The deaths attributed to breast cancer according to the previous steps, were proportionally, redistributed among the five-year age groups of elderly women at the age of 60 years old.

*v*) The standardized rates of mortality: deaths of elderly women of breast cancer corrected by badly defined causes, under-registered and garbage codes calculated the standardized rates of mortality in each micro-region using as a standard population, a census population of elderly women in Brazil in 2010. The rates showed 100,000 elderly women.

Maps of the Northeast micro-regions presented regional differences in the standardized mortality rates of elderly women with breast cancer were elaborated by using TabWin software, version 3.6 from DATASUS.

Second Step: Application of the *Modelagem de Equações Estruturais* (MEE) (Structural Equations Modeling).

The MEE consists of the simultaneous analysis of a series of casual relations among the variables.[13] This method is quite feasible with non-observational template variables, as the latent variable on living conditions. This technique can be organized into two sub-templates according to the proposed relational structure for the study variables:[14] the measurement of the sub-template (measurement equations), which establishes how the exogenous latent variables ($\xi$) are measured by the observable variables ($X$). That is,

$$X = \Lambda\xi + \varepsilon$$

Where $\Lambda$ is the matrix of the factorial weight and $\varepsilon$, the vector of random errors; and the structural sub-template (structural equations), which represents the causal relation between exogenous ($\xi$) and endogenous ($\eta$) variables. This sub-template has the following equation:

$$\eta = \Gamma\xi + B\eta + \delta$$

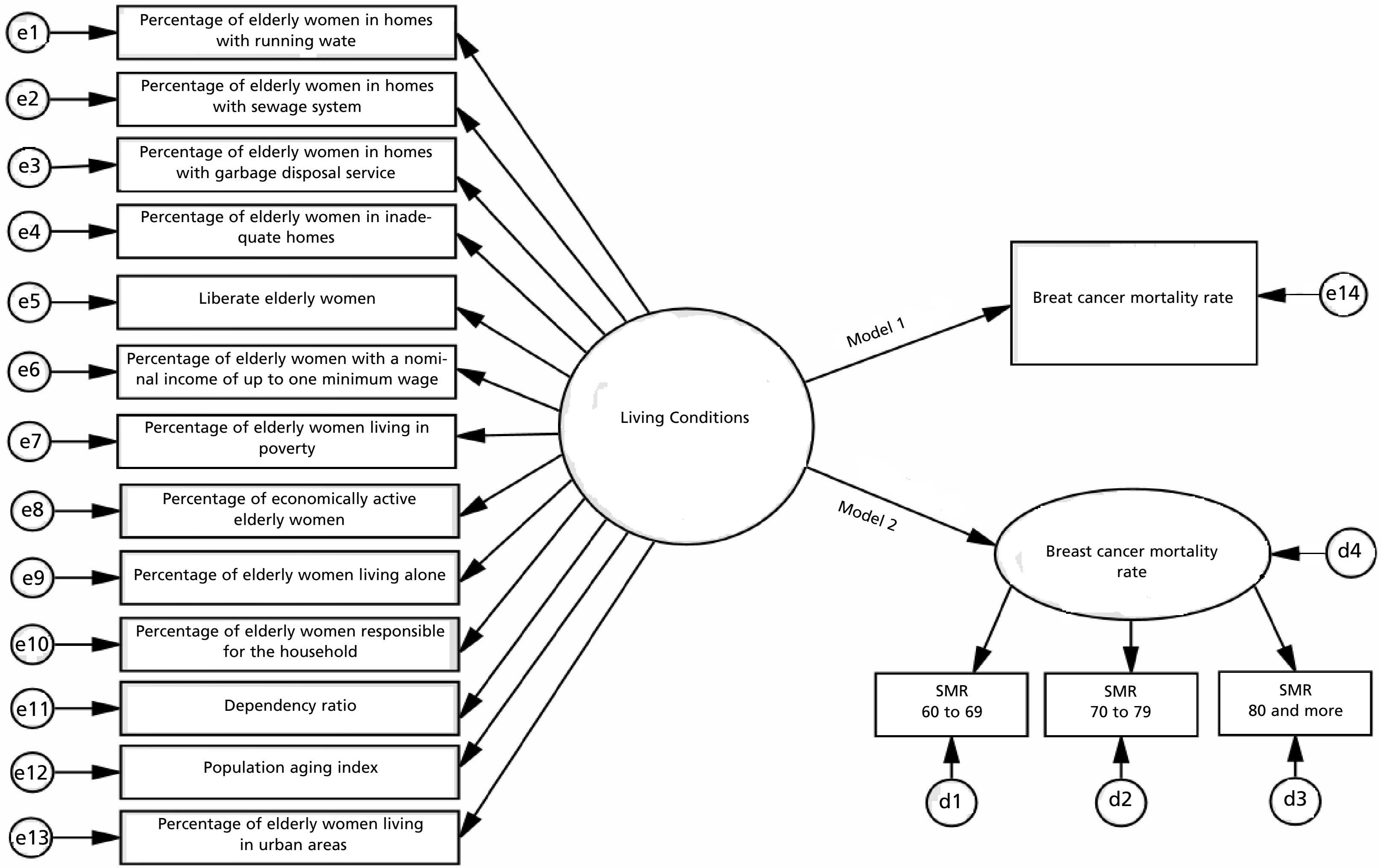
Where $\Gamma$ and $B$ are the factorial weight matrices and $\delta$, the random error vector.

The proposed theoretical models (Figure 1) involve the relation between the exogenous variable on living conditions, measured indirectly by the indicators obtained from the SISAP-Idoso (Elderly), and the endogenous variable standardized rate on the breast cancer mortality, measured directly (Model 1) and measured indirectly by the age-specific mortality rates (Model 2). Thus, the difference in age for breast cancer mortality were considered in the comparisons of the models.

AMOS (Analysis of Moment Structures)[15] software was used in the MEE application. The estimation of the model was performed by the maximum likelihood of the method. The analysis provided the adjustment to the measurement sub-template using the standardized estimates and the adjustment to the structural factorial weight by using the indexes of adjustment quality.[16]

**Figure 1**

The proposed models for breast cancer mortality in a diagram path.




Source: Own elaboration using the AMOS software.

Random errors= e1, e2, ..., e13 (indicators) and e14, d1, d2, d3, d4 (mortality rates).

SMR= Specific Mortality Rate.

## Results

After the concluding the correction steps, the number of deaths increased significantly in all age groups and in both years (Table 1). In total, the increase was 372 deaths in 2010 and 359 in 2015, which meant a variation of 31.2% and 22.3% in each year, respectively. The variations in the respective mortality rates specifically for each age group would have been around these values. Also note that the rates had increased with age in both years. In 2010, the rates were 38.6 in the 60 to 64 years old age group and 81.6 in the age group of 80 and more after the correction, with a ratio of 2.1 between them. In 2015, these rates were 44.1 and 107.7, respectively, corresponding to a ratio of 2.4.

In Figure 2 shows the spatial distribution of standardized breast cancer mortality rates according to micro-regions in 2010 and 2015. Despite a short period of five years, there were important changes in the categorization of micro-regions according to the rate interval, particularly in micro-regions located closer to the coast. In 2015, the number of micro-regions with rates included in the interval of smaller magnitudes decreased, compared to 2010, consequently, more micro-regions were grouped in higher magnitudes.

A total of 130 (69.5%) micro-regions in 2010 and 105 (56.1%) in 2015 was included in the smaller magnitude range. In addition, in 2010, 19 (10.2%) micro-regions presented rates above 70.7, while in 2015 the percentage was a little more than the double, 41 (21.9%),micro-regions.

It is worth mentioning that in 2010 five micro-regions presented rates in the most extreme interval (between 94.2 and 117.8): the places were: Coelho Neto-MA, Canindé-CE, Serra de São Miguel-RN, Seridó Ocidental-PB, and only one capital Aracaju-SE. In 2015, the number rose to seven: Cascavel-CE, Serra Pereiro-CE, Mossoró-R.N, Vale do Açu-RN, Baixo Cotinguiba-SE, and two capitals, Recife-PE, and Aracaju-SE.

In 2010, the means of breast cancer mortality rates in the micro-regions were lower in Maranhão, Piauí and Alagoas states, ranging from 25.5 to 36.2. There were means between 38.9 and 41.1 in Paraíba, Bahia and Rio Grande do Norte. The highest means varied between 45.0 and 48.1, corresponding to the states of Ceará, Pernambuco and Sergipe. On the other hand, in 2015, the lowest mean rates were also the Maranhão, Piauí and Alagoas, which varied from 28.1 to 37.9. With means of 44.7 and 49.8, respectively, Bahia and Paraíba, presented intermediate values. Ceará, Pernambuco, Sergipe and Rio Grande do Norte presented the highest means with values between 53.4 and 57.4.

Adjustments were made with different combinations of the indicators considered in the study in search of models with significant regression coefficients and good adjustment indices of quality. The models showed well adjustment for the following four indicators: percentage of elderly women in homes with running water, percentage of illiterate elderly women, percentage of elderly women in poverty, and dependency ratio.

The structural equations modeling presented satisfactory adjustment indices for both models, as shown in Table 2. In both cases, the discrepancy function (chi-square) did not present statistical significance at the level of 0.05, not rejecting, so, the hypothesis of a global fit of the model. The normalized chi-square (chi-square divided by the degrees of freedom) met the adjustment of parsimony. The goodness of fit index (GFI), the GFI adjustment, normed fit index (NFI), comparative fit index (CFI), and Tukey-Lewis index (TLI) met the acceptance levels for the reference values (above 0.90) as well as the root mean square error approximation (RMSEA) which provided an inferior value to the limit of 0.08. Based on the multiple $R^2$, it was found that the proportion of the breast cancer mortality rate variance explained by the latent variable on living conditions was higher in Model 2 (76.8%) than in Model 1 (34.0%). Thus, with $R^2$ much higher, lowers the RMSEA, and a higher standardized coefficient, Model 2 potentiated the power of relations.

The estimated standardized regression coefficients are shown in Figure 3. The four selected indicators were significant ($p<0.001$) to measure the latent variable on elderly women's living conditions in the Northeast micro-regions. Positive coefficients related to the percentage of elderly women living in homes with running piped water indicated a positive relation with good living conditions. On the other hand, the coefficients with negative values indicated that better living conditions were associated to lower percentages of illiterate elderly women and in poverty, as well as a lower dependency ratio. The standardized coefficients estimated in 0.583 and 0.876 in models 1 and 2, respectively, showed a strong positive relation between living in good conditions and the mortality rates for female breast cancer in the Northeast. In summary, observing the mortality rates for this cancer were positively associated to a higher percentage of elderly women living in homes with running water, a lower percentage of illiterate elderly women, a lower percentage of elderly women living in situation of

**Table 1**

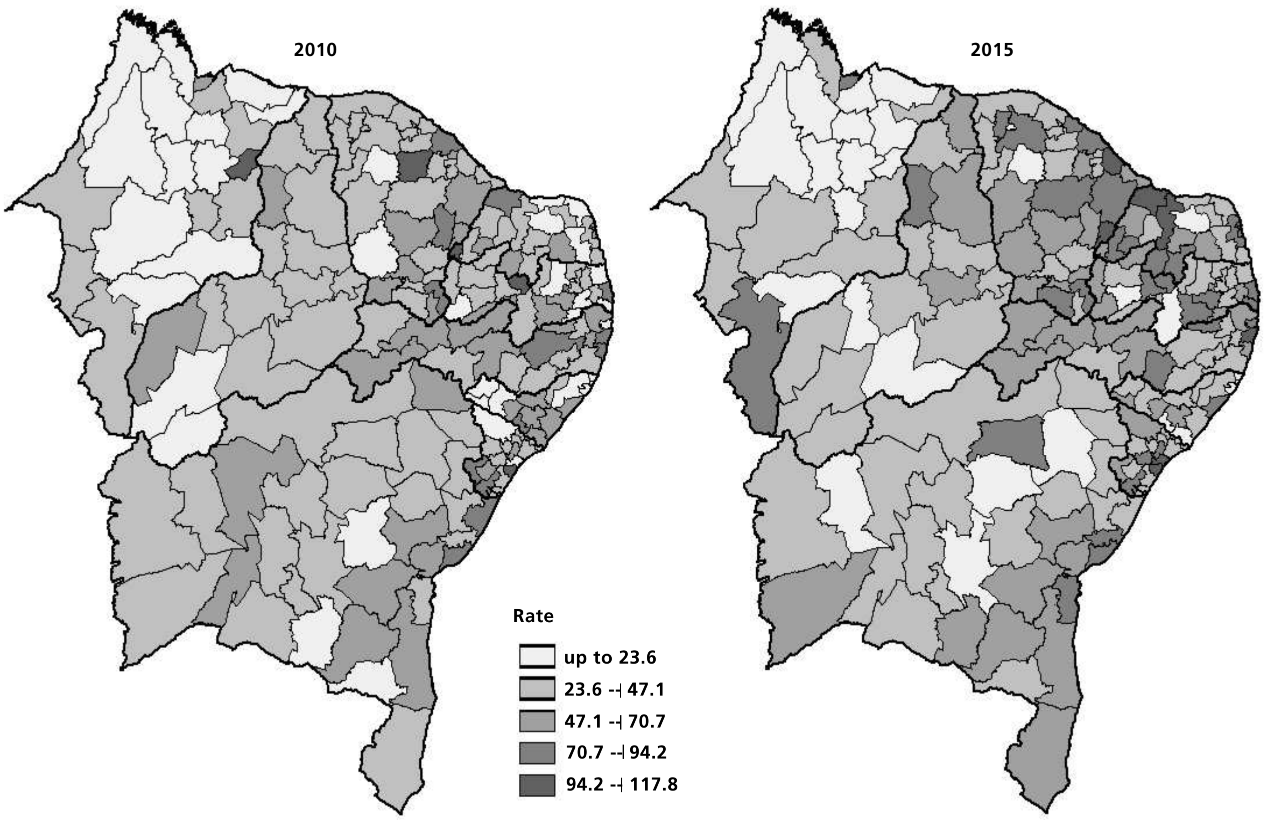
Registered and corrected breast cancer deaths and age-specific mortality rates (per 100,000 elderly women), Northeast, Brazil, 2010 and 2015.

| Age | 2010 | | | | | 2015 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Registered | | Corrected | | Rate variation (%) | Registered | | Corrected | | Rate variation (%) |
| | n | rate | n | rate | | n | rate | n | rate | |
| 60-64 | 258 | 29.4 | 338 | 38.6 | 31.0 | 353 | 36.2 | 429 | 44.1 | 21.7 |
| 65-69 | 230 | 33.6 | 302 | 44.2 | 31.5 | 316 | 40.7 | 388 | 49.9 | 22.7 |
| 70-74 | 226 | 40.7 | 299 | 53.7 | 31.9 | 259 | 44.5 | 318 | 54.5 | 22.4 |
| 75-79 | 160 | 42.7 | 212 | 56.4 | 32.1 | 233 | 52.9 | 286 | 65.1 | 23.1 |
| 80 e + | 317 | 62.6 | 413 | 81.6 | 30.3 | 444 | 88.1 | 542 | 107.7 | 22.2 |
| Total | 1192 | 39.7 | 1564 | 52.2 | 31.2 | 1604 | 49.0 | 1963 | 59.9 | 22.3 |

Basic data source: Mortality Information System from the Ministry of Health.

**Figure 2**

Standardized mortality rates for breast cancer (per 100 thousand elderly women) in the micro-regions of the Northeast, 2010 and 2015.




Source: Own elaboration using the Tabwin software.

**Table 2**

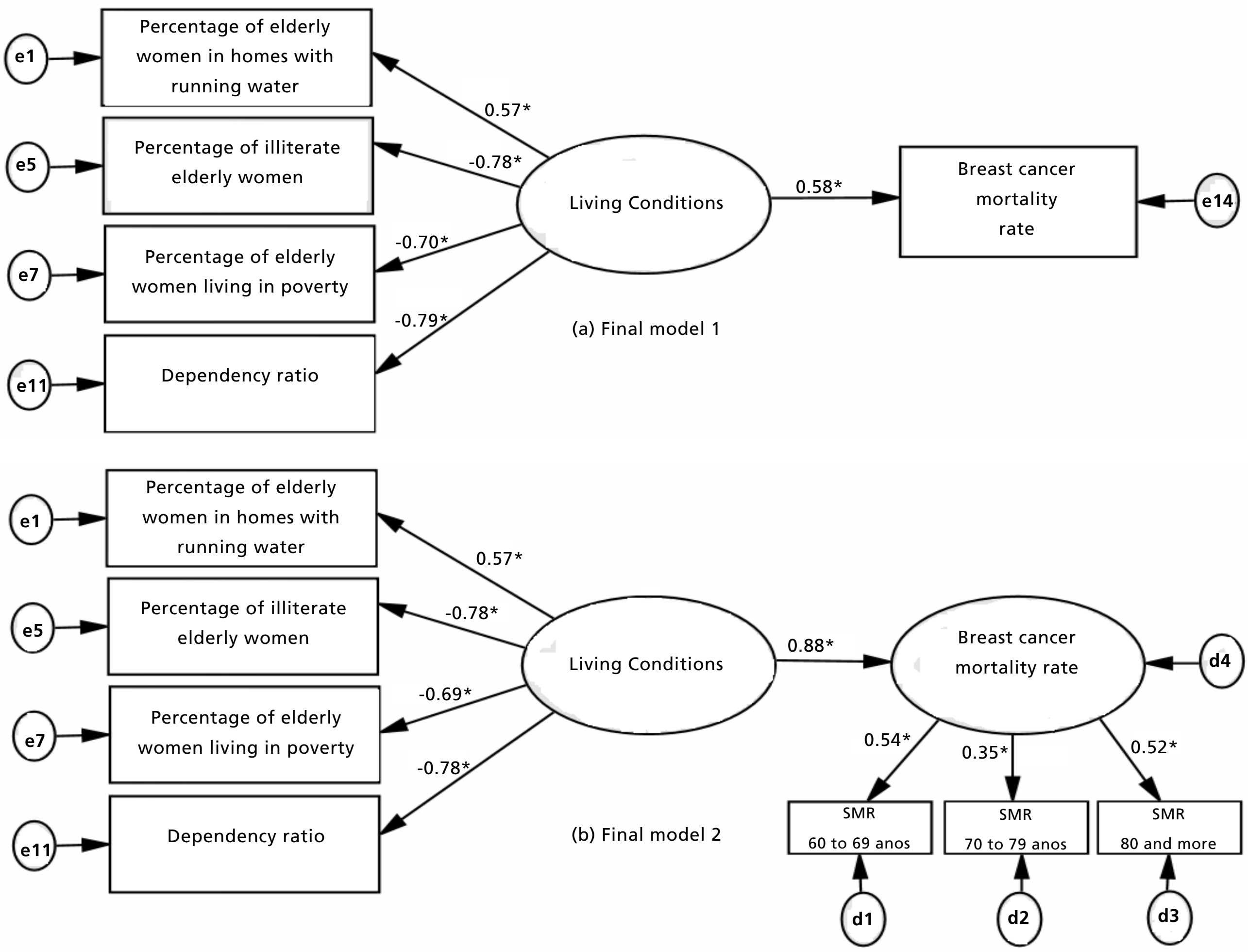
Adjustment index of modeling on elderly women mortality in the micro-regions of the Northeast for breast cancer, according to the final models, 2010.

| Adjustment index | Acceptance level | Model 1 | Model 2 |
|---|---|---|---|
| Discrepency function (*p*) | *p*>0.05 | 9.716 (0.084*) | 19.808 (0.100*) |
| Normed chi-square | between 1 and 2 | 1.943 | 1.524 |
| Goodness of Fit Index (GFI) | >0.90 | 0.979 | 0.968 |
| Adjusted GFI (AGFI) | >0.90 | 0.937 | 0.931 |
| Normed Fit Index (NFI) | >0.90 | 0.966 | 0.940 |
| Comparative Fit Index (CFI) | >0.90 | 0.983 | 0.978 |
| Tukey-Lewis Index (TLI) | >0.90 | 0.966 | 0.964 |
| Root mean square error (RMSEA) | <0.08 | 0.073 | 0.054 |
| Multiple square correlation ($R^2$) | ≈1, better | 0.340 | 0.768 |

Source: Own elaboration
(*) *p*>0.05 indicates an overall adjustment of the model.

**Figure 3**

Standardized estimates of the structural equations modeling for the final models in relation between the living conditions and breast cancer mortality, Northeast, 2010.




Source: own elaboration with the use of AMOS Software.
*Standardized estimations (significant correlations, *p*< 0.001); Random errors= e1, e5, e7, e11 (indicators) and e14, d1, d2, d3, d4 (mortality rates); SMR= Specific Mortality Rate.

poverty, and a lower dependency ratio.

## Discussion

Despite the advances, the quality of the death data in the Northeast may compromise the reliability of the mortality rates.[17] However, the use of the corrected death registrations by under-registering, redistributing badly defined and non-specific causes of mortality occurred important improvements on the data. With a variation in the number of deaths before and after the correction was of 31.2% in 2010 and 22.3% in 2015, the considerable increase in the quality of numbers of deaths after correcting, allowed a greater accuracy in the estimation of mortality rates at micro-region levels.

This fact draws attention to the managers to perceive better the true levels of mortality of the disease when dealing in planning actions in the health public and epidemiologically. Thus, because these levels are higher than those registered, there is an increased need for measures to be taken in the sense of reinforcing the training of physicians to correctly fill out death certificates, exercising more the observation regarding to the registrations and improving the system of collecting and monitoring of data, and among other measures.

Since the first registrations of the *Sistema de Informação sobre Mortalidade* (SIM) (Mortality Information System), breast cancer is a malignant neoplasm that kills women each year in Brazil. This pattern is no different in the Northeast of the country, where the mortality rates have increased considerably in recent years. According to this study, the corrected rates of deaths of elderly women jumped from 52.2 in 2010 to 59.9 in 2015, an increase of 14.8% over a short period of time.

The levels of female breast cancer mortality observed in 2010 and 2015 do not point to a reduction or stabilization, but to a rise in deaths in the coming years in the Northeast, which is a great concern. The increase in the rates in all the States varied between 4.7% (Alagoas) and 39.7% (Rio Grande do Norte) in the period. The States of Rio Grande do Norte, Sergipe, Pernambuco and Ceará presented the highest rates and, therefore, demand stronger actions to stop advancing deaths because of the disease.

It was observed that regional inequalities in breast cancer mortality are positively associated to living conditions reflected in the education, income and housing condition indicators. Therefore, the rates were higher in the micro-regions with lower percentage on illiterate elderly women and in situation of poverty, lower dependency ratio and higher percentage of elderly people living in homes with running water. According to recent research, cancer is already the main cause of death in about 10% of the Brazilian municipalities, most of them located in the more developed regions of the country, precisely where life expectancy and the Índice de *Desenvolvimento Humano* (IDH) (Human Development Indice) are the highest.[4]

If the mortality of elderly women is associated positively to the socioeconomic level the increase in the mortality rates in 2015 comparing to 2010 may be one of the possible causes to improve the living conditions, generally linked to the aging population and a higher incidence of this tumor. Studies indicate that the incidence of breast cancer is increasing in many countries, including Brazil,[1,2] and it grows in all socioeconomic categories, but the difference remains in magnitude between poor and rich women. In general, women of higher economic classes present a higher incidence. The higher prevalence of reproductive factors in the richer classes, such as lower age at menarche, lower parity, higher age for the first childbirth and menopause, the higher is the life expectancy, and among other factors and it has been pointed out as the most responsible for the positive association between the incidence of breast cancer and the socioeconomic level.[18] Thus, since the variation in mortality is influenced by differences in incidence, this may explain why the mortality rates of elderly women due to breast cancer were higher in the micro-regions with better living conditions, mostly located at the coast or nearby.

The opposite in Brazil, the estimates indicate that in 2029 cancer will be the first cause of death,[19] however, a process of reducing cancer mortality rates already occurs in developed countries. According to the American Cancer Society, in the United Sates, female breast cancer mortality rates decreased 39% from 1989 to 2015. Since 2007, in that country, breast cancer death rates have been stabilized in younger women, but have declined in elderly women. These decreases are believed to result in detecting cancer earlier due to screening and awareness programs as well as better treatments.[20] In Brazil, there is an increase in these rates, both in young and old women in the last years.[21]

The concern in controlling breast cancer is relatively recent in Brazil, having as a historical mark in its inclusion of the *Programa de Assistência Integral à Saúde da Mulher* (Integral Care for Women's Health Program) from the Health Ministry in the 1980s.[22] Since then, the actions to control the disease have been driven for other initiatives, including the *Política Nacional de Atenção Oncológica*[23] *e o Plano Nacional de Fortalecimento da Rede de Prevenção, Diagnóstico e Tratamento do Câncer*.[24] (National Policy on Oncological Care and the National Plan to Strengthen the Network on Cancer Prevention, Diagnosis and Treatment) However, there are regional disparities in the conduct of these programs, being more efficient in the South and Southeast regions, which have a better oncological infrastructure that includes higher rates of mammography coverage, access to health services and better quality of treatment. To access the health services in these economically advanced regions also varies between cities in the countryside of the States and its capitals, which reflects disparities in breast cancer mortality rates.[25] Regional disparities are also present in the Northeast, with greater difficulties in accessing treatment for patients living in the countryside of the States. In addition, death registrations tend to be better covered in the larger cities and the capitals of the Northeast.

However, the possibility of limitations in this study should be taken in consideration. The quality of death registerations can be cited as the main one, despite the use of correction techniques which significantly increases in vital registration on the coverage were observed in the Northeast as a whole. However, as being disintegrated in micro-region level, there was a diversity in the correction factor values, particularly increasing in the distant micro-regions of the coast areas, considering its characteristics being less developed. In the statistic point of view, there may be a possible distortions in the quality of the death data in some micro-regions – even because its population has little representative in the Northeast region and would not have the potential to alter the relation found between the indicators on the living conditions and female breast cancer mortality. The statistical significance of the models was strong in evidencing the relation found.

Regarding to modeling, a lack of data at the ecolo-gical level (municipal or regional) is a major constraint for this kind of researches in Brazil, particularly in the Northeast. Depending on the availability of these data, such as motivations for future research, it is suggested to incorporate indicators of the categories as modifiable risk factors (smoking, alcoholism, eating habits, body weight, etc.), occupational, hospital, behavioral, and among others, in modeling.

As modeling signaled the importance of considering age in the relation between the living conditions and breast cancer mortality, since the model with age-specific rates was more adequate to explain the relation in the power hoping to incorporate a greater range of indicators in which would be very useful to explore new models and in relation to other categories than social, economic and demographic, which were dealt here. Categories of environmental, clinical, or risk factor indicators would certainly broaden the array of options for modeling approaches with variables closely related to female breast cancer mortality.

The results found in this study postulate as potential contributions to understand the epidemiology of female breast cancer and for the development and implementation of specific strategies to control the disease, which should be taken into account the populational composition in each State, besides improving death registerations in the Northeast. Among the strategies for conducting governmental policies and actions in the social and health care, this research draws the attention to the relevance of the described relation, therefore, the improvement of the socioeconomic level could increase the incidence of this cancer and if there is no improvement in the overall survival through global therapeutic measurements, the mortality levels will also increase.

## Authors' contributions

Carvalho JB - Data processing (collection, analysis and interpretation) and article writing. Paes NA - Elaboration and final review of the article. All the authors approved the final version of the manuscript.

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Received on September 23, 2018

Final version presented on February 22, 2019

Approved on April 24, 2019