BMC Public Health

https://doi.org/10.1186/s12889-025-25385-2

Article in Press

Individual and contextual factors associated with breast cancer screening in Brazil

Received: 29 August 2023

Accepted: 21 October 2025

Published online: 23 March 2026

Cite this article as: Tiensoli S.D., Felisbino-Mendes M.S., Sousa Romeiro A.M. *et al.* Individual and contextual factors associated with breast cancer screening in Brazil. *BMC Public Health* (2025). https://doi.org/10.1186/s12889-025-25385-2

Sabrina Daros Tiensoli, Mariana Santos Felisbino-Mendes, Amanda Maria Sousa Romeiro, Cesar Oliveira, Erika Aparecida Silveira & Gustavo Velasquez-Melendez

Individual and contextual factors associated with breast cancer screening in Brazil

Sabrina Daros Tiensoli[1], Mariana Santos Felisbino-Mendes[1], Amanda Maria de Sousa Romeiro[2], Cesar de Oliveira[3*], Erika Aparecida Silveira[2,3], Gustavo Velasquez-Melendez[1]

[1]Posgraduate Program in Nursing, School of Nursing, Department of Maternal-Child Nursing and Public Health, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

[2]Postgraduate Program in Health Sciences, Faculty of Medicine, Federal University of Goiás, Goiânia, Brazil

[3]Department of Epidemiology & Public Health, University College London, London, UK

* Corresponding author: Dr Cesar de Oliveira (c.oliveira@ucl.ac.uk)

Abstract

Background: Breast cancer screening aims to reduce mortality in women, as it is the most common and deadliest cancer among them. Various individual and contextual factors may impact screening coverage. We analysed the association of breast cancer screening in Brazil with individual and contextual variables. **Methods:** This is a cross-sectional analysis from the first wave of the Brazilian National Health Survey (Pesquisa Nacional de Saude - PNS). The sample comprised of 8,682 women aged 50 to 69 living in all five geopolitical Brazilian regions. Multilevel logistic regression was used to estimate the Odds Ratio (OR, 95% CIs). Random effects were estimated using the intraclass correlation coefficient (ICC) values and the per cent variance reduction. **Results:** The individual variables associated with breast cancer screening were: high level of education, living with a partner, being overweight, practising physical activity, no tobacco use, and having health insurance. Regarding contextual variables, higher numbers of mammography examinations were performed in those states with higher levels of Human Development Index (HDI), Social Development Index (SDI) and number of mammography devices. **Conclusions:** Clear state inequalities underscore the importance of public health policies covering the entire target population and promoting breast cancer screening.

Keywords: breast cancer, screaming, mammography examination, overweight, smoking, social iniquities

INTRODUCTION

Breast cancer is the most common type of cancer among women, and it ranks as the fifth leading cause of death worldwide. In 2020, an estimated 19.3 million new cases were reported. It is the most prevalent cancer type, with the highest incidence rates occurring in developed countries (1). In 2023, 73,610 incident cases of neoplasms were registered in Brazil, representing 30% of all neoplasms in women, excluding non-melanoma skin cancer (2). The worldwide mortality rate was estimated at 6.9% within all cancer types, configuring the major cause of mortality due to cancer among women, especially in developing countries (1).

One of the strategies for reducing mortality is early diagnosis through screening programs (3,4). In the international context, it is possible to observe disparities between developed countries and low- and middle-income countries (LMICs). For example, mammography screening in Europe has reduced breast cancer mortality by approximately 26%, while in LMICs, such as Morocco in 2016, it managed to detect breast cancer in 1.0/1000 screened women (5). Thus, early screening relies on reference services, diagnostic infrastructure, strategies at the public health level, and access to financial and technological resources (6).

According to Brazilian guidelines, women aged 50 to 69 should undergo a mammography exam (ME) (7) for breast cancer screening every two years, with a proposed coverage goal of 70% (8). In 2021, 3,497,439 mammograms were performed on women through the Unified Health System (SUS), with 3,145,930 of them being screening mammograms, reaching 65.3% of the target population (9,10). However, it is possible to identify disparities among Brazilian regions and states, particularly in areas with significant sociodemographic, economic, and cultural inequalities, such as the North, Northeast, and Midwest (11,12).

Certain individual factors may impact access to mammography examinations, including sociodemographic and economic variables like age, low education level, family income, unhealthy lifestyle habits, presence of other health conditions, and poor self-assessment of health status. In addition, there are predictors that could influence women's adherence to breast cancer prevention (13-16), such as visceral obesity in postmenopausal women associated with breast cancer (17). Previous Brazilian studies indicate potential contextual variables related to mammography

examination, such as access to health services, specialized health professionals, detection and diagnosis services, public policies, Human Development Index (HDI) and Social Development Index (SDI) (18–21).

Due to Brazil's vast geographical size and regional differences influenced by social, economic, and cultural factors, it is important to consider a range of variables beyond just the individual to better understand the complex relationship between individual and environmental factors as determinants of health outcomes in the country. Few nationally representative population studies have addressed this proposed association (12,22,23). Therefore, the objective of this study was to analyse the association of individual and contextual factors with breast cancer screening in Brazil.

METHODS

This is a population-based cross-sectional study that used data from the first edition of the Brazilian National Health Survey (PNS – Pesquisa Nacional de Saude), a national household survey representative of the non-institutionalized resident population of rural and urban areas of Brazil. The objective of PNS was to characterize the health status and lifestyle of the Brazilian population and to collect information regarding access to and use of health services. The sampling process consisted of three stages, the third of which corresponds to the selection of adult residents aged 18 or older among all the residents in the household (24,25). The questionnaire for this resident contained several questions related to non-communicable chronic diseases, lifestyle, and medical care (26).

In 2013, 69,954 households were selected, and 60,202 individuals aged 18 or older were interviewed, resulting in a response rate of 86.1% (24,25). Of the 60,202 individuals, 35,969 were women, with the sample used for this study consisting of the target age group for breast cancer screening i.e., 50 to 69 years in 2013 (n=9,049) (Figure 1).

The outcome variable was having had a mammography within two years or less, as determined by the following questions: "Have you had a mammography exam?" and "When was the last time you had a mammography exam?”

The individual explanatory variables were divided into sociodemographic, clinical, and behavioural characteristics. The sociodemographic characteristics were self-reported: skin colour, as a proxy for race (white, brown and black, yellow and Indigenous) (27); age, in years; education, in years of study; marital status (with partner - married; without partner - single, legally separated or divorced, divorced, widowed); region of residence; health insurance coverage. The clinical and lifestyle characteristics were body mass index (BMI) classification according to the international standardization (28), calculated by dividing the weight (in kg) by the squared height (in meters); abusive consumption of alcoholic beverages; practice of physical activity; smoking; self-assessment of health status (positive - very good, good; negative - regular, bad, very bad). Weight and height were measured using an electronic scale and a digital stadiometer (25). Abuse of alcoholic beverages was considered as the ingestion of four or more doses for women, on a single occasion, at least once in the 30 days prior to the interview. One dose of alcoholic beverage is equivalent to one glass of wine, one can of beer, or one dose of cachaça, whiskey, or any distilled alcoholic beverage (29).

The state contextual variables used were Primary Care (PC) coverage, considering the average coverage of each state between the years 2010, 2011 and 2012 (30) (0 to 49.9%; 50 to 74.9%; 75 to 100% coverage); the Human Development Index (HDI) of 2010 (31); Gini Index (GI) of household income per capita in 2010, considered the sum of monthly incomes of household residents, in Brazilian reais, divided by the number of its residents (32); Social Development Index (SDI) (33); and Number of Mammographers per 100 thousand inhabitants per federal unit, all categorized in quartiles.

The SDI is an indicator based on the geometric average of *per capita* income, years of schooling of people aged 15 years or older and total fertility rate for 2013 (34). This indicator ranges from zero to one, with a value of zero indicating a low socio-demographic development index, with lower income, lower education, and higher fertility rates (33). The number of mammography devices for each state was obtained from the National Health Facilities Census (CNES in Portuguese), considering mammography devices with simple, stereotactic and computerized controls, which were in use in December 2012. The parameter defined by the Ministry of Health is 1 mammography apparatus per 240,000 inhabitants or 0.42 per 100,000 inhabitants (35).

For the descriptive analysis, we estimated the prevalence of RME based on the multilevel logistic null model, which provides standardized estimates of the prevalence within each context, although it may not perfectly match the observed prevalences due to the nature of multilevel modelling, which accounts for the hierarchical structure within the data. Unadjusted and adjusted analyses were performed by sociodemographic, clinical, and behavioural characteristics associated with mammography examination. Multilevel logistic regression with random intercept was used, with the first level represented by individual variables and the second level by states. We estimated the Odds Ratio (OR) and their 95% CIs.

The existence of collinearity between variables of both analytical levels was verified, and when there was a high correlation between variables, especially between the contextual ones, we decided to estimate more than one model. The modelling comprised the following steps: 1) analysis of the null model, which includes only the random intercept; 2) inclusion of individual-level variables; 3) inclusion of contextual-level variables.

The random effects were measured by the intraclass correlation coefficient (ICC) and percentual values of change in variance. The ICC was quantified to examine the proportion of the total variance assigned to explanatory contextual variables. The percent variance reduction was calculated between the null model and each subsequent model to assess the proportion of variance explained by the included variables. Akaike's information criterion (AIC) and Bayesian information criterion (BIC) were used to compare the models and assess fit, with the best model being considered the one with the lowest AIC and BIC (36).

Data were analysed using *Stata* software, version 14 and a significance level of 5%. A subpopulation was created, not excluding participants who did not meet the inclusion criteria, only restricting the analyses to the subpopulation of interest (37). The free software QGIS was used to elaborate the map of chances of mammography examination by states. The contextual data used were extracted from electronic databases in the public domain, such as the Brazilian Institute of Geography and Statistics (IBGE in Portuguese), CNES, Department of Primary Care (DAB in Portuguese), and Institute for Health Metrics and Evaluation (IHME), which are available for use by researchers.

The PNS was approved by the National Research Ethics Committee (Conep No. 328.159/2013 and CAAE No. 10853812.7.0000.0008) and followed all ethical precepts, according to Resolution 466/12 of the National Health Council, respecting the secrecy, confidentiality, and autonomy of the participants. All interviewees signed the Informed Consent Form, which can be found on the PNS website (26).

RESULTS

The study population was composed of 9,049 women aged 50 to 69 years (Figure 1), with a predominance of women who self-reported having white skin colour/race (50.9%), aged 50 to 59 years (59.6%), with 0 to 8 years of schooling (64.8%), who lived with a partner (53.1%), residents in the Southeast region (47.9%), and who had no private health insurance coverage (67.9%). Most women were overweight (38.3%), did not abuse alcohol (96.9%), did not practice physical activity (72.8%), did not smoke (61.5%), and self-assessed their health status as negative (52.0%) (Table 1).

The prevalence of mammography examinations was 54.4%. The higher prevalence was observed in women with white skin colour/race (59.8%) compared to the brown/black ones; in the younger age groups i.e., 50 to 59 years (57.1%); with 12 years or more of schooling (74.4%) compared to the lower schooling; living with a partner (57.8%); living in the Southeast (62.3%) and South (60.0%) regions compared to the other ones; having health insurance coverage (75.1%); among who practised physical activity (73.3%); , and self-assessed their health status as positive (61.3%) (Table 1).

Figure 2 shows the prevalence of realization of mammography exam (RME), according to the Brazilian states. The highest prevalence was observed in the Southeast and South states of Brazil, highlighting the contextual variability of this outcome.

Association with contextual variables in unadjusted analyses are shown in Table 2. In the multilevel analysis, variability in the odds of mammography examination was observed among the states. The ICC was 6.01%, indicating that approximately 6% of the variability of mammography examination was accounted for states, leaving 94% of the variability to be accounted for individual

characteristics of women and other unmeasured variables (Table 3).

The individual-level predictors of mammography examination were high education (9 or more years of schooling), marital status (with partner), nutritional status (overweight), physical activity practice, no smoking, and health insurance coverage.

The OR of mammography examination increased with increasing HDI quartile. Women who were in the highest quartile were 1.70 (1.16-2.49) times more likely to realize mammography. Women who live in states in the top quartile of SDI were 84% more likely to realise mammography than their counterparts in the first quartile. Similarly, women who lived in states in the top quartile of the number of mammography devices per 100,000 population were 2.16 (1.50-3.13) times more likely to realise mammography. The models presented in Table 3 were fitted separately because of collinearity between the contextual variables was verified, with HDI being correlated with SDI (r =0.96) and the number of mammography devices (r =0.77), and SDI with the number of mammography devices (r =0.76), and models were run for each contextual variable.

When evaluating the model fit, a reduction in the AIC and BIC values was observed after the inclusion of the individual and contextual level variables (HDI, SDI, and number of mammography devices per 100,000 inhabitants), which means that the inclusion of the variables improved the model fit. Model 5, with the individual variables and the contextual variable number of mammography devices per 100,000 inhabitants, offered the greatest reduction in the variability among the UFs and in the AIC and BIC values.

DISCUSSION

This is the first study in Brazil to show that breast cancer screening, along with individual factors, is linked to socioeconomic indicators of the states. Overall, we found that the breast cancer screening rate was low (54.4%), which is below the recommended level for reducing mortality (8,38). States in the Southeast and South regions of the country are performing more screening than the ones in the North. Individual variables associated with the mammography examination were women with a high level of education, i.e., ≥9 years, living with a partner, being overweight, practising physical exercise, not smoking and having health insurance. The contextual variables

were living in states with higher levels of HDI, SDI and higher numbers of mammography devices.

The coverage of screening programs for breast cancer in Brazil is low and below the recommendation of the World Health Organization since it is recommended that they be organized and of high quality, with the capacity to cover at least 70% of the population (38). Compared to high-income countries, the coverage of the North (64%), West (62%) and South (69%) regions of the European continent (39), since the expenses dedicated to ensuring the quality of these programs are greater and cannot be less than 10-20%, since the investment will result in a decrease in mortality (40), preventing approximately 21,700 deaths per year (39).

The North region has the lowest healthcare coverage in Brazil due to socioeconomic inequalities. These inequalities have led to uneven access to health services and poorer health outcomes. This region is the poorest, and although poverty has decreased in the country overall, the North has seen slower progress. As a result, there is a lack of equipment and specialists, and lower screening rates. Previous research has shown that women living in economically disadvantaged areas in Brazil face challenges in accessing healthcare (22, 23).

This study found that high education, healthy lifestyle, being overweight, and private health insurance were associated with mammography examinations, as they are associated with greater access to information and health services (41). Similar results were found in a previous Brazilian study (12), in Asian countries (41,42) and in previous systematic reviews (12,13,15) since higher knowledge about the disease and performing breast self-examination are fundamental activities for the prevention and early detection of breast cancer (42). Marital status can also influence women's adherence since a previous systematic review indicated that single or unmarried patients were more likely to be diagnosed in advanced stages (43).

Healthy behaviours, such as regular physical activity and not smoking, increase the likelihood of undergoing a mammography examination. Previous evidence indicates that individuals with healthy habits are more likely to schedule medical appointments and be concerned about their health status (11,12,44). Physical activity, especially at high-intensity levels, is a strong predictor of preventive behaviour for breast cancer (45–48). Lifetime smoking increases the risk of invasive

breast cancer (49). If smoking starts more than 10 years before the first childbirth, the risk of developing cancer is 85% (50).

In the present study, overweight women were more likely to have a mammogram than underweight women. This finding differs from the results from an American study that did not find screening disparities among women from different body mass index categories. However, the risk was higher for postmenopausal obese women developing breast cancer (51). Conversely, a review study showed a low adherence of overweight and obese women who were less likely to comply with prevention recommendations (52). Efforts to reduce overweight and alcohol consumption and encourage physical activity are needed to impact the reduction of breast cancer incidence (1).

The low screening coverage in the Brazilian states with low HDI and SDI levels is corroborated by previous studies in which the North, Northeast and Midwest regions were the most affected. The absence of a private health insurance plan and not going to the doctor in the last year are factors associated with low adherence to mammography (11,12). It is important to emphasize the significance of the Brazilian Unified Health Service (SUS) in reaching less privileged regions and improving access to healthcare services, specialists, and equipment. Additionally, it plays a crucial role in developing healthcare strategies that facilitate early diagnosis and reduce disparities related to access to examinations.

Contextual variables at the state level were significantly associated with mammography examinations. The HDI has directly influenced mammography coverage in smaller contexts, such as municipalities (22). The sociodemographic development index of the Federal District was also associated with mammography examination. States with higher indexes had greater odds of mammography examination, reinforcing the Gini index found for the HDI. Places with greater economic disparities have greater disparities in health (12), such as lower coverage of the exam.

This study showed an association between the number of mammography devices and mammography examinations. The adequate number of equipment proved to be necessary for better access and assistance (16). However, no differences were found in the odds of mammography examination according to primary care coverage. The identification of events that occur from the

request of the mammography exam to the delivery of the result implies a chain of activities that can be assisted by primary care, such as community engagement, active search of the target population by Community Health Agent, request for mammography by professionals, integrated actions to women's health and monitoring of mammography results, reaching up to 88% of the population (53).

The absence of association of the Gini Index (GI) with mammography examination in this study contradicts the positive results of this association when evaluating the GI of Brazilian health municipalities (22) or microregions (23). State-level groupings may attenuate GI differences between smaller settings, such as municipalities. Comparison of the findings of this study with others in the literature is limited due to the different methodologies adopted (11,23,54). Covering the population beyond what is recommended for breast cancer screening does not allow for estimating the actual coverage and clarifying the factors related to it as well as when using the ratio of exams, there may be overestimation in screening if the same woman performs the exam more than once a year. Moreover, the comparison between organized and opportunistic screening is not feasible since, in Brazil, opportunistic screening prevails (55).

The study was notably strong because it considered not only individual factors but also contextual variables. This approach helped to improve our understanding of the contextual factors associated with breast cancer screening in the country. Additionally, it allowed for the estimation of the variation in screening rates based on socioeconomic differences in different states. It also provided a more comprehensive understanding of the complex relationship between individual characteristics and the surrounding context as influences on health. In this case, determinants of breast cancer screening, a structuring program of health care for Brazilian women in primary health care. Furthermore, the individual variables were collected through face-to-face questionnaires, increasing the results' reliability and reducing information bias. As a potential limitation, it should be noted that our use of contextual data was restricted. Additionally, the unit of analysis was the federative units, which partially limited our ability to include a wide variety of indicators of inequalities between states.

Our findings could be crucial for future studies. The emphasis is on the quality of primary care, the level of screening, and the impact of the COVID-19 pandemic (10). This impact may have led to reduced screening as it was no longer a priority during the health emergency. In addition, the economic situation in the country has worsened. Therefore, it is possible to foresee worse scenarios that may be revealed in future research. To ensure appropriate planning of public policies for women's health, it is important to consider the context and tailor the actions towards women who exhibit more characteristics associated with lower odds of undergoing a mammography examination. The presence of public policies aimed at promoting the socioeconomic development of the federal units could lead to an increase in mammography coverage. Additionally, focusing on an organized and strategic screening program will be crucial in preventing deaths from cancer.

REFERENCES

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin. 2021 May;71(3):209–49.

2. INCA IN de CJAG da S. Estatísticas de câncer. [cited 2023 Jun 10]. Estatísticas de câncer. Available from: https://www.gov.br/inca/pt-br/assuntos/cancer/numeros

3. Massat NJ, Dibden A, Parmar D, Cuzick J, Sasieni PD, Duffy SW. Impact of Screening on Breast Cancer Mortality: The UK Program 20 Years On. Cancer Epidemiol Biomarkers Prev. 2016 Mar 1;25(3):455–62.

4. Wu N, Huang Z, Shen Y, Park J, Phang J, Makino T, et al. Reducing False-Positive Biopsies using Deep Neural Networks that Utilize both Local and Global Image Context of Screening Mammograms. J Digit Imaging. 2021 Dec;34(6):1414–23.

5. Mandal R, Basu P. Cancer screening and early diagnosis in low and middle income countries: Current situation and future perspectives. Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz. 2018 Dec;61(12):1505–12.

6. Da Costa Vieira RA, Biller G, Uemura G, Ruiz CA, Curado MP. Breast cancer screening in developing countries. Clinics. 2017;72(4):244–53.

7. INCA IN de CJAG da S. Diretrizes para a detecção precoce do câncer de mama no Brasil. 2015;

8. Bernal RTI, Malta DC, Iser BPM, Monteiro RA. Método de projeção de indicadores das metas do Plano de Ações Estratégicas para o Enfrentamento das Doenças Crônicas não

Transmissíveis no Brasil segundo capitais dos estados e Distrito Federal. Epidemiol E Serviços Saúde. 2016 Sep;25(3):455–66.

9. INCA IN de CJAG da S. Rastreamento do câncer de mama na população-alvo [Internet]. 2022 [cited 2023 Jun 11]. Available from: https://www.gov.br/inca/pt-br/assuntos/gestor-e-profissional-de-saude/controle-do-cancer-de-mama/dados-e-numeros/rastreamento-do-cancer-de-mama-na-populacao-alvo

10. INCA IN de CJAG da S. Mamografias no SUS [Internet]. 2022 [cited 2023 Jun 11]. Available from: https://www.gov.br/inca/pt-br/assuntos/gestor-e-profissional-de-saude/controle-do-cancer-de-mama/dados-e-numeros/mamografias-no-sus

11. Barbosa YC, Oliveira AGC, Rabêlo PPC, Silva FDS, Santos AMD. Fatores associados à não realização de mamografia: Pesquisa Nacional de Saúde, 2013. Rev Bras Epidemiol. 2019;22:e190069.

12. Tiensoli SD, Felisbino-Mendes MS, Velasquez-Melendez G. Health Iniquity, Unhealthy Behavior, and Coverage of Mammography in Brazil. Rev Bras Enferm. 2020;73(suppl 5):e20200011.

13. Azriful A, Mallapiang F, Kurniati Y. Literature Review: Social Determinant of Health in Breast Cancer Patients Survival. Open Access Maced J Med Sci. 2021 Aug 8;9(E):624–8.

14. Rollet Q, Tron L, De Mil R, Launoy G, Guillaume É. Contextual factors associated with cancer screening uptake: A systematic review of observational studies. Prev Med. 2021 Sep;150:106692.

15. Mottram R, Knerr WL, Gallacher D, Fraser H, Al-Khudairy L, Ayorinde A, et al. Factors associated with attendance at screening for breast cancer: a systematic review and meta-analysis. BMJ Open. 2021 Nov;11(11):e046660.

16. Wu Z, Liu Y, Li X, Song B, Ni C, Lin F. Factors associated with breast cancer screening participation among women in mainland China: a systematic review. BMJ Open. 2019 Aug;9(8):e028705.

17. Silveira EA, Kliemann N, Noll M, Sarrafzadegan N, Oliveira C. Visceral obesity and incident cancer and cardiovascular disease: An integrative review of the epidemiological evidence. Obes Rev [Internet]. 2021 Jan [cited 2023 Jun 28];22(1). Available from: https://onlinelibrary.wiley.com/doi/10.1111/obr.13088

18. Zolghadr Z, Salehi M, Dehnad A, Zayeri F. A Study of Relationship Between Breast Cancer Mortality Rate and Human Development Index: Global Trend Analysis from 1990 to 2017. Int J Cancer Manag [Internet]. 2020 Aug 19 [cited 2023 Jun 11];13(8). Available from: https://brieflands.com/articles/ijcm-101813.html

19. Zhang S, Wang H, Liu B, Yu J, Gao Y. Socioeconomic status index is an independent determinant of breast cancer screening practices: Evidence from Eastern China. Bowles EJA, editor. PLOS ONE. 2022 Dec 14;17(12):e0279107.

20. Gehlert S, Hudson D, Sacks T. A Critical Theoretical Approach to Cancer Disparities: Breast Cancer and the Social Determinants of Health. Front Public Health. 2021 May 21;9:674736.

21. Plourde N, Brown HK, Vigod S, Cobigo V. Contextual factors associated with uptake of breast and cervical cancer screening: A systematic review of the literature. Women Health. 2016 Nov 16;56(8):906–25.

22. Bezerra HDS, Melo TFVD, Barbosa JV, Feitosa EELC, Sousa LCM. Avaliação do acesso em mamografias no Brasil e indicadores socioeconômicos: um estudo espacial. Rev Gaúcha Enferm [Internet]. 2018 Oct 22 [cited 2023 Jun 11];39(0). Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1983-14472018000100457&lng=pt&tlng=pt

23. Nogueira MC, Fayer VA, Corrêa CSL, Guerra MR, Stavola BD, dos-Santos-Silva I, et al. Inequities in access to mammographic screening in Brazil. Cad Saúde Pública. 2019;35(6):e00099817.

24. Souza-Júnior PRBD, Freitas MPSD, Antonaci GDA, Szwarcwald CL. Desenho da amostra da Pesquisa Nacional de Saúde 2013. Epidemiol E Serviços Saúde. 2015 Jun;24(2):207–16.

25. Szwarcwald CL, Malta DC, Pereira CA, Vieira MLFP, Conde WL, Souza Júnior PRBD, et al. Pesquisa Nacional de Saúde no Brasil: concepção e metodologia de aplicação. Ciênc Saúde Coletiva. 2014 Feb;19(2):333–42.

26. Damacena GN, Szwarcwald CL, Malta DC, Souza Júnior PRBD, Vieira MLFP, Pereira CA, et al. The Development of the National Health Survey in Brazil, 2013. Epidemiol E Serviços Saúde. 2015 Jun;24(2):197–206.

27. Barbosa AP, Pereira RH, Campos MR. Race and Health: The Social, Economic, and Racial Determinants of Health Inequities in Brazil. Cadernos de Saude Publica. 2015 31(5): 767-779. doi:10.1590/0102-311X00132114

28. Weir CB, Jan A. BMI Classification Percentile And Cut Off Points [Internet]. StatPearls - NCBI Bookshelf; 2023 [cited 2023 Jun 11]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK541070/

29. Brazil, Ministry of Health. Vigitel Brasil 2016: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: estimativas sobre frequência e distribuição sociodemográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2016 / Ministério da Saúde, Secretaria de Vigilância em Saúde. Brasília; 2017. 160 p.

30. Brazil, Ministry of Health, Secretariat of Primary Health Care (SAPS). e-Gestor Basic Care [Internet]. [cited 2023 Jun 11]. Available from:

https://egestorab.saude.gov.br/paginas/acessoPublico/relatorios/relHistoricoCoberturaAB.xhtml

31. Instituto Brasileiro de Geografia e Estatística (IBGE). Índice de Desenvolvimento Humano [Internet]. 2020 [cited 2020 Oct 13]. Available from: https://cidades.ibge.gov.br/brasil/sp/pesquisa/37/0?tipo=cartograma

32. Instituto Brasileiro de Geografia e Estatística (IBGE). Socioeconomic indicators. Gini index of household income per capita [Internet]. 2010 [cited 2020 Oct 13]. Available from: http://tabnet.datasus.gov.br/cgi/idb2011/b09ufc.htm

33. Institute Health Metrics and Evaluation (IHME). Global Burden of Disease (GBD). Socio-Demographic Index (SDI) [Internet]. 2020 [cited 2020 Oct 13]. Available from: http://www.healthdata.org

34. Global Burden of Disease 2015 study: summary of methods used. Rev Bras Epidemiol. 2017 May;20(suppl 1):4–20.

35. Brazil. Datasus. Imaging equipment used in health [Internet]. [cited 2020 Oct 13]. Available from: http://tabnet.datasus.gov.br/tabdata/LivroIDB/2edrev/e18.pdf

36. Goldstein H. Multilevel statistical models. 4th ed. United Kingdom: University of Bristol; 2011.

37. West BT, Berglund P, Heeringa SG. A Closer Examination of Subpopulation Analysis of Complex-Sample Survey Data. Stata J Promot Commun Stat Stata. 2008 Dec;8(4):520–31.

38. A short guide to cancer screening: increase effectiveness, maximize benefits and minimize harm. WHO Regional Office for Europe; 2022.

39. Zielonke N, Kregting LM, Heijnsdijk EAM, Veerus P, Heinävaara S, McKee M, et al. The potential of breast cancer screening in Europe. Int J Cancer. 2021 Jan 15;148(2):406–18.

40. European guidelines for quality assurance in breast cancer screening and diagnosis. European Union; 2013.

41. Dibisa TM, Gelano TF, Negesa L, Hawareya TG, Abate D. Breast cancer screening practice and its associated factors among women in Kersa District, Eastern Ethiopia. Pan Afr Med J [Internet]. 2019 [cited 2023 Jun 29];33. Available from: http://www.panafrican-med-journal.com/content/article/33/144/full/

42. Bhandari D, Shibanuma A, Kiriya J, Hirachan S, Ong KIC, Jimba M. Factors associated with breast cancer screening intention in Kathmandu Valley, Nepal. Pakpour AH, editor. PLOS ONE. 2021 Jan 22;16(1):e0245856.

43. Yuan R, Zhang C, Li Q, Ji M, He N. The impact of marital status on stage at diagnosis and survival of female patients with breast and gynecologic cancers: A meta-analysis. Gynecol Oncol. 2021 Sep;162(3):778–87.

44. Kardan-Souraki M, Moosazadeh M, Khani S, Hamzehgardeshi Z. Factors Related to Breast Cancer Screening in Women in the Northern Part of Iran: A Cross-Sectional Study. Open Access Maced J Med Sci. 2019 Feb 15;7(4):637–42.

45. Dixon-Suen SC, Lewis SJ, Martin RM, English DR, Boyle T, Giles GG, et al. Physical activity, sedentary time and breast cancer risk: a Mendelian randomisation study. Br J Sports Med. 2022 Oct;56(20):1157–70.

46. Papadimitriou N, Dimou N, Tsilidis KK, Banbury B, Martin RM, Lewis SJ, et al. Physical activity and risks of breast and colorectal cancer: a Mendelian randomisation analysis. Nat Commun. 2020 Jan 30;11(1):597.

47. Ligibel JA, Basen-Engquist K, Bea JW. Weight Management and Physical Activity for Breast Cancer Prevention and Control. Am Soc Clin Oncol Educ Book. 2019 May;(39): e22–33.

48. Azubuike SO, Hayes L, Sharp L, Alabi A, Oyesegun RA, McNally R. Physical activity and the risk of breast cancer among Nigerian women. Cancer Epidemiol. 2022 Jun;78:102163.

49. Park HA, Neumeyer S, Michailidou K, Bolla MK, Wang Q, Dennis J, et al. Mendelian randomisation study of smoking exposure in relation to breast cancer risk. Br J Cancer. 2021 Oct 12;125(8):1135–45.

50. Gaudet MM, Carter BD, Brinton LA, Falk RT, Gram IT, Luo J, et al. Pooled analysis of active cigarette smoking and invasive breast cancer risk in 14 cohort studies. Int J Epidemiol. 2016 Dec 28; dyw288.

51. Miles RC, Lehman CD, Mercaldo SF, Tamimi RM, Dontchos BN, Narayan AK. Obesity and breast cancer screening: Cross-sectional survey results from the behavioral risk factor surveillance system. Cancer. 2019 Dec;125(23):4158–63.

52. Lee K, Kruper L, Dieli-Conwright CM, Mortimer JE. The Impact of Obesity on Breast Cancer Diagnosis and Treatment. Curr Oncol Rep. 2019 May;21(5):41.

53. Sala DCP, Okuno MFP, Taminato M, Castro CPD, Louvison MCP, Tanaka OY. Breast cancer screening in Primary Health Care in Brazil: a systematic review. Rev Bras Enferm. 2021;74(3):e20200995.

54. Petrelli A, Giorgi Rossi P, Francovich L, Giordani B, Di Napoli A, Zappa M, et al. Geographical and socioeconomic differences in uptake of Pap test and mammography in Italy: results from the National Health Interview Survey. BMJ Open. 2018 Sep;8(9):e021653.

55. Moraes DCD, Almeida AMD, Figueiredo END, Loyola EACD, Panobianco MS. Opportunistic screening actions for breast cancer performed by nurses working in primary health care. Rev Esc Enferm USP. 2016 Feb;50(1):14–21.

Declarations

Ethics approval and consent to participate

The PNS was approved by the National Research Ethics Committee (Conep No. 328.159/2013 and CAAE No. 10853812.7.0000.0008) and followed all ethical precepts, according to Resolution 466/12 of the National Health Council, respecting the secrecy, confidentiality, and autonomy of the participants. All interviewees signed the Informed Consent Form. More detailed information on ethical procedures can be found on the PNS website: https://www.pns.icict.fiocruz.br/

Consent for publication

Not applicable

Availability of data and materials

PNS de-identified data is publicly available at: https://www.pns.icict.fiocruz.br/bases-de-dados/
SDI data was collected at: https://ghdx.healthdata.org/
PHC data were collected at: https://datasus.saude.gov.br/informacoes-de-saude-tabnet/
GI and HDI were collected at: https://www.ibge.gov.br/pt/inicio.html

Competing interests

The authors declare no competing interests.

Funding

This work was supported by the Economic and Social Research Council (ESRC) (grant number ES/T008822/1).

Authors' contributions

S.D.T., M.S.F.M and G.V.M designed the study, analysed data and wrote the main manuscript text. S.D.T., M.S.F.M., A.M.S.R., C. de O., E.A.S. and G.V.M. interpretation of data and substantively revised the manuscript. All authors approved the final manuscript.

Acknowledgements

This article is part of the PhD dissertation of Sabrina Daros Tiensoli, Graduate Program in Nursing, Department of Maternal and Child Nursing and Public Health, School of Nursing at the Universidade Federal de Minas Gerais.

GVM and EAS are research fellow from Brazilian National Council of Research and Technology (CNPq)

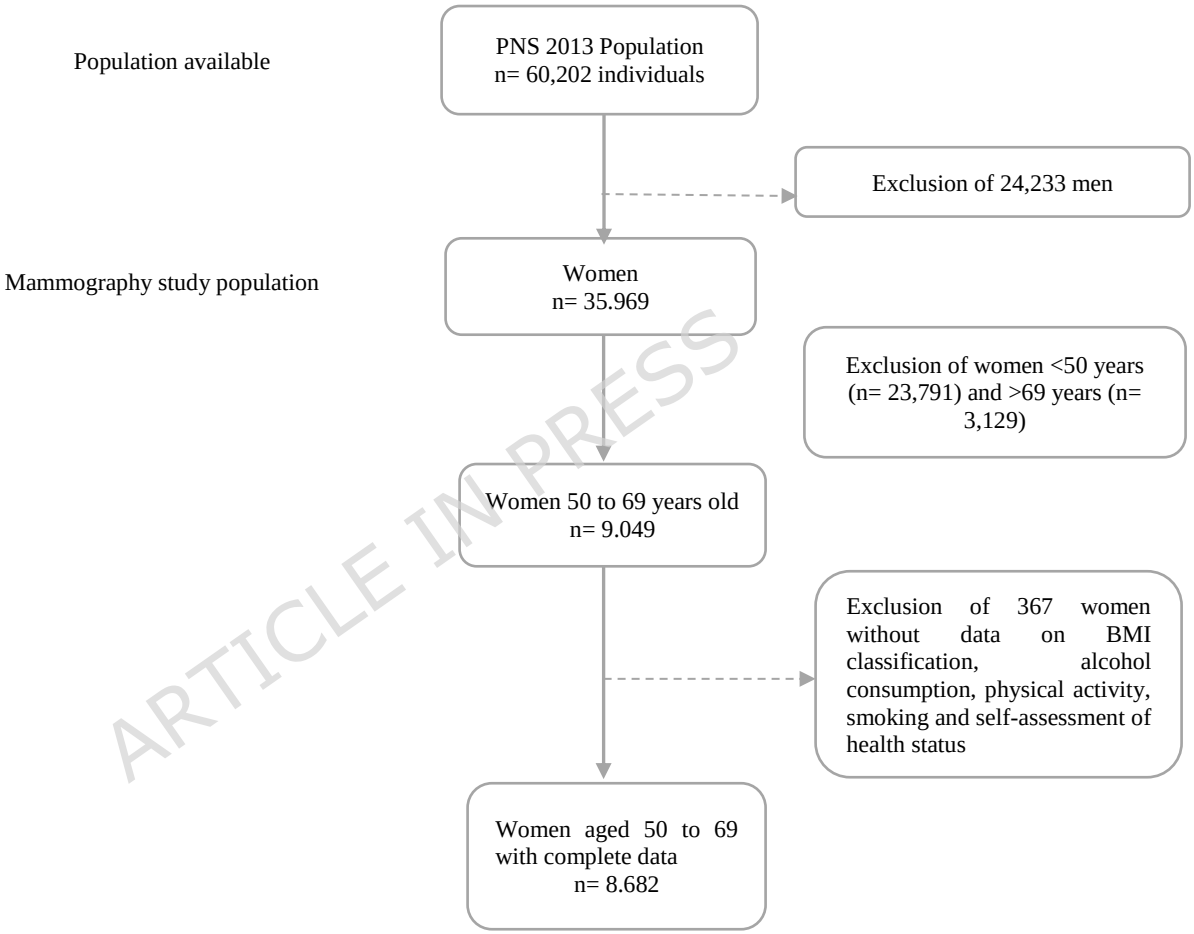

Figure 1 - Flowchart of the study population.

Table 1 - Prevalence of realization of mammography exam (RME) in Brazilian women aged 50 to 69 years, in the 2 years prior to the survey, according to selected variables. PNS, 2013.

Variables	Women 50 to 69 years old		RME
	n*	%† (±EP) ‡	%† (95% CI) §
Skin color/race (self-reported)	**9,048**		
White	4,003	50.9 (1.0)	59.8 (57.07-62.57)
Brown and black	4,895	47.5 (1.0)	48.6 (46.08-51.10)
Yellow	84	1.0 (0.2)	61.9 (43.44-77.44)
Indigenous	66	0.6 (0.1)	45.6 (26.33-66.34)
Age group (years)	**9,049**		
50 a 59	5,289	59.6 (0.8)	57.1 (54.65-59.57)
60 a 69	3,760	40.4 (0.8)	50.5 (47.56-53.39)
Education (years)	**9,049**		
0 a 8	5,776	64.8 (0.9)	46.4 (44.13-48.75)
9 a 11	1,980	21.5 (0.7)	65.8 (62.03-69.44)
12 or more	1,293	13.7 (0.7)	74.4 (69.30-78.89)
Marital status	**9,049**		
With partner	3,946	53.1 (0.9)	57.8 (54.92-60.60)
No companion	5,103	46.9 (0.9)	50.7 (48.12-53.18)
Region	**9,049**		
Southeast	2,517	47.9 (1.0)	62.3 (58.99-65.50)
South	1,255	15.3 (0.6)	60.0 (55.62-64.17)
Midwest	1,163	7.2 (0.3)	48.6 (44.75-52.52)
North	1,427	5.5 (0.3)	33.0 (28.62-37.78)
Northeast	2,687	24.1 (0.8)	41.9 (38.91-44.88)
Health insurance coverage	**9,049**		
Yes	2,704	32.1 (1.0)	75.1 (71.86-78.15)
No	6,345	67.9 (1.0)	44.7 (42.51-46.84)
BMI Classification	**8,682**		
Low weight	172	1.7 (0.2)	31.8 (20.33-46.03)
Appropriate weight	2,499	28.2 (0.8)	52.9 (49.49-56.27)
Overweight	3,320	38.3 (0.8)	56.5 (53.51-59.43)
Obesity	2,691	31.8 (0.8)	54.6 (51.26-57.88)
Abusive consumption of alcoholic beverages	**8,682**		
No	8,363	96.9 (0.2)	54.4 (52.45-56.36)
Yes	319	3.1 (0.2)	55.4 (46.39-64.09)
Physical activity practice	**8,682**		
Yes	2,253	27.2 (0.8)	73.3 (70.24-76.09)
No	6,429	72.8 (0.8)	47.4 (45.21-49.59)
Smoking	**8,682**		

No	5,378	61.5 (0.8)	55.6 (53.10-58.01)
Ex-smoker	2,005	22.3 (0.7)	56.5 (52.82-60.19)
Yes	1,299	16.2 (0.6)	47.2 (42.48-52.05)
Self-assessment of health status	**8,682**		
Positive (very good and good)	4,082	48.0 (0.9)	61.3 (58.47-63.98)
Negative (regular, bad, and very bad)	4,600	52.0 (0.9)	48.1 (45.61-50.70)

Note: * sample number, † population estimate, ‡ standard error, § 95% confidence interval, BMI: Body Mass Index.

Figure 2- Prevalence of realization of mammography exam (RME), according to the Brazilian states.

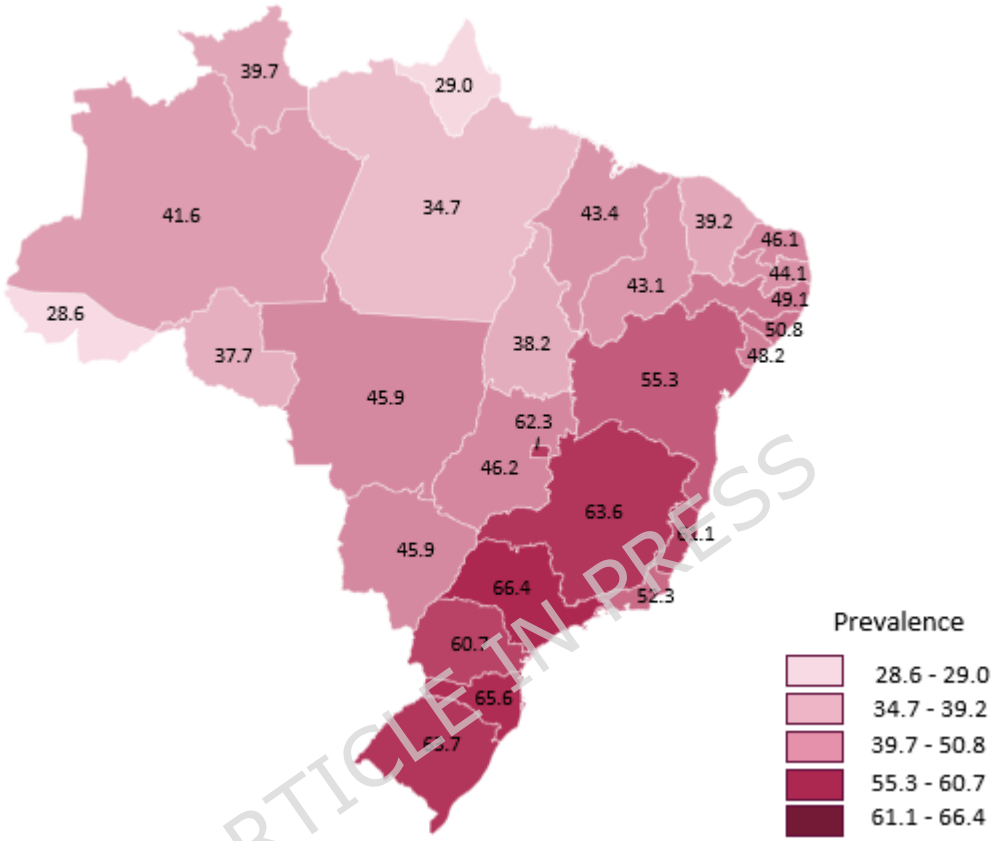

Table 2 - Unadjusted ORs and 95% CI of contextual variables associated to RME.

Contextual variables	RME OR (95%CI)
Primary Care Coverage	
0 a 49.9%	Ref.
50.0 a 74.9%	0.60 (0.24-1.49)
75.0 a 100.0%	0.45 (0.18-1.13)
HDI	
1stquartile (0.631-0.672)	Ref.
2nd quartile (0.673-0.724)	0.85 (0.62-1.17)
3rd quartile (0.725-0.760)	**1.67 (1.21-2.31)**
4th quartile (0.761-0.824)	**2.19 (1.50-3.19)**
SDI	
1stquartile (0.5809-0.6233)	Ref.
2nd quartile (0.6234-0.6706)	1.04 (0.74-1.46)
3rd quartile (0.6703-0.7170)	**1.47 (1.02-2.13)**
4th quartile (0.7171-0.8179)	**2.34 (1.60-3.43)**
GI of family income *per capita*	
1st quartile (0.4601-0.5178)	0.98 (0.60-1.60)
2nd quartile (0.5179-0.5301)	1.18 (0.73-1.88)
3rd quartile (0.5302-0.5565)	1.33 (0.81-2.17)
4th quartile (0.5566-0.6143)	Ref.
Number of mammography devices/100,000 inhabitants	
1st quartile (0.43-1.45)	Ref.
2nd quartile (1.46-1.96)	**1.64 (1.18-2.27)**
3rd quartile (1.97-2.55)	**1.92 (1.37-2.70)**
4th quartile (2.56-3.28)	**2.78 (1.88-4.12)**

Note: OR - Odds Ratio; IC95% - 95% Confidence Interval

Table 3- Multilevel logistic regression models (OR and 95%CI) for RME in Brazil.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Fixed Effect					
Intercept (B_0; 95%CI)	-0.07 (0.25;0.10)	-1.39 (-1.77; -1.01)	-1.52 (-1.93; -1.11)	-1.56 (-1.98; -1.15)	-1.78 (-2.19; -1.36)
Contextual					
HDI					
1st quartile (0.631-0.672)			Ref.	-	-
2nd quartile (0.673-0.724)			0.87 (0.63-1.21)	-	-
3rd quartile (0.725-0.760)			**1.43 (1.03-1.99)**	-	-
4th quartile (0.761-0.824)			**1.70 (1.16-2.49)**	-	-
SDI					
1st quartile (0.5809-0.6233)			-	Ref.	-
2nd quartile (0.6234-0.6706)			-	1.03 (0.74-1.44)	-
3rd quartile (0.6703-0.7170)			-	1.29 (0.90-1.84)	-
4th quartile (0.7171-0.8179)			-	**1.84 (1.27-2.67)**	-
Number of mammography devices per 100,000 inhabitants					
1st quartile (0.43-1.45)			-	-	Ref.
2nd quartile (1.46-1.96)			-	-	**1.59 (1.16-2.16)**
3rd quartile (1.97-2.55)			-	-	**1.67 (1.21-2.30)**
4th quartile (2.56-3.28)			-	-	**2.16 (1.50-3.13)**
Individuals					
Education					
0 to 8 years		Ref.	Ref.	Ref.	Ref.
9 to 11 years old		**1.65 (1.46-1.85)**	**1.64 (1.46-1.85)**	**1.64 (1.46-1.85)**	**1.65 (1.46-1.86)**
12 or older		**2.03 (1.73-2.39)**	**2.04 (1.73-2.40)**	**2.03 (1.73-2.39)**	**2.04 (1.73-2.40)**
Marital status					
No partner		Ref.	Ref.	Ref.	Ref.
With partner		**1.24 (1.13-1.36)**	**1.24 (1.13-1.36)**	**1.24 (1.13-1.36)**	**1.24 (1.13-1.36)**
Nutritional status					
Appropriate weight		Ref.	Ref.	Ref.	Ref.
Low weight		0.78 (0.55-1.11)	0.78 (0.55-1.11)	0.78 (0.55-1.11)	0.78 (0.55-1.11)
Overweight		**1.16 (1.04-1.30)**	**1.16 (1.03-1.30)**	**1.16 (1.03-1.30)**	**1.16 (1.04-1.30)**

Obese		1.07 (0.95-1.21)	1.07 (0.95-1.21)	1.07 (0.95-1.21)	1.07 (0.95-1.21)
Physical activity practice					
No		Ref.	Ref.	Ref.	Ref.
Yes		**2.08 (1.86-2.33)**	**2.08 (1.86-2.33)**	**2.08 (1.86-2.33)**	**2.08 (1.86-2.33)**
Smoking					
Yes		Ref.	Ref.	Ref.	Ref.
Ex-smoker		**1.37 (1.17-1.60)**	**1.37 (1.18-1.61)**	**1.37 (1.17-1.61)**	**1.38 (1.18-1.61)**
Never smoked		**1.42 (1.23-1.62)**	**1.42 (1.24-1.62)**	**1.42 (1.24-1.62)**	**1.42 (1.24-1.62)**
Private health plan					
No		Ref.	Ref.	Ref.	Ref.
Yes		**2.59 (2.30-2.92)**	**2.56 (2.28-2.89)**	**2.58 (2.29-2.90)**	**2.57 (2.28-2.90)**
Random effect - σ^2 u0 - Federal Units					
Intercept variance (95%CI)	0.2141 (0.120-0.381)	0.1509 (0.082-0.276)	0.0864 (0.045-0.165)	0.0947 (0.049-0.181)	0.0785 (0.040-0.152)
Variance reduction (%)		29.5	59.6	55.8	63.3
Intraclass correlation coefficient - ICC (95%CI)	0.061 (0.035-0.103)	0.043 (0.024-0.077)	0.025 (0.013-0.047)	0.027 (0.014-0.052)	0.023 (0.012-0.044)
AIC	11670.84	10591.17	10584.27	10586.84	10582.07
BIC	11684.98	10676	10690.31	10692.88	10688.11

Notes: OR- Odds Ratio; CI95% - 95% confidence interval; HDI - Human Development Index; SDI - Sociodemographic Development Index; AIC- Akaike information criterion; BIC - Bayesian information criterion; B - beta coefficient; Model 1 - null model; Model 2 - model adjusted by individual variables; Models 3, 4 and 5 - models with the individual and contextual variables