

# Construction of a Dashboard for the Analysis of Cancer Data in the Southeast Health Macroregion of Minas Gerais

<https://doi.org/10.32635/2176-9745.RBC.2023v69n4.4285>

*Construção de um Dashboard para Análise dos Dados de Câncer na Macrorregião de Saúde do Sudeste de Minas Gerais*

*Construcción de un Dashboard para el Análisis de Datos de Cáncer en la Macrorregión de Salud del Sudeste de Minas Gerais*

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## ABSTRACT

**Introduction:** Dashboards are interactive data visualization tools that simplify large amounts of information. In the context of health, they are used in different settings, such as cancer related data in the country, although, usually, only analyzes of States and Capitals are available. **Objective:** Describe the construction of a cancer-related dashboard in the Southeast Health Macroregion of Minas Gerais (MSSMG). **Method:** Step-by-step study of the construction of an open-source code dashboard and its utilization for descriptive analysis of data related to mortality by malignant neoplasms and breast and cervical cancer screening in MSSMG between 2010 and 2019. **Results:** A dashboard was produced with official data on cancer mortality, coverage of preventive exams and socioeconomic assessment, which allows an extensive analysis for the region. Higher mortality by cancer in men was found with the utilization of this tool, and that lung cancer was the main cause of death. It was also possible to visually analyze the spatial distribution of the standardized mortality rate and the mean coverage of cervical cytology and mammography exams in the period. **Conclusion:** Creation of a comprehensive dashboard on cancer at MSSMG and sharing the results. The panel has been shown to be versatile by simplifying statistical processes and visualization, facilitating the formulation of ideas, **possibilities and offering clear and intuitive information.**

**Key words:** epidemiology; neoplasms; spatial analysis; public health; mortality registries.

## RESUMO

**Introdução:** *Dashboards* são ferramentas interativas de visualização de dados que simplificam grandes quantidades de informações. No contexto da saúde, eles são utilizados em diversas situações como em dados relativos ao câncer no país, ainda que, normalmente, haja disponibilidade somente para análise de Estados e Capitais. **Objetivo:** Descrever a construção de um *dashboard* relacionado ao câncer na Macrorregião de Saúde Sudeste de Minas Gerais (MSSMG). **Método:** Construção passo a passo de um *dashboard* com uso de código aberto e sua utilização para análise descritiva de dados relacionados à mortalidade por neoplasias malignas e exames de triagem para o câncer de mama e do colo do útero na MSSMG entre os anos de 2010-2019. **Resultados:** Foi produzido um *dashboard* com dados oficiais sobre a mortalidade por câncer, cobertura de exames preventivos e variáveis socioeconômicas, que permite uma análise extensa sobre o tema na Região. Com o uso dessa ferramenta, verificou-se que a mortalidade por câncer entre homens é elevada e o câncer de pulmão foi a principal causa de morte. Ainda foi possível analisar visualmente a distribuição espacial da taxa de mortalidade padronizada e da cobertura média do período dos exames de citologia do colo do útero e da mamografia. **Conclusão:** Criação de um *dashboard* abrangente sobre câncer na MSSMG e compartilhamento dos resultados obtidos. O painel demonstrou versatilidade ao simplificar processos estatísticos e visualizações, facilitando a formulação de ideias, hipóteses, e oferecendo informações claras e intuitivas.

**Palavras-chave:** epidemiologia; neoplasias; análise espacial; saúde pública; registros de mortalidade.

## RESUMEN

**Introducción:** *Dashboards* son herramientas interactivas de visualización de datos que simplifican grandes cantidades de información. En el ámbito de la salud, se utilizan en diferentes contextos, como datos relacionados con el cáncer en el país, aunque, normalmente, solo se dispone de análisis de Estados y Capitales. **Objetivo:** Exponer la construcción de un panel de control relacionado con el cáncer en la Macrorregión de salud del Sudeste de Minas Gerais (MSSMG). **Método:** Construcción paso a paso de un *dashboard* usando código abierto y el uso de esta herramienta para el análisis descriptivo de datos relacionados con la mortalidad por neoplasias malignas y los exámenes de detección de cáncer de mama y cuello uterino en la MSSMG entre los años 2010-2019. **Resultados:** Se elaboró un *dashboard* con datos oficiales de mortalidad por cáncer, cobertura de exámenes preventivos y evaluaciones socioeconómicas, que permite un análisis amplio sobre el tema en la región. Con el uso de esta herramienta se percibió que existe una mayor mortalidad por cáncer entre los hombres y que el cáncer de pulmón fue la principal causa de muerte. También fue posible analizar visualmente la distribución espacial de la tasa de mortalidad estandarizada y la cobertura media del período de los exámenes de citología cervical y mamografía. **Conclusión:** Creación de un *dashboard* integral sobre cáncer en la MSSMG y intercambio de los resultados obtenidos. El panel demostró versatilidad al simplificar procesos estadísticos y visualizaciones, facilitando la formulación de ideas, posibilidades y ofreciendo información clara e intuitiva.

**Palabras clave:** epidemiología; neoplasias; análisis espacial; salud pública; registros de mortalidad.

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## INTRODUCTION

Dashboards are interactive visualization tools aimed to simplify large amounts of data utilizing visual representations with summarized information as effectively as possible<sup>1</sup>. They can be utilized in innumerable settings and in health as well<sup>2,3</sup>, with different formats and functions through graphs, charts and tables, containing information of a country or small regions. Whether produced by investigators with specific finalities, they can respond to different questions with relevant information<sup>3</sup>, as the incidence of some disease or services provided by a basic health attention unit.

The COVID-19 challenges stimulated the strengthening of these tools, expanding the discussion and the opportunity of having health data within a wide temporal and geographic context, as the evolution of the pandemic in countries, metropolitan capitals and small municipalities. This background led to the construction of many types of visualization of health data, inspiring the production of dozen of dashboards and posting in the social media targeted to specific population groups for better information to the reader<sup>2,4-9</sup>.

Brazil counts with some dashboards for specific health contexts. The Health Basic Attention Information System (SISAB)<sup>10</sup> is an easy-to-access platform that offers public data about basic attention and other relevant information on the operation of a health service of a limited geographic area available to users of *e-Gestor* or *e-SUS*<sup>11,12</sup> at a specific basic unit. Easily visualized spreadsheets and charts of indicators of syphilis and HIV in addition to data related to severe acute respiratory syndrome are found in infographics produced by *Fundação Oswaldo Cruz (FIOCRUZ)*<sup>15,16</sup>.

The availability of information associated with graphic visualization eventually lead to more democratic health services and improves the perception of several contexts portrayed<sup>17</sup>. In addition, specific dashboards for each health area can help the elaboration of more effective public policies and improvement of health services offered to the population.

The population health was drastically affected by this important disease with significant impact on their quality-of-life and morbimortality. In Brazil, it caused an estimated loss of 3154.45 disability-adjusted life years (DALY) per thousand inhabitants, an age-standardized 114.52 deaths per thousand inhabitants in 2019<sup>18,19</sup> and the estimate of 704 thousand new cases for each year of the triennium 2023-2025<sup>20</sup>.

The National Cancer Institute (INCA) publishes annually comprehensive cancer data with updated estimates and a multifunctional dashboard with many

variables related to the mortality caused by this disease titled “*Atlas On-line de Mortalidade*”<sup>21</sup> (Online Mortality Atlas) developed between 1996 and 2014.

As it is a country-wide publication with descriptive analysis of States and Capitals, there are limitations when the context are health Macro and Micro Regions. Additionally, it is possible to access official municipal data related to the “*Sistema de Informação do Câncer do Colo do Útero (Siscolo)*” (Cervical Cancer Information System), “*Sistema de Informação do Câncer de Mama (Sismama)*” (Breast Cancer Information System), “*Sistema de Informação do Câncer (Siscan)*” (Cancer Information System) and “*Painel Oncologia*”<sup>22</sup> (Oncology Panel) but without the same graphic resources visualized in data panels, very useful for descriptive analysis of small regions.

The objective of this study is the production of a dashboard related to cancer mortality and screening coverage of breast and cervical cancer and other selected variables in the demographic and spatial context of the Southeast health Macroregion of the State of Minas Gerais (MSSMG), in addition to descriptive results of dashboard-based analysis. It is believed that this tool can help to provide health relevant information able to stimulate effective interventions and local context studies.

## METHOD

The process of production of a dashboard depends on several factors. Issues related to the end user, its utilization and level of complexity of the panel will be discussed. The main goal is to create content to help the end user and facilitate data analysis that otherwise would demand more time and potential risk of errors during the process. Typically, the end users are the investigators who will produce the panel, students and professionals, teachers, public in general and managers. The panel is multifunctional, as, for instance, government-level monitoring, health surveillance and methodological support in teaching classes.

Similarly, the level of complexity will be contingent upon the expertise of the creators and their technical skills in preparing appealing visualizations to help the user to analyze specific data.

It was considered the production of a tool for different end users – investigators, medical students, health professionals of the macroregion and regional/municipal managers, aimed to describe cancer mortality aspects at the region and period investigated such as demographics, specific causes, spatial distribution and description of the coverage of mammograms and colposcopy (spatial distribution). Knowing who were the users and the

proposed end use, it was possible to conceptualize which variables, statistical processing and graphic resources would be required.

Mortality data for the period, population and maps of the region were compiled with the software R Project for Statistical Computing (R)<sup>23</sup>, version 4.2.3 and the respective databases: *microdatasus* – Mortality Information System (SIM) of the National Health System (DATASUS)<sup>24</sup>; *brpop* – Instituto Brasileiro de Geografia e Estatística (IBGE)<sup>25</sup> and DATASUS<sup>26</sup>; and *geobr* – Instituto de Pesquisa Econômica Aplicada (Ipea)<sup>27</sup>. In addition, other data were obtained from public and government sites: 2010 Census (IBGE)<sup>28</sup>, coverage of basic attention (SISAB)<sup>29</sup>, coverage of health insurers (Agência Nacional de Saúde Suplementar – ANS)<sup>30</sup>, Health Management and Superintendents (DATASUS)<sup>31</sup> and screening coverage of female cancers (*Sistema de Informação Ambulatorial – SIA*)<sup>32</sup>.

Given the targeted population – health professionals – some data treatment statistical tools and graphic visualization were selected: central tendency statistics and dispersion of health indicators as mortality rates, in addition to presentation and visualization of data as tables, graphics and maps. Measures of association as standardized mortality rate (SMR) further to forms of visualization of these measures through interactive maps were utilized as well.

The quality of the final use is closely related to the tool utilized for its creation, expertise and experience of the coder. Tools as Excel, Google Spreadsheets, Google Data Studio, Microsoft Power BI and programming languages as R and Python can create similar results, depending on the users' skill<sup>1</sup>. The free-access, easy-to-reproduce collaborative language R was selected for the present study because the team was familiarized with its application which allows the optimized use of the computer memory in addition to direct access to the data.

Several libraries were utilized to construct the dashboard, the user interface and base-codes were developed within the framework of the package *shiny* and reproduced by the package *flexdashboard*. The maps and graphs were produced by the packages *ggplot2*, *ggrodges* and *mapview*, while the package *sf* was utilized for spatial processing. The package *idiverse* was applied for the whole processing and treatment of the data.

A descriptive, cross-sectional and longitudinal analysis was performed for this investigation from January 1<sup>st</sup> 2010 to December 31<sup>st</sup> 2019 for mortality data and January 1<sup>st</sup> 2008 to December 31<sup>st</sup> 2017 for coverage of preventive tests. The scope is MSSMG with 94 municipalities and 19,401.60 km<sup>2</sup>. Mortality data were obtained from the International Classification of Diseases and Related

Health Problems (ICD-10)<sup>33</sup> C00 to C97 and D46 according to the “*Indicadores e Dados Básicos de Saúde da Rede Interagencial de Informações para a Saúde*”<sup>34</sup>.

The results analyzed were: (1) mortality by all malignant neoplasms; (2) mortality by most frequent malignant neoplasms; (3) demographic distribution per sex and age and most frequent malignant neoplasms; (4) comparison of absolute frequency of 2010 and 2019 per malignant neoplasm; (5) spatial distribution of malignant neoplasms; (7) spatial distribution of coverage of mammograms and colposcopy exams.

Absolute and relative values described the results, the relative information were expressed in percent, proportional mortality ratio (PMR) or age-standardized rates and calculated per 100 thousand inhabitants. When necessary, data related to age were aggregated in five-years up to the age range of 80 years and categorized as “80+” for older than 80.

Raw rates were calculated per frequency of observations divided by the total population of the municipalities in the period. Standardized rates were calculated utilizing the new world standard population<sup>35</sup> with the package *epitools*, and the package *SpatialEpi* for deaths expected required to estimate PMR (ratio between actual and expected deaths). Screening coverage was estimated as described in an article published earlier according to INCA standards<sup>36</sup>.

The approval by the Institutional Review Board (IRB) was waived because only secondary public data were utilized in compliance with Directive 510/2016<sup>37</sup> of the National Health Council.

## RESULTS

The basic structure of the dashboard is divided in an upper navigation bar and an additional field to accommodate the visualizations and other information. There are options to choose which page to browse and grouped in selection menus if the themes are the same. Not all pages are addressed herein as there are innumerable results out the study scope (Figure 1).

The pages available are: about; dictionary; general mortality; mortality by sex; comparison per period; maps; cervix cytology coverage and mammogram coverage (Table 1).

The results are limited due to the innumerable possible variations and graphic presentations generated by variables and filters. All the available possibilities of analysis can be found at [https://jpmedeirosg.shinyapps.io/dash\\_cancer\\_rbc/](https://jpmedeirosg.shinyapps.io/dash_cancer_rbc/).

19,636 deaths by malignant neoplasms were found in the period analyzed, most of them in males (10,761) and 8,875 in females. Great part of 12,261 deaths occurred in

the second quinquennium analyzed, 2015-2019, 9,255, in 2010-2014, in older than 60 years (13,922) and 5,714 in younger than 60 years old.

### **Comparison of malignant neoplasm per sex between 2010 and 2019**

In 2010, the five main causes of deaths for men and women were bronchus and lung cancers, followed by breast, prostate, stomach and esophagus (Figure 2A). In 2019 despite bronchus and lungs continued as more frequent, breast, prostate, stomach and colon stood out (Figure 2B).

The comparison showed that bronchus and lungs continued as the main cause for men in 2010, followed by prostate, stomach, esophagus and ranked fifth, brain and pancreas with the same number of deaths (Figure 2C). This same distribution was seen in 2019 in relation to the four most frequent types, but in fifth, no specification of location. The most frequent cancers in females in 2010 were breast, bronchus and lungs, cervix, liver and intrahepatic biliary ducts, but in 2019, breast cancer is ranked first followed by colon, pancreas and no specification of location (Figure 2D).

The population pyramid shows that in the period 2010-2019, most of the deaths occurred in older than 60 years and a progressive increase of the frequency of deaths was noticed up to 56-60 years of age, similar from that age-range up to 76-80 years and highest frequency for 80 years and older (Figure 3A).

For the density graph (Figure 3B), divided in ten causes of most frequent deaths for men and women, it was noticed that the majority of the causes has distribution similar to the normal curve with asymmetry more at left or right depending on the cause. Some flat lines were observed, for instance, female esophagus and colon cancers

and an anomalous curve of male's breast cancer due to the small number of occurrences.

For the proportion of causes for both sexes (Figure 3C), in addition to the differences, it was noticed that males were more affected by nearly all the main causes, while women only for colon and pancreas cancers.

A rise of the 10-year standardized mortality rate per 100 thousand inhabitants from 50.32 to 144.94 (upper and lower values) was found when the rates of the periods were analyzed. Lower values of spatial distribution standard were noticed close to Ubá and West of the region near the border with the State of Rio de Janeiro and upper values at the East border with the same State. These results are unsupported by deeper analyzes and the visualization would potentially raise scientific questions and help further researches.

Between 2008 and 2017, the mean coverage of cervix cytology was higher than 80% mainly in regions close to Ubá and West of the region (Figure 4B). Regions with high coverage appear across the region but without perceptible visual grouping. Likewise, lower values were visually dispersed.

In this same period, mammogram coverage portrays a pattern lower than 80% in nearly the entire region, the only two cities with values above 80% were close to Ubá (Figure 4C). Western and Southern cities close to the border with the State of Rio de Janeiro appear to concentrate the worst coverage of the Region.

## **DISCUSSION**

This article presented the construction of a dashboard and an example of its utilization with results of malignant



**Figure 1.** Print screen of the first page of the dashboard

**Note:** Below the upper blue address bar there is a field to report the production of the dashboard and information offered.

**Table 1.** Description of the available pages, functions and graphic utilized

| Page                                 | Objective  | Graphic resources  |
|--------------------------------------|--|--|
| About                                | Describe the data, period analyzed, treatment of the data and authors  |  |
| Dictionary                           | What each one of the variables available for analysis mean   | Table  |
| General mortality                    | Aggregate mortality of different types of cancer for both sexes, age-ranges and periods                              | Tree map<br>Table  |
| Mortality per sex                    | Distribution of mortality of different types of cancer for both sexes, age-ranges and periods                        | Population pyramid<br>Density graph<br>Relative bar chart<br>Table |
| Comparison among periods             | Easy-to-compare periods for different types of cancer per sex, age-ranges and periods                                | Bar chart<br>Table   |
| Maps                                 | Spatial distribution of variables per microregions in the two quinquennials and decenniums analyzed                  | Maps   |
| Cytology coverage of cervical cancer | Interactive map portraying the distribution and results of the coverage of the variable with selection of the period | Map<br>Table   |
| Mammogram coverage                   | Interactive map portraying the distribution and results of the coverage of the variable with selection of the period | Map<br>Table   |

neoplasms data on the MSSMG from 2010 to 2019. These results show the versatility of methods of data visualization that allow fast modifications that otherwise would had to follow intense and repetitive processing. In addition, it analyzed a health macroregion not included in an available dashboard<sup>21</sup>, making this instrument useful to bring benefits to specific areas, usually not investigated.

The creation of a dashboard is challenging. In the process of its construction, decisions have to be taken about the final presentation of the content as when to exhibit numbers and tables and when visualizations should be presented, the interaction level allowed, how much information should be included in one page, and customization to be friendly and informative to the user<sup>1</sup>.

The end-user had to be selected, in addition to the utility and level of complexity to support decision-taking, similar to the relevance of a design of a scientific trial with research question to be eventually responded or not through the application of a previously devised method<sup>38</sup>. Therefore, the final product has a specific purpose which facilitates its production.

Interactive tables and visualizations were offered to present the data most of the times. The user can select filters and browse with the mouse to visualize numbers and additional information related in interactive visualizations. If unprocessed data are chosen, tables can

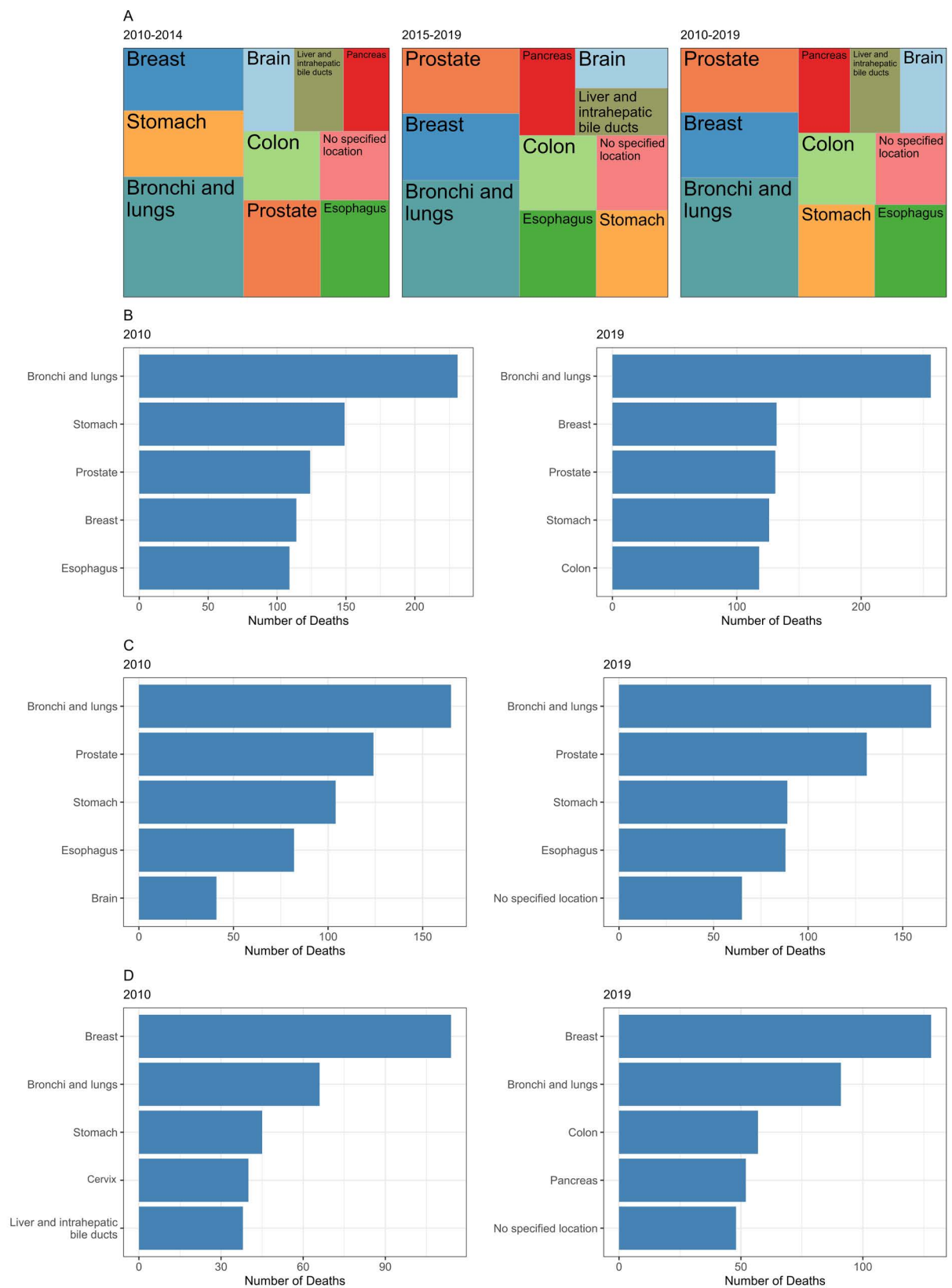
be accessed easily. Non-interactive visualizations were used only when technical limitations were found. These components highlight the dashboard's analytical nature of allowing the formulation of relevant questions and ideas for the end user<sup>1</sup>.

Similar to the world standard which excludes sex-related cancers, higher proportional mortality was found in males for all most common anatomic sites<sup>39</sup>. On MSSMG, however, colon and pancreas cancers appear more in women, curiously, because genetic, hormone and behavioral factors usually are the cause of high mortality in men<sup>40</sup>.

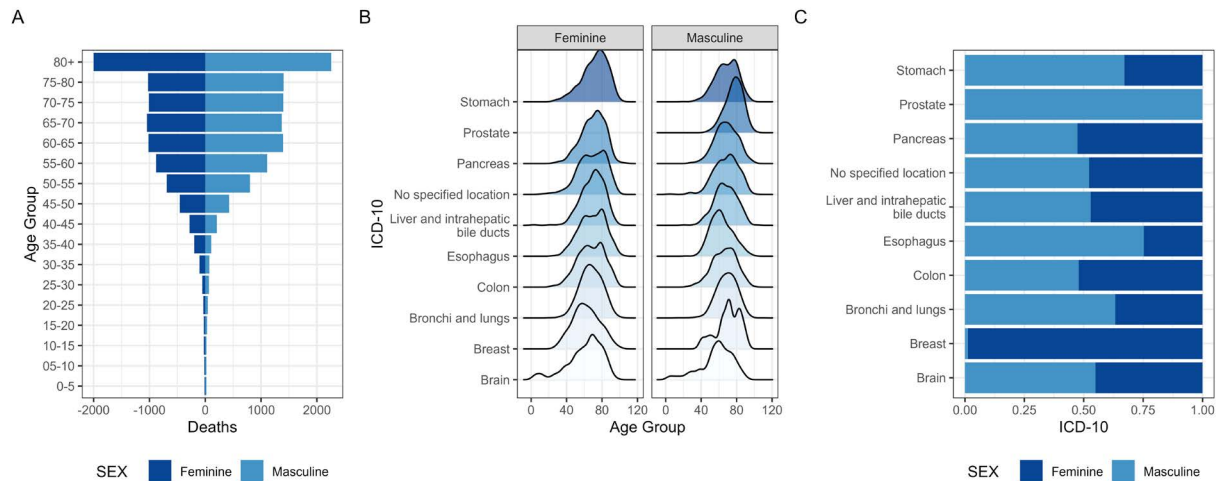
Spatial agglutination of higher or lower cancer rates in different areas lead to the necessity of studies which analyze factors associated with the spatial heterogeneity. In this case, to understand why standardized rates are concentrated in municipalities close to Ubá with lower values or higher when nearing the Region's Eastern part of the border with the State of Rio de Janeiro (Figure 4), spatial studies may be necessary<sup>41</sup>.

Likewise, it is interesting to analyze the spatial distribution of the mean of coverage of cervix cytology and mammogram in the period available and notice that many microregions with lower mortality rates have better coverage.

This pattern is seen again on microregions close to Ubá. Screening and diagnosis are closely related

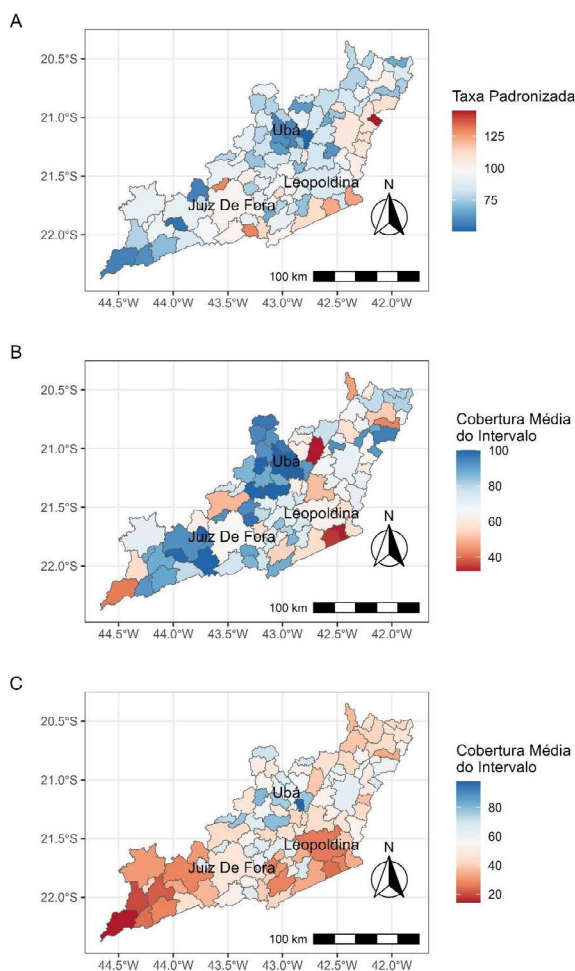


**Figure 2.** Tree map of cause of deaths per code of malignant neoplasm in 2010-2014, 2015-2019 and 2010-2019 for both sexes. Comparison between 2010 and 2019 per cause of deaths and code of malignant neoplasm (A); Both sexes (B); Male (C); Female (D)



**Figure 3.** Population pyramid of deaths by malignant neoplasms (A); graph of density of the ten main causes of deaths by malignant neoplasm and sex (B); proportion per sex of the ten main causes of death by malignant neoplasm (C)

**Caption:** ICD-10 = International Classification of Diseases and Related Health Problems – 10th edition.



**Figure 4.** Map of distribution of the standard rates of the macroregion South-Southeast of Minas Gerais 2010-2019 (A); map of the spatial distribution of coverage of preventive cervix cytology (B); mammograms between 2008 and 2017 (C)

to mortality of many malignant neoplasms<sup>42-44</sup> and although the coverage rates addressed in the present study are related to specific cancers, they are also indicative of the quality of regional health services. A good local service of primary and secondary attention is able to perform interventions that stimulate preventive measures the user should adopt through different ways, in addition to the possibility of reducing the individual risk as in obesity, diabetes *mellitus*, tobacco use and adherence to preventive exams<sup>43,45-47</sup>.

Two key aspects stand out regarding the limitations of constructing a dashboard. The first is the origin of the data and their biases whose reliability and relevance of the results achieved are narrowly related to their quality. As much as the quality and reliability of death notifications have greatly improved<sup>48</sup> as earlier mentioned, many death registers for the region in question were not locally specified, suggesting that many deaths might have been unrecorded due to errors in filling the death certificates<sup>49</sup>.

The second aspect is the non-evaluation of the final result by the user, given that feedback during and after the creation process optimizes the results and make it more relevant. To promote the use of the dashboard by managers, health professionals and students is a way to get feedback, encouraging and creating a space to receive critiques and suggestions.

Regardless of the limitations, the goal of the dashboard to offer visualizations and analyzes was achieved. The analytic nature of the panel allows to investigate deeply the data presented in addition to customization with filters, maps, graphs and organization.

The dashboard becomes an invaluable tool to explore data interactively, opening the possibility of finding patterns, trends and relations that can feed decision-taking and future actions. The panel offers a unique opportunity of investigation and deepening of the different aspects approached through manipulation and visualization of the data dynamically and helping the comprehensive understanding of the scenario in question.

Dashboards offer not only immediate insights but is a continuous source of challenges and reflections, stimulating the exploration and improvement of the knowledge about the area of interest. It encourages the progress of researches and well-founded decision-taking while stimulating the deep analysis of the data and hypothesis to be further investigated<sup>17</sup> in addition to relevant and accessible information, supporting the formulation of more effective public policies targeted to the local population.

## CONCLUSION

The creation of a dashboard containing data related to cancers on the MSSMG was described, further to some results achieved with its utilization. The selection of the end user – a simple and straightforward step – followed by the arduous process of understanding its finality and selection of the visual presentation of the data were the foundation of its production.

The panel is versatile and able to provide optimized information to the user simplifying the statistical processes further to visualizations which facilitates the formulation of ideas and hypothesis.

Despite the limitations related to the quality of the data and its correct record, in addition to the impossibility of being evaluated by other users, the dashboard has been proven to be a useful tool to explore and analyze the cancers on that region. The user is able to access and understand the facts as effectively as possible based in clear forms of presentation, minimizing the necessity of applying complex statistical processes or create visualizations from scratch.

## CONTRIBUTIONS

Both authors contributed substantially to the study design, acquisition, analysis and/or interpretation of the data, wording and/or critical review. They approved the final version to be published.

## DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

## FUNDING SOURCES

None.

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Recebido em 17/8/2023  
Aprovado em 13/11/2023