

Temporal trend, hospital mortality, and cost of hospitalizations for acute myocardial infarction and heart failure in the last 20 years

Tendência temporal, mortalidade hospitalar e custo das internações por infarto agudo do miocárdio e insuficiência cardíaca nos últimos 20 anos

Tendencia temporal, mortalidad hospitalaria y costo de las hospitalizaciones por infarto agudo de miocardio e insuficiencia cardíaca en los últimos 20 años

Received: 11/12/2025 | Revised: 11/30/2025 | Accepted: 12/02/2025 | Published: 12/04/2025

Larissa Luma Tomasi Febras

ORCID: <https://orcid.org/0000-0003-2409-0306>

Moinhos de Vento Hospital, Porto Alegre, Brazil

E-mail: larissatomasif@gmail.com

Iliane Rezer Bertão

ORCID: <https://orcid.org/0000-0003-3429-7896>

Universidade Franciscana, Brazil

E-mail: iliane_bertao@hotmail.com

Jaqueline Eilert Fagundes

ORCID: <https://orcid.org/0000-0003-3664-2673>

Instituto de Cardiologia, Porto Alegre, Brazil

E-mail: jaqueline.eilert@gmail.com

Belisa Alves Marin

ORCID: <https://orcid.org/0000-0001-7026-4413>

Moinhos de Vento Hospital, Porto Alegre, Brazil

E-mail: belisa.alves@hmv.org.br

Mauricio Santiago Soper

ORCID: <https://orcid.org/0009-0005-2446-3194>

Moinhos de Vento Hospital, Porto Alegre, Brazil

E-mail: mauriciosantiago8888@gmail.com

Sidiclei Machado Carvalho

ORCID: <https://orcid.org/0000-0001-7996-0896>

Moinhos de Vento Hospital, Porto Alegre, Brazil

E-mail: sidiclei.carvalho@hmv.org.br

Jonas Michel Wolf

ORCID: <https://orcid.org/0000-0001-7577-464X>

Moinhos de Vento Hospital, Porto Alegre, Brazil

E-mail: jonas.wolf@hmv.org.br

Abstract

Objective: To analyze the temporal trend, hospital mortality, and cost of hospitalizations for Acute Myocardial Infarction (AMI) and Heart Failure (HF) in Brazil from 2001 to 2021. **Methodology:** Ecological study based on secondary data from DATASUS, including hospitalizations for AMI and HF among individuals aged ≥ 15 years. Percentage changes and temporal trends in hospitalization, mortality, and hospital costs were calculated. **Results:** AMI hospitalizations increased by approximately 326.66% ($R^2 = 0.975$; $p < 0.001$), while HF hospitalizations decreased by more than 40% ($R^2 = 0.957$; $p < 0.001$). Mortality from AMI decreased ($p < 0.001$; $R^2 = 0.652$), whereas mortality from HF increased ($p < 0.001$; $R^2 = 0.961$). The mean hospitalization cost was R\$ 3,774.79 for AMI and R\$ 1,845.05 for HF. **Conclusion:** The observed variations in hospitalization, mortality, and cost trends reflect changes in risk factors and health care practices, emphasizing the need for continuous surveillance and public policies aimed at reducing morbidity, mortality, and economic burden associated with cardiovascular diseases.

Keywords: Myocardial Infarction; Heart Failure; Hospital Mortality; Hospital Costs; Epidemiology.

Resumo

Objetivo: Analisar a tendência temporal, a mortalidade hospitalar e o custo das internações por Infarto Agudo do Miocárdio (IAM) e Insuficiência Cardíaca (IC) no Brasil, entre 2001 e 2021. **Metodologia:** Estudo ecológico baseado em dados secundários do DATASUS, incluindo internações por IAM e IC em indivíduos com idade ≥ 15 anos. Foram calculadas as variações percentuais e a tendência temporal das taxas de internação, mortalidade e custos hospitalares. **Resultados:** As internações por IAM aumentaram em aproximadamente 326,66% ($R^2 = 0,975$; $p < 0,001$), enquanto as

internações por IC diminuíram mais de 40% ($R^2 = 0,957$; $p < 0,001$). A mortalidade por IAM reduziu-se ($p < 0,001$; $R^2 = 0,652$), enquanto a mortalidade por IC apresentou aumento ($p < 0,001$; $R^2 = 0,961$). O custo médio das internações foi de R\$ 3.774,79 para IAM e R\$ 1.845,05 para IC. Conclusão: As variações observadas nas tendências de internação, mortalidade e custos refletem mudanças nos fatores de risco e na atenção à saúde, reforçando a necessidade de vigilância contínua e políticas públicas voltadas à redução da morbimortalidade e dos custos associados às doenças cardiovasculares.

Palavras-chave: Infarto do Miocárdio; Insuficiência Cardíaca; Mortalidade Hospitalar; Custos Hospitalares; Epidemiologia.

Resumen

Objetivo: Analizar la tendencia temporal, la mortalidad hospitalaria y el costo de las hospitalizaciones por Infarto Agudo de Miocardio (IAM) e Insuficiencia Cardíaca (IC) en Brasil, entre 2001 y 2021. Metodología: Estudio ecológico basado en datos secundarios del DATASUS, incluyendo hospitalizaciones por IAM e IC en individuos de ≥ 15 años. Se calcularon los cambios porcentuales y la tendencia temporal de las tasas de hospitalización, mortalidad y costos hospitalarios. Resultados: Las hospitalizaciones por IAM aumentaron aproximadamente un 326,66% ($R^2 = 0,975$; $p < 0,001$), mientras que las hospitalizaciones por IC disminuyeron más del 40% ($R^2 = 0,957$; $p < 0,001$). La mortalidad por IAM disminuyó ($p < 0,001$; $R^2 = 0,652$), mientras que la mortalidad por IC aumentó ($p < 0,001$; $R^2 = 0,961$). El costo medio de hospitalización fue de R\$ 3.774,79 para IAM y R\$ 1.845,05 para IC. Conclusión: Las variaciones observadas en las tendencias de hospitalización, mortalidad y costos reflejan cambios en los factores de riesgo y en la atención sanitaria, destacando la necesidad de vigilancia continua y políticas públicas para reducir la morbimortalidad y los costos asociados a las enfermedades cardiovasculares.

Palabras clave: Infarto de Miocardio; Insuficiencia Cardíaca; Mortalidad Hospitalaria; Costos Hospitalarios; Epidemiología.

1. Introduction

In 2019, in Brazil, approximately 41.8% of deaths were attributed to chronic non-communicable diseases (NCDs), among which acute myocardial infarction (AMI) and heart failure (HF) stand out. These diseases require prolonged and continuous treatment, which entails a high economic and social impact, burdening individuals, families, and health systems (Brazil, 2020; Duncan et al., 2012).

The risk of developing cardiovascular diseases (CVD), such as AMI, increases progressively with age. It is estimated that, at age 30, this risk reaches approximately 50% in previously healthy individuals. AMI stands out among CVDs as the leading cause of death worldwide (Rapsomaniki et al., 2014; Benjamin et al., 2019). In 2021 alone, 3.81 million deaths from CVD were recorded, highlighting the burden of these conditions on health loss, reduced quality of life, and increased costs for healthcare systems (Duncan et al., 2012; Vaduganathan et al., 2022).

The objective of this study is to analyze the temporal variations in hospitalizations, hospital mortality rates, and the average cost of hospitalizations for AMI and HF, in Brazil, over the last two decades. The 21-year time frame was adopted considering that each of these diseases presents distinct therapeutic and evolutionary trajectories, allowing for a better understanding of their clinical and economic burden over time.

2. Methodology

This is an observational study, based on direct documental research in information systems (Pereira et al., 2018), with an ecological design. It employs descriptive statistics using data class, absolute frequency, and relative frequency in percentage (Shitsuka et al., 2014), as well as statistical analysis (Bekman & Costa Neto, 2009). The study is based on a population-based time series (Nascimento et al., 2015), using data from the Hospital Information System (SIH/SUS), available on the DATASUS platform (Department of Informatics of the Unified Health System – SUS). This national database gathers information on epidemiology, morbidity, health care, and demography in Brazil (BRASIL, 2021).

All hospitalizations for heart failure and myocardial infarction in Brazil between January 2001 and December 2021 were included for patients aged ≥ 15 years and of both sexes (male and female). These hospitalizations were categorized by the

following variables: age group, sex, average cost of hospitalization, average length of hospital stay, deaths, and mortality rate.

The collected data were tabulated in Microsoft Office Excel, version 2021, and submitted to analysis in SPSS, version 26.0. Qualitative variables were presented as absolute (n) and relative (%) frequencies, while quantitative variables were shown by the mean and standard deviation. The distribution of quantitative data was assessed using the Kolmogorov-Smirnov test with Lilliefors correction, and variances were assessed using Levene's test.

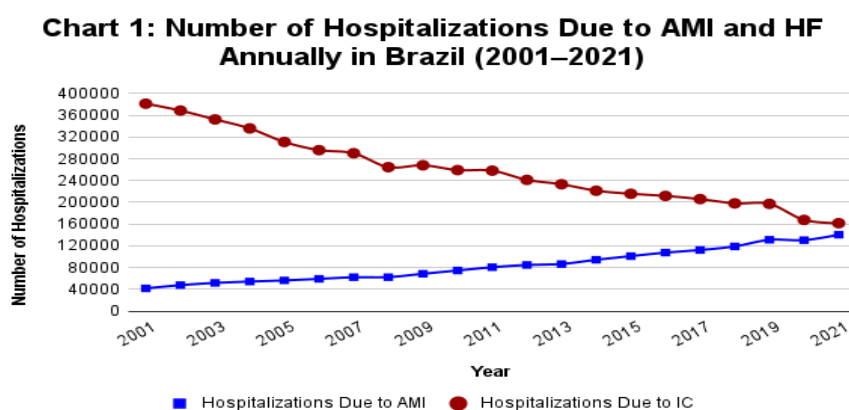
The mortality rate is calculated on the platform by the number of deaths from a specific cause, expressed per 100,000 inhabitants, occurring in a given location and period, and estimates the risk of a person dying from a selected cause. On the other hand, the average cost of hospitalization expresses the average value of resources spent by the SUS (Brazilian Public Health System) in providing hospital care, in the specialties foreseen. Variations in average values are due to the relative frequency of the types of care provided, which have differentiated remuneration.

For the temporal trend and mortality rate analyses, linear regression was used, estimating the annual variation and finding the specific years in which significant changes occurred. In the analysis of the average cost of hospitalization, the values were initially corrected according to the National Consumer Price Index (IPCA), calculated by the Brazilian Institute of Geography and Statistics (IBGE) (<https://www.ibge.gov.br/explica/inflacao.php>), which aims to measure the inflation of a set of products and services traded in the country, using July of each year as a reference period, followed by the mean and standard deviation (IBGE, 2023). Student's t-test was used to compare the mean mortality rates between sexes over the years; while the analysis of variance (ANOVA) followed by Tukey's HSD post-hoc test was applied to compare the mean mortality rates between age groups and the average cost of hospitalizations per year in each group. Pearson's correlation coefficient was used to correlate the average length of stay with the hospital mortality rate. A p-value <0.05 was considered statistically significant, and all tests employed were two-tailed.

The data from the study population do not require review/approval by the CEP-CONEP system (Ethics and Research Committee - National Ethics and Research Committee), according to Resolution No. 510, of April 7, 2016, as they involve only publicly available and unrestricted access data that do not identify the research participants.

3. Results

Between 2001 and 2021, 5,417,266 hospitalizations for heart failure were recorded in the studied population, with 51% being male and 71.68% in the 60 years or older age group. This number decreased from 381,442 in 2001 to 161,191 in 2021 (42%), observing an inverse linear behavior in the temporal analysis, where 95.7% ($R^2 = 0.957$; $p < 0.01$) of the variation in the number of hospitalizations is explained by the variation over the years, that is, over the years hospitalizations had a strong downward trend, as illustrated in Graph 1.

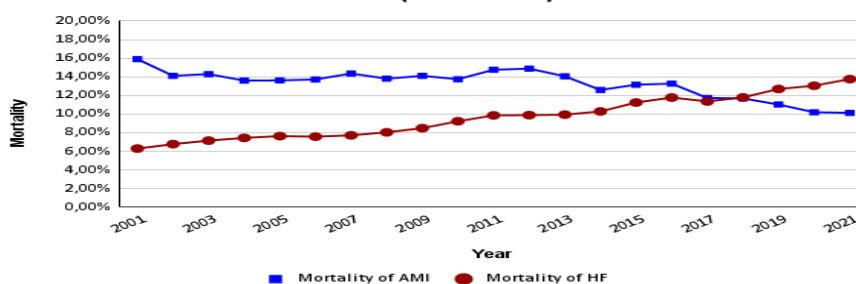


Source: Authors.

Regarding myocardial infarction, a total of 1,760,369 hospitalizations were recorded, with 63.47% being male and 74.79% in the 50 to 79 age group. These hospitalizations increased from 41,148 in 2001 to 134,412 in 2021 (326.66%), showing a direct linear behavior ($R^2 = 0.975$; $p < 0.01$), with a strong upward trend, diverging from heart failure (graph 1).

In the mortality rate analysis, heart failure (HF) showed a direct linear behavior ($R^2 = 0.961$; $p < 0.01$), with an increasing trend over the years (Graph 2), while myocardial infarction (MI) showed an inverse linear behavior ($R^2 = 0.652$; $p < 0.01$), with a downward trend during the study period, according to Graph 2.

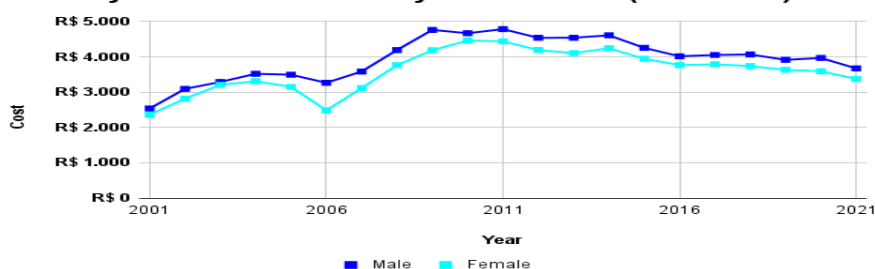
Chart 2: Mortality of Hospitalizations for AMI and HF Annually in Brazil (2001–2021)



Source: Authors.

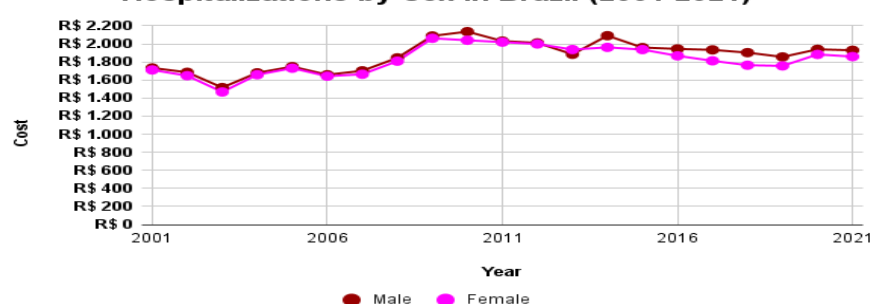
When analyzing the average cost of hospitalizations, an average value of R\$3945.12 is noted for males and R\$3604.47 for females, with MI, with 2011 being the year with the highest investment in men (R\$4785.59) and 2010 in women (R\$4462.35), as shown in Graph 3. In HF, as shown in Graph 4, we have an average of R\$1869.95 for males and R\$1820.15 for females, with 2010 (R\$2135.20) and 2009 (R\$2061.48) were among the years with the highest investment.

Chart 3: Mean Cost of Hospitalizations Related to Acute Myocardial Infarction by Sex in Brazil (2001-2021)



Source: Authors.

Chart 4: Mean Cost of Heart Failure-Related Hospitalizations by Sex in Brazil (2001-2021)



Source: Authors.

In the analysis of mortality over the years by age group, a significant difference was observed between ages in all periods studied ($p < 0.01$). In all years analyzed and for both diseases under study, the age group of 80 years or more stood out as the one with the highest mortality rate.

When we consider the average correlation between length of hospital stay and mortality, we notice a distinct pattern. Specifically, in patients aged 60 or older diagnosed with HF, a strong positive correlation was observed ($p < 0.01$). This indicates that, in this age group, an increase in length of stay is associated with a higher mortality rate.

However, this trend did not remain consistent when analyzing AMI. The correlation between length of stay and mortality was not statistically significant in all periods studied for this specific disease. This points to significant differences in mortality between age groups over the years and also to the importance of length of hospital stay as a predictive factor, especially in older patients with Heart Failure.

4. Discussion

This observational study identified several epidemiological particularities between AMI and heart failure (HF). The variables analyzed included gender, age group, number of hospitalizations, mortality, and associated costs, considering the evolution of these parameters over time.

Other studies demonstrate that in the development of CVD, factors such as age and gender have a significant impact. As described by Oliveira et al. (2024) and Soares et al. (2024), both sexes show an increasing tendency towards the occurrence of CVD with advancing age. However, from the age of 44, men begin to present a higher risk, with a marked increase in incidence rates (Oliveira et al., 2024; Soares et al., 2024). Data obtained in this study revealed that men also have a higher frequency of hospitalizations and mortality associated with AMI and HF, especially in the older age groups.

Regarding the demographic profile, it is noticeable that there is a higher proportion of men hospitalized, something already reported in other studies that observed a higher prevalence of cardiomyopathy and myocarditis in male individuals (Nascimento et al., 2019; Soares et al., 2024). Additionally, a higher incidence was observed in the age group above 50 years, with an estimated 33% of men and 28% of women affected by heart failure from the age of 55 onwards (PORTO et al., 2023).

Other risk factors that contribute to the development of heart failure (HF) and myocardial infarction (MI) include sedentary lifestyle, stress, increased abdominal circumference, family history of cardiovascular disease (CVD), overweight, dyslipidemia, and alcohol consumption (Troncoso et al., 2018). Furthermore, other studies report not only an increase in the incidence of these conditions over time, but also project that this trend will continue to grow (Nilson et al., 2022). Our data partially corroborate these findings, as an increase in deaths resulting from hospitalizations for HF and hospitalizations for MI is observed, but not in deaths related to hospitalizations for MI. Further studies are needed to elucidate this discrepancy.

Ischemic heart disease is one of the main causes of heart failure; however, our study did not show a direct relationship between the two diseases, which may be justified by advances in the treatment of cardiac ischemia, such as pharmacological and interventional therapies. Therefore, survival rates have increased and the risk of recurrent ischemic events has decreased, particularly due to the widespread adoption of reperfusion therapy (Gioppatto et al., 2024).

Even with the decrease in the number of hospitalizations between 2008 and 2019, heart failure still accounted for one-third of hospitalizations due to cardiovascular disease. With a 32% increase in costs, it was also the leading cause of heart disease expenditure in Brazil (Oliveira et al., 2022). This decrease in hospitalizations is largely due to the implementation of public policies, the expansion of health networks, the expansion of Primary Health Care (PHC), and easier access to these services (Santos; Viela & Oliveira, 2021).

Between 2001 and 2021, the mortality rate from heart failure (HF) in the country showed a significant increase, rising from 6.58% to 13.7%. Studies show a relationship between poor adherence to treatment and hospitalization for HF (Albuquerque et al., 2024), as well as an association between decompensated HF and death (Rohde et al., 2018), which can contextualize this statistical increase. These factors contribute to placing Brazil among the countries with the highest rates of HF mortality in the Western Hemisphere (Ciapponi et al., 2016).

Heart failure (HF) is a chronic and progressive disease, the condition of which can worsen due to various other comorbidities. Readmissions due to acute exacerbations, relatively common among patients, generally occur due to poor adherence to care and poor medication management, leading to complications. Patients admitted with HF already have a long average length of stay, reaching 9.5 days (SD=16.1), and readmissions are associated with an even longer stay (Borges et al., 2023).

A strong correlation was also found between average length of stay and mortality rate in heart failure. This finding suggests that the length of hospital stay may be a significant indicator of the severity of the condition and the risk of complications and death. Heart failure patients with a longer average length of stay likely have a more severe clinical picture, requiring a longer period of intensive care and treatment (Souza et al., 2018).

Currently, there are validated applications that can help in living with heart failure, among which we can mention "Tum Tum". Although it is under development, it promises to be able to provide educational guidance, resources for recognizing signs of clinical decompensation, a record for monitoring body weight, reminders for medication use, and a schedule of appointments and exams, having demonstrated potential to promote better self-care (Souza et al., 2022).

Regarding AMI (Acute Myocardial Infarction), studies show a prevalence in men between 60 and 80 years of age, while in women the incidence of diagnosis has been shown to occur at a more advanced age. Regarding deaths, approximately 42% of male patients die from AMI before the age of 65, almost double the rate for female patients, of whom 22.7% die (Troncoso et al., 2018).

Regarding healthcare costs, it is observed that treatment for AMI (Acute Myocardial Infarction) has high costs, being the pathology with the highest government investment, even when compared to the costs of HF (Oliveira et al., 2022). The average cost involved in the hospitalization process is R\$ 3,774.79. Common procedures throughout the care process, such as Doppler echocardiography, can lead to an increase of 2% to 6.7% when performed before percutaneous coronary intervention or during surgery (respectively) (Marques et al., 2012). It is possible that the economic impacts are even greater, exceeding 700 million reais when considering costs beyond care, since the patient's prognosis involves a reduction in their productivity and, sometimes, death (Melo et al., 2024).

On December 13, 2011, the AMI care pathway and the acute coronary syndrome protocol were approved through Ordinance No. 2,994. This document provided universal access to procedures, medications, orthoses, prostheses, and special materials within the SUS (Brazilian Unified Health System), also guaranteeing coronary angioplasty (BRASIL, 2011). The effects of this change were observed in the significant increase in procedures performed; non-primary angioplasty procedures doubled, while primary angioplasty procedures increased by 31% (Oliveira et al., 2022). Our data indicate that this policy may have positively influenced the outcomes of many patients, as a reduction in mortality from AMI has been observed since 2012, from 15.30% to 10.29% in 2021.

New technologies are emerging with the goal of increasing the quality of care offered. One example is SAFE HEART, which was conceived and developed by a team of nurses with the purpose of identifying potential risks of AMI (Acute Myocardial Infarction), using a smartwatch to monitor and record cardiac activity (Souza et al., 2021).

Even considering these findings, the present study cannot establish a causal relationship between them. Additionally, given the way the data is stored, it is not possible to analyze each patient individually. Nevertheless, it is possible to obtain a general overview of the costs and mortality associated with AMI and HF in Brazil.

5. Conclusion

This study concludes that the data show the progress of care, but also how much remains to be achieved. Attention to preventive efforts, improvements in screening, diagnosis and early treatment of these diseases and their exposed risk factors are all pertinent choices to avoid more deaths.

Acknowledgments

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

- Albuquerque, D. C. de, Barros e Silva, P. G. M. de, Lopes, R. D., Hoffmann-Filho, C. R., Nogueira, P. R., Reis, H., Nishijuka, F. A., Martins, S. M., Figueiredo Neto, J. A. de, Pavanello, R., Souza Neto, J. D. de, Danzmann, L. C., Gemelli, J. R., Rohde, L. E. P., Hernandez, M. E., Rivera, M. A. M., Simões, M. V., Santos, E. S. dos, Canesin, M. F., Zilli, A. C., Nakagawa Santos, R. H., Jesuino, I. de A., Mourilhe-Rocha, R., Moura, L. Z., Marcondes-Braga, F. G., & Mesquita, E. T. (2024). In-hospital management and long-term clinical outcomes and adherence in patients with acute decompensated heart failure: Primary results of the first Brazilian Registry of Heart Failure (BREATHE). *Journal of Cardiac Failure*, 30(5), 639–650. <https://doi.org/10.1016/j.cardfail.2023.08.014>.
- Bekman, O. R. & Costa Neto, P. L. O. (2009). *Análise estatística da decisão* (2ª ed.). Editora Blucher.
- Benjamin, E. J., Muntner, P., Alonso, A., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Das, S. R., Delling, F. N., Djousse, L., Elkind, M. S. V., Ferguson, J. F., Fornage, M., Jordan, L. C., Khan, S. S., Kissela, B. M., Knutson, K. L., Kwan, T. W., Lackland, D. T., Lewis, T. T., Lichtman, J. H., Longenecker, C. T., Loop, M. S., Lutsey, P. L., Martin, S. S., Matsushita, K., Moran, A. E., Mussolino, M. E., O'Flaherty, M., Pandey, A., Perak, A. M., Rosamond, W. D., Roth, G. A., Sampson, U. K. A., Satou, G. M., Schroeder, E. B., Shah, S. H., Spartano, N. L., Stokes, A., Tirschwell, D. L., Tsao, C. W., Turakhia, M. P., VanWagner, L. B., Wilkins, J. T., Wong, S. S., & Virani, S. S. (2019). Heart disease and stroke statistics—2019 update: A report from the American Heart Association. *Circulation*, 139(10), e56–e528. <https://doi.org/10.1161/CIR.0000000000000659>.
- Borges, M. M., Custódio, L. A., Cavalcante, D. F. B., Pereira, A. C., & Carregaro, R. L. (2023). Custo direto de internações hospitalares por doenças crônicas não transmissíveis sensíveis à atenção primária em idosos. *Ciência & Saúde Coletiva*, 28(1). <https://doi.org/10.1590/1413-81232023281.08392022>.
- Brasil, Ministério da Saúde. Banco de dados do Sistema Único de Saúde-DATASUS. Disponível em <https://datasus.saude.gov.br/>. Acesso em 12 de julho de 2021.
- Brasil, Ministério da Saúde. (2011, 13 de dezembro). Portaria nº 2.994, de 13 de dezembro de 2011. http://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2994_15_12_2011.html.
- Ciapponi, A., Alcaraz, A., Calderón, M., Matta, M. G., Chaparro, M., Soto, N., & Bardach, A. (2016). Burden of heart failure in Latin America: A systematic review and meta-analysis. *Revista Española de Cardiología (English Edition)*, 69(11), 1051–1060. <https://doi.org/10.1016/j.rec.2016.04.054>.
- Gioppatto, S., Prado, P. S., Elias, M. A. L., Carvalho, V. H. de, Paiva, C. R. da C., Alexim, G. de A., Reis, R. T. B., Nogueira, A. C. C., Soares, A. A. de S. M., Nadruz, W., Carvalho, L. S. F. de, & Sposito, A. C. (2024). O impacto clínico e econômico do atraso na terapia de reperfusão: Evidências do mundo real. *Arquivos Brasileiros de Cardiologia*, 121(5), e20230650. <https://doi.org/10.36660/abc.20230650>.
- IBGE – Instituto Brasileiro de Geografia e Estatística. Índice Nacional de Preços ao Consumidor Amplo. Disponível em <https://www.ibge.gov.br/explica/inflacao.php>. Acesso em 02 de janeiro de 2023.
- IBGE – Instituto Brasileiro de Geografia e Estatística. (n.d.). Inflação: Explica IBGE. <https://www.ibge.gov.br/explica/inflacao.php>.
- Marques, R., Mendes, A., Leite, M. G., Estela C. B. (2012). Costs of the chain of treatment procedures in acute myocardial infarction in Brazilian reference and specialized hospitals. *Revista da Associação Médica Brasileira*, 58(1), 104–111. <https://doi.org/10.1590/S0104-42302012000100022>.
- Melo, A. L. A. S., Santos, J. B. C. P., Pessoa, G. D., Resende, C. D. G., Costa, T. G. R., Abreu, F. T. de, Souza Júnior, O. A. de, Dalla Rosa, A. C., Ross, F. S., Schelbauer, G. T., Borges, A. C. B., Ribeiro, P. A., & Lima, B. A. A. (2024). Impacto do infarto agudo do miocárdio na saúde pública: Desafios e estratégias de intervenção. *Revista Contemporânea*, 4(4), e3843. <https://doi.org/10.56083/RCV4N4-090>.
- Ministério da Saúde. (2020). *Vigitel Brasil 2020*. <https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/vigitel/relatorio-vigitel-2020-original.pdf/view>.
- Nascimento, B. R., Brant, L. C. C., Naback, A. D. N., Veloso, G. A., Polanczyk, C. A., Ribeiro, A. L. P., Malta, D. C., Ferreira, A. V. L., & Oliveira, G. M. M. (2022). Carga de doenças cardiovasculares atribuível aos fatores de risco nos países de língua portuguesa: Dados do estudo “Global Burden of Disease 2019”. *Arquivos Brasileiros de Cardiologia*, 118(6), 1028–1048. <https://doi.org/10.36660/abc.20210680>.

Nascimento E. G. S., Tavares, O., Shitsuka, R., de Souza A. F. (2015). Um algoritmo baseado em técnicas de agrupamento para detecção de anomalias em séries temporais. In: Estudos e Práticas de Aprendizagem de Matemática e Finanças com Apoio de Modelagem (pp.155-186). 1Chapter. Publisher: Ciência Moderna. https://www.researchgate.net/publication/292078932_Um_algoritmo_baseado_em_tecnicas_de_agrupamento_para_deteccao_de_anomalias_em_ser_ies_temporais.

Nilson, E. A. F., Gianicchi, B., Ferrari, G., & Rezende, L. F. M. (2022). *The projected burden of non-communicable diseases attributable to overweight in Brazil from 2021 to 2030*. *Scientific Reports*, 12, Article 22483. <https://doi.org/10.1038/s41598-022-26585-4>.

Oliveira, G. M. M., Brant, L. C. C., Polanczyk, C. A., Malta, D. C., Biolo, A., Nascimento, B. R., Souza, M. F. M., De Lorenzo, A. R., Fagundes Júnior, A. A. de P., Schaan, B. D., Castilho, F. M. de, Cesena, F. H. Y., Soares, G. P., Xavier Junior, G. F., Barreto Filho, J. A. S., Passaglia, L. G., Pinto Filho, M. M., Machline-Carrion, M. J., Bittencourt, M. S., Pontes Neto, O. M., Villela, P. B., Teixeira, R. A., Sampaio, R. O., Gaziano, T. A., Perel, P., Roth, G. A., & Ribeiro, A. L. P. (2022). Estatística cardiovascular – Brasil 2021. *Arquivos Brasileiros de Cardiologia*, 118(1), 115–373. <https://doi.org/10.36660/abc.20211012>.

Oliveira, G. M. M., Brant, L. C. C., Polanczyk, C. A., Malta, D. C., Biolo, A., Nascimento, B. R., Souza, M. F. M., De Lorenzo, A. R., Fagundes Júnior, A. A. P., Schaan, B. D., Silva, C. G. S. e, Castilho, F. M., Cesena, F. H. Y., Soares, G. P., Xavier Junior, G. F., Barreto Filho, J. A. S., Passaglia, L. G., Pinto Filho, M. M., Machline-Carrion, M. J., Bittencourt, M. S., Pontes Neto, O. M., Villela, P. B., Teixeira, R. A., Stein, R., Sampaio, R. O., Gaziano, T. A., Perel, P., Roth, G. A., & Ribeiro, A. L. P. (2024). Estatística cardiovascular – Brasil 2023. *Arquivos Brasileiros de Cardiologia*, 121(2), e20240079. <https://doi.org/10.36660/abc.20240079>.

Pereira, A. S., Shitsuka, D. M., Parreira, F. J., & Shitsuka, R (2018). Metodologia da pesquisa científica. [free ebook]. Santa Maria: Editora da UFSM.

Porto, J. D. S., Pina, G. C., Boaventura, D. D., Maranhão, M. M., Figueiredo, A. V. S. M. V., Junqueira Filho, M. C., Inácio, G. P., Carneiro, T. P., Sá, L. S. F. de, Soerger, M., Guerra, R. F. O., Silva, V. H. N. da, & Quinzani, B. de F. (2023). Aspectos sociodemográficos e clínicos de pacientes com insuficiência cardíaca. *Brazilian Journal of Health Review*, 6(5). <https://doi.org/10.34119/bjhrv6n5-560>.

Rapsomaniki, E., Timmis, A., George, J., Pujades-Rodriguez, M., Shah, A. D., Denaxas, S., White, I. R., Caulfield, M. J., Deanfield, J. E., Smeeth, L., Williams, B., Hingorani, A., & Hemingway, H. (2014). Blood pressure and incidence of twelve cardiovascular diseases: Lifetime risks, healthy life-years lost, and age-specific associations in 1.25 million people. *The Lancet*, 383(9932), 1899–1911. [https://doi.org/10.1016/S0140-6736\(14\)60685-1](https://doi.org/10.1016/S0140-6736(14)60685-1).

Rohde, L. E. P., Montera, M. W., Bocchi, E. A., Clausell, N. O., Albuquerque, D. C. de, Rassi, S., Colafranceschi, A. S., Freitas Júnior, A. F. de, Ferraz, A. S., & Barretto, A. C. P. (2018). Diretriz brasileira de insuficiência cardíaca crônica e aguda. *Arquivos Brasileiros de Cardiologia*, 111(3), 436–539. <https://doi.org/10.5935/abc.20180190>.

Santos, S. C., Villela, P. B., & Oliveira, G. M. M. (2021). Mortalidade por insuficiência cardíaca e desenvolvimento socioeconômico no Brasil, 1980 a 2018. *Arquivos Brasileiros de Cardiologia*, 117(5), 944–951. <https://doi.org/10.36660/abc.20200902>.

Shitsuka, R., Shitsuka R. I. M. C., Shitsuka, D. M., Shitsuka C. D. W. M. (2014). Matemática fundamental para tecnologia. (2ed). Editora Érica.

Sousa, M. M., de, Lopes, C. T., Almeida, A. A. M., Almeida, T. da C. F., Gouveia, B. de L. A., & Oliveira, S. H. dos S. (2022). Desenvolvimento e validação de aplicativo móvel para o autocuidado de pessoas com insuficiência cardíaca. *Revista da Escola de Enfermagem da USP*, 56. <https://doi.org/10.1590/1980-220X-REEUSP-2022-0315pt>.

Souza, M. R. de, Oliveira, M. L. C. de, Barbosa, E. M. C., Menezes, E. G., Araújo, G. S. de, Nascimento, S. M., & Carvalho, D. B. M. de F. (2021). Validação de conteúdo: Aplicativo móvel SAFE HEART para monitoramento e identificação de risco de infarto. *Revista Baiana de Enfermagem*, 35. <https://doi.org/10.18471/rbe.v35.44403>.

Souza, S. C. de, Silva e Silva, C. M. da, Reis, H. F. C. dos, & Neto, M. G. (2018). Número de internações hospitalares, custos hospitalares, média de permanência e mortalidade por insuficiência cardíaca nas regiões brasileiras, no ano de 2017. *Revista de Ciências Médicas e Biológicas*, 17(3). <https://doi.org/10.9771/cmbio.v17i3.28626>.

Troncoso, L. T., Oliveira, N. C. C., Leporaes, R. A., Eira, T. L., & Pinheiro, V. P. (2018). Estudo epidemiológico da incidência do infarto agudo do miocárdio na população brasileira. *Cadernos da Medicina*, 1(1).

Vaduganathan, M., Mensah, G. A., Turco, J. V., Fuster, V., Roth, A. G. (2022). The global burden of cardiovascular diseases and risk. *Journal of the American College of Cardiology*, 80(25), 2361–2371. <https://doi.org/10.1016/j.jacc.2022.10.014>.