Prevalence and Economic Impact of Acute Myocardial Infarction in the Brazilian Public Health System: Care and Economic Analysis and the Impacts of the Coronavirus Disease

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Abstract

Background

This study aimed to describe the general and specific context of hospitalizations for acute myocardial infarction (IAM) in the Brazilian public health system and its main indicators of economic care in the pre- and post-coronavirus-disease (COVID-19) period.

Methods

The main assistance and economic indicators of care related to IAM, together with the Brazilian public health system, were evaluated in the period between January 2011 and April 2021, comparing the pre- and post-pandemic indicators. The research figures were descriptive and exploratory, using data from the Ministry of Health. The main data evaluated were lethality, number of hospitalizations, average length of hospital stay, and hospitalization costs. The ARIMA and general regression models were used to analyze the monthly outcomes pre and post COVID-19, thus enabling the alteration of care and economic behavior of IAM cases with the public health system.

Results

Hospitalization for IAM has been on the rise for the past 10 years, with a slight decrease after COVID-19. There was an equally slight increase in lethality, with a significant decrease in the mean length of stay of hospitalized patients. The economic aspects of IAM show that more than US\$ 762 million were invested during the reporting period. The average ticket presents a clear decrease in investment per capita, with a real devaluation of 70.04% in the period from 2011 to April 2021, which may be related to two main hypotheses: (1) increased effectiveness and (2) cost analysis of the effectiveness of care and/or chronic underfunding of the Brazilian public health system.

Conclusions

There was a historical increase in hospitalizations and a reduction in IAM-related deaths.

1. Introduction

Brazil covers a surface area of 8.5 million km^2 and has a population of approximately 211 million people.[1,2] Its health system comprises the state segment implemented through the Unified Health System (SUS) and the private sector.[3] Created in 1988,[5] with constitutional provision, the SUS serves approximately 76% of the Brazilian population,[7,10] which, despite its historical achievement in coverage and access, suffers strongly due to chronic underfunding.[4,6] Currently, the Unified Health System has

5,161 general hospitals,[8,9] 1,045 specialized hospitals,[8] and 9,935 basic health units,[13] thus covering 239,329 clinical beds,[13] 204,874 surgical beds,[13] and 514,004 medical professionals.[13]

The country faces great challenges in the field of health care,[4] partially because of the intense socioeconomic inequality (Gini Index, 50.9).[5,6] In this context, cardiology has a high prevalence of care in SUS. The specialty, together with SUS, has a total of 15,624 cardiologists and 1,147 cardiovascular surgeons, 4,583 clinical beds, and 3,091 surgical beds, and it performed over 115,299,459 hospitalizations (from January 2011 to April 2021), of which 1,087,901 were linked to acute myocardial infarction (IAM).[13]

In this context, the central objective of this research was to understand the specific context of IAM with the Brazilian public health system and its main indicators of assistance and economics, as well as the impact of COVID-19.

2. Methods

This descriptive and exploratory study used secondary data from the following official sources: TAbnet,[13] IBGE,[1,21] IPEADATA,[2] Anahp,[9] Agência Nacional de Saúde,[10] and Trading Economics.[11] Data were subjected to quantitative analysis. In addition, this study examined the history of IAM in the Brazilian public health system during the last decade.

A descriptive statistical analysis was performed, which allowed us to understand the historical series of evolution of cardiology, more specifically IAM, highlighting for each of the states of the Federation, from January 2011 to April 2021, the following: lethality, number of hospitalizations, average hospital stay rate, average ticket paid by SUS, and total payments.

The analysis of the average ticket was performed considering its nominal value, and it was corrected by the General Index of Brazilian Consumer Prices in Health (IPCA—Health),[2] thus enabling the comparison of not only the historical series in its value, but also its ability to convert into value over time.

Following the experience of research carried out in cardiology,[22] para the comparative analysis between the pre-and post-COVID-19 periods and for the analysis of interrupted time series, data were summable, disregarding the Federative Unit, and demonstrated as monthly measures. Monthly hospitalizations were relativized by 100,000 inhabitants in Brazil. The permanence data represent a monthly average on days when the patient remained hospitalized; the lethality rate represents the monthly average of deaths by active patients; and the average monthly ticket, which portrays the financial value (in dollars) received by hospitals for each hospitalization related to heart failure.

An analysis of interrupted time series (STI) was performed to estimate the changes in the levels and trends of the variables studied, caused by the emergence of coronavirus at the national level. The cut-off point was defined in the months of March–April 2020, separating previous data from the pre-COVID-19

period, and the subsequent data from the COVID-19 period. The ARIMA method was used to model the time series. The overall regression model for analyzing outcomes monthly can be described as

$$Y_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 T X_t,$$

where β_0 is the initial level when $T = 0$, β_1 is the tendency of the outcome related to the increase of the time units, β_2 corresponds to the change in level after the beginning of the pandemic, and β_3 indicates the change in the monthly trend. Descriptive analyses of the variables, normality tests, and comparisons between periods with the Student or Mann–Whitney tests were also performed, according to the distribution of the variables. The analyses were performed using the SPSS 25.0 program, and the graphs were elaborated in Microsoft Excel. Statistical significance for all tests was defined as a p-value < 0.05.

3. Results

Descriptive analysis: Hospitalization, permanence, lethality, and expenses.

The IAM showed a significant increase in the number of hospitalizations in the last decade, with stability from the advent of the pandemic. As noted in Table 1, in 2011, a total of 81,446 hospitalizations were recorded nationwide, increasing to 132,614 in 2019. More specifically, in 2020, reaching 129,710 cases with a downward trend curve for 2021, which until April had a total of 30,737 cases, with a monthly average of 7,684 cases, 28.91% lower than the monthly average of 2020.

Observing the nominal values in relation to the population, there was an increase of 41.43 cases per 100,000 inhabitants in 2011 to 61.26 cases per 100,000 inhabitants in 2020, making a significant increase of 47.86% (Table 1).

Table 1
Historical series of IAM hospitalizations from 2011 to 2020 for every
100,000 inhabitants

Year	Admissions	Population	Percentage (%)	100 Habits
2011	81,446	196,589,921	0.04%	41.43
2012	85,309	198,310,734	0.04%	43.02
2013	87,462	200,033,072	0.04%	43.72
2014	96,068	201,752,062	0.05%	47.62
2015	101,539	203,462,824	0.05%	49.91
2016	108,527	205,160,483	0.05%	52.90
2017	114,053	206,840,164	0.06%	55.14
2018	120,436	208,496,988	0.06%	57.76
2019	132,614	210,126,079	0.06%	63.11
2020	129,710	211,722,560	0.06%	61.26

Observing the historical series of IAM hospitalizations by state of the Brazilian federation, the general behavior of Brazil was repeated in all regions, without exceptions, thus demonstrating the evident increase in prevalence, considering the data presented in Figure 1.

Although the history of hospitalizations from IAM with the Brazilian Unified Health System shows a significant increase, the rate of permanence of hospitalized patients is within a range of little elasticity. As shown in Graph 2, in 2011, the rate of permanence of hospitalized patients with IAM was 6.72 days on average, reaching a period of 7.60 days in 2018, with a decrease from 2020, which has an average of 6.92 days, and 5.51 in 2021 (data until April).

When observing this historical series of permanence by the states of Brazilian Federation, the general data for the country are presented differently across the states. Thus, Mato Grosso do Sul, Paraná, Roraima, and Sergipe are increasing throughout the study period. All other states follow the national trend and show a reduction in the length of stay from 2020 to 2021. Table 2 presents in blue the periods of increasing permanence, and in yellow, the periods of decreasing permanence.

Table 2
Historical series of average rate of IAM permanence by states of the
Federation from 2011 to April 2021

States	2011	2015	2019	2020	*2021
Acre	7. 22	11. 86	9. 51	7. 38	6. 65
Alagoas	6. 54	7. 25	8. 76	9. 37	6. 80
Amapá	8. 43	8. 52	8. 31	8. 38	3. 65
Amazon	8. 54	10. 83	11. 57	10. 90	9. 66
Bahia	8. 77	9. 95	8. 66	8. 29	7. 03
Ceará	6. 97	8. 35	8. 25	10. 48	7. 89
Federal District	16. 70	11. 87	12. 24	14. 20	10. 78
Holy Spirit	7. 82	7. 90	7. 77	5. 91	4. 66
Goias	4. 34	4. 51	4. 84	5. 47	4. 75
Marana	4. 79	9. 10	11. 35	10. 86	8. 23
Mato Grosso	6. 13	7. 92	6. 40	6. 28	5. 24
Mato Grosso do Sul	4. 67	5. 00	5. 87	6. 30	6. 58
Minas Gerais	6. 59	6. 59	7. 27	7. 03	5. 98
Stop	6. 01	6. 94	7. 23	8. 55	3. 85
Paraiba	4. 60	4. 35	6. 02	7. 08	5. 60
Paraná	4. 36	4. 72	5. 08	4. 94	5. 46
Pernambuco	7. 73	9. 52	11. 11	10. 09	10. 50
Piaui	4. 44	6. 45	6. 55	4. 10	2. 00
Rio de Janeiro	9. 76	12. 25	13. 26	11. 60	8. 85
Rio Grande do Norte	8. 21	9. 48	10. 25	8. 52	7. 74
Rio Grande do Sul	6. 40	6. 98	7. 75	7. 56	6. 80
Rondonia	4. 80	6. 95	9. 42	9. 63	7. 49
Roraima	7. 17	7. 95	10. 22	12. 25	12. 76
Santa Catarina	6. 90	8. 08	6. 60	8. 24	5. 40
Sao Paulo	9. 13	9. 63	9. 49	8. 84	7. 43

* Corresponding to data until April 2021

States	2011	2015	2019	2020	*2021
Sergipe	5. 33	6. 70	10. 38	10. 77	11. 31
Tocantins	5. 24	5. 68	6. 13	5. 62	2. 10
* Corresponding to data until April 2021					

Among the probable explanations of the relevant differences between the states of the Brazilian Federation, the structural differences in resources for health care and care protocols represent the central hypothesis.[12]

Regarding the IAM lethality, COVID-19 promoted a significant increase in mortality worldwide;[15] in addition to the increase of deaths from the pandemic, several countries also observed a significant increase in deaths from cardiovascular diseases.[15] The lethality of IAM decreased from 2011 (14.77%) to 2019 (10.69%), with percentage stability in 2020 (10.69%) and a small increase in 2021 (January to April: 11.15%). Among the probable hypotheses, the historical decrease followed by stability and the small post-COVID-19 increase, it is possible to highlight the decrease or delay of the population's demand for assistance in cases of lower severity, as well as the dedicated allocation of health structures for exclusively COVID-19 cases in 2020 and 2021. Graph 3 shows the historical series of IAM mortality rates from 2011 to April 2021.

When observing this historical series of the IAM mortality rate, one can notice a historical decrease in lethality in almost all states from 2011 to 2019, except for Ceará, Maranhão, and Paraíba. By descriptively analyzing the pre- and post-COVID-19 period, it is possible to identify that most states, following national trends, had a small worsening of lethality from 2020, whose statistical analysis is presented in the article. The state-specific data are shown in Table 3.

Table 3
Historical series of IAM lethality rate by states of the Federation from 2011 to April 2021

States	2011	2015	2019	2020	*2021
Acre	27.70%	22.75%	19.67%	15.78%	30.36%
Alagoas	19.62%	17.13%	16.01%	13.41%	19.81%
Amapá	6.19%	17.69%	9.77%	14.79%	6.67%
Amazon	10.72%	10.41%	10.51%	12.57%	7.00%
Bahia	13.81%	12.23%	10.59%	11.30%	10.82%
Ceará	10.26%	12.73%	13.67%	13.69%	11.21%
Federal District	9.84%	11.78%	3.58%	3.42%	4.04%
Holy Spirit	12.84%	8.57%	5.60%	7.17%	5.95%
Goias	11.97%	11.98%	8.92%	8.12%	7.26%
Maranhao	13.08%	15.32%	12.15%	15.24%	16.60%
Mato Grosso	19.81%	13.96%	10.67%	8.73%	8.67%
Mato Grosso do Sul	14.62%	13.33%	11.71%	9.43%	11.76%
Minas Gerais	10.20%	9.32%	8.11%	8.16%	7.55%
Stop	16.81%	14.23%	12.02%	10.18%	11.16%
Paraiba	18.36%	8.32%	11.51%	20.27%	17.35%
Paraná	13.47%	13.17%	10.93%	11.26%	10.55%
Pernambuco	12.00%	10.24%	9.91%	9.81%	10.88%
Piaui	14.53%	9.29%	7.17%	6.47%	4.94%
Rio de Janeiro	14.05%	15.06%	12.28%	11.86%	13.47%
Rio Grande do Norte	15.82%	13.36%	9.65%	8.47%	9.70%
Rio Grande do Sul	11.24%	10.20%	8.45%	7.50%	8.97%
Rondonia	20.84%	15.71%	10.85%	10.53%	8.81%
Roraima	24.91%	13.91%	12.41%	8.99%	15.03%
Santa Catarina	10.37%	9.23%	8.62%	8.69%	10.59%
Sao Paulo	13.10%	11.85%	9.54%	9.69%	9.31%

* Corresponding to data until April

States	2011	2015	2019	2020	*2021
Sergipe	16.64%	14.16%	12.15%	10.67%	15.25%
Tocantins	15.82%	12.80%	12.09%	12.56%	7.31%
* Corresponding to data until April					

Regarding the amounts spent by public health, in the period from January 2011 to April 2021, there was a total sum of over 762 million dollars,[11,13] of which 12.04% were allocated to elective cases and 87.96% to cases classified as urgency or emergency. The amounts allocated for IAM can be considered relevant to the reality of public health in the country. Graph 4 thus shows the historical series of the amounts spent on IAM in the Brazilian public health year by year.

During this period, the average payment ticket for IAM went from US$ 598.78 in 2011 to US$ 707.05 in 2021, representing a nominal growth of 18.08%. The average period ticket is shown in Graph 5.

If we consider the health price adjustment index in the Brazilian market (IPCA Saúde) during the same period, there is an adjustment of 88.12%,[2,11] as shown in Graph 6.

When relating the average ticket to the Health IPCA during the same period, it is observed that although in nominal terms, the average ticket represents an increase of 18.08%, in real terms, when considering the price adjustment indexes of the same period, there is a relevant reduction of 70.04% in the average ticket of IAM visits from 2011 to April 2021. This percentage mismatch in time can be explained by two main hypotheses: the first and most likely is due to the chronic sub-financing of the Brazilian health system,[4] the focus of many markets research analysis;[6,22] the second is due to the improvement of care conditions, technologies, and care protocols.

COVID-19 impact analysis

To analyze the impact of COVID-19 on IAM, a total of 124 months from January 2011 to April 2021 were analyzed. The initial 111 months were considered as the pre-COVID-19 period, from January 2011 to March 2020, and 13 months later as the COVID-19 period, from April 2020 to April 2021.

Hospitalizations per 100,000 inhabitants had a median of 92.45 (77.68–106.98) monthly hospitalizations, with a minimum value of 36.72 in April 2021, and a maximum of 129.54 in July 2019. In the comparison between the periods, there was a historical increase in hospitalizations until 2020 (Table 1). In the analysis of ITS, the trend of hospitalizations in the pre-COVID-19 period was in an increasing curve of 0.519 ($p < 0.001$) monthly hospitalizations, which underwent a trend change of -4.648 ($p < 0.001$) after the beginning of the COVID-19 period, as observed in Tables 2 and 3 and Figure 2, evidencing, therefore, that IAM in attention to COVID-19 generated a decrease in IAM hospitalizations, in relation to the growth trend of cases before the pandemic.

Table 4
Comparison between the periods

	Pre-COVID-19 Period (SD, IQR)	COVID-19 period (SD, IQR)	*p-value*
Admissions per 100,000 inhabitants	91.09 (77.40-106.56)	109.17 (94.11-118.32)	0.04
Length of stay (days)	7.20 (0.54)	6.40 (1.14)	0.03
Lethality rate (%)	12.69 (1.71)	11.02 (1.78)	0.001
Average Ticket	450.30 (380.17-514.74)	500.70 (464.44-583.51)	0.01
SD. Standard deviation; IQR. Interquartile range.			

The mean length of stay due to IAM throughout the period was 7.11 (DS; 0.67) days, with a minimum value of 3.54 days in April 2021, and a maximum value of 8.83 days in August 2018. The mean length of stay was reduced by 0.80 (p = 0.03) when comparing the COVID-19 period with the pre-COVID-19 period (Table 4). In the initial period, the average length of stay was 6.78 days with a monthly increase trend of 0.007 days (p = 0.001). After the beginning of the COVID-19 period, there was a change in the trend, resulting in a negative slope of -0.157 (p = 0.005) (Table 5).

Table 5
Interrupted time series analysis.

	Pre-COVID-19 Period Coefficient	Pre-COVID-19 Period Slope	*p*-value	Level Change	*p*-value	Slope Change	*p*-value
Admissions per 100,000 inhabitants	64.52	0.519	<0.001	-9.228	0.155	-4.648	<0.001
Lenght of stay (days)	6.78	0.007	0.001	-0.387	0.337	-0.157	0.005
Lethality rate (%)	14.87	-0.039	<0.001	1.445	0.062	-0.097	0.343
Average Ticket (BRL)	380.96	1.510	0.002	-41.441	0.600	-0.114	0.991

The lethality rate averaged 12.49% (DS; 1.78) in the accumulated period, with the lowest value of 8.98% in September 2019, and a higher value of 16.28% in June 2012. The lethality rate decreased from 12.69–11.02% compared to that during the pre-COVID-19 period (Table 3). In the STI analysis, the lethality rate

suffered a monthly decrease of -0.039 percentage points from the beginning, remaining with a similar trend and throughout the period studied (Table 4); thus, there was no significant change in lethality, although the first four months of 2021 presented a small increase (Graph 3).

The average ticket exercised by the hospitals had a median of US$ 457.23 (IQR: 387.30-525.46) during the study period. The lowest amount was US$ 276.81 in December 2011, and the maximum amount was US$ 906.17 in October 2018. The analysis did not demonstrate relevant impacts on this variable due to COVID-19, confirming the economic analyses already presented in the research.

Upper left graph. Monthly IAM admissions per 100,000 inhabitants. Upper right graph. Monthly mean length of stay in days. Lower left graph. Monthly percent IAM lethality rate. Lower right graph. Monthly average ticket in US$ dollars

Open dots represent pre-COVID-19 period monthly data, and black solid dots represent the COVID-19 period. The dashed line illustrates monthly trends. The vertical solid line represents the time interruption between the periods.

4. Discussion

Health care is implemented through a complex system that combines economic elements and assistance in a single environment.[6] In the Brazilian health system, these elements are operationalized through the public system[17] and private sector,[6] both with the challenge of providing access and quality in health care.[23]

In Brazilian public health, challenges are aggravated by many circumstances, including economic and social inequality, geographical extension, regulation of the public sector, and public budget.

In this sense, describing and analyzing the history of IAM in the Brazilian public health system, as well as the impacts of COVID-19, can help guide the scenarios and trends of public assistance in the specialty of cardiology for the coming years, as well as in its economic and social impacts.[24]

In the national context, Brazilian cardiology represents 3.26% of the total number of physicians available in the country,[13] with approximately 2.42% of the beds available, exclusive, and IAM is one of the pathologies showing great prevalence and economic representation in the specialty.

In general, the representativeness of the prevalence of cases with the Brazilian public system has increased in the past 10 years (increasing curve of 0.519; p < 0.001), which underwent a trend change of -4.648 (p < 0.001) following the beginning of the pandemic.

Regarding the length of stay rate of the hospitalized patient, this indicator has little oscillation in the entire period studied, such as a small reduction of 0.80 (p = 0.03) days when comparing the COVID-19 period with the pre-COVID-19 period, resulting in a negative trend slope (-0.157; p = 0.005).

The lethality of IAM decreased from 2011 to 2019, with a small increase during the first months of 2021, not presenting a significant change due to COVID-19. The analysis by states shows that most regions follow the national trend, with the exception of Ceará, Maranhão, and Paraíba, whose realities raise the importance of establishing specific public health strategies and policies, respecting regional particularities.[24]

The investments made in Brazilian public health care for IAM care in the period analyzed totaled US$ 762 million, predominantly destined for urgent and emergency cases (87.96%). In this period, the average payment ticket for IAM had a nominal growth of 18.08%, resulting in a displacement of 70.04% in relation to the main Brazilian price indicator (IPCA-Saúde), demonstrating strong evidence of chronic underfunding of the Brazilian public health system.

Regarding the advent of COVID-19, the historical increase in cases is clearly observable, without a statistically significant impact on COVID-19. Lethality, which until then was a historical trend of decrease, although presenting a small increase during the COVID-19 period, was not significant. The average rate of hospital stay showed a downward trend, with a negative inclination due to COVID-19. There is no direct relationship between the economic impacts of IAM and COVID-19.

Therefore, the conjuncture of analyses made from the data shows the care and economic importance of cardiology, more specifically IAM before the population using the Brazilian unified health system, which has a historical increase in hospitalizations, although a lower lethality rate, due to its increased prevalence, represents a higher number of deaths.

In a context where access to health is a major challenge, one should also pay attention to the aspect of the average rate of permanence, which until 2019 presented itself as an increasing trend curve. Another important aspect to consider is the economic aspects of IAM, as well as other pathologies[16], are levant expenditure with the Brazilian public system[14], which should be based on the improvement of the financing of complex specialties such as IAM, avoiding the scrap of health care, especially in more vulnerable regions.[12]

Finally, as a final consideration, the initiative to understand IAM health care in the Brazilian public context stands out, which purpose is to contribute to the access and qualification of health care, safeguarding premises of access to health,[18] effectiveness,[22] sustainability,[6] cost effectiveness,[16] quality,[17] and humanization,[20] highlighting the role of the state and organized civil society, in the improvement of governance tools that ensure the implementation of public policies in health,[19] from an integrated vision, in the most diverse specialties, regions, and levels of care.[21]

Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

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Figures
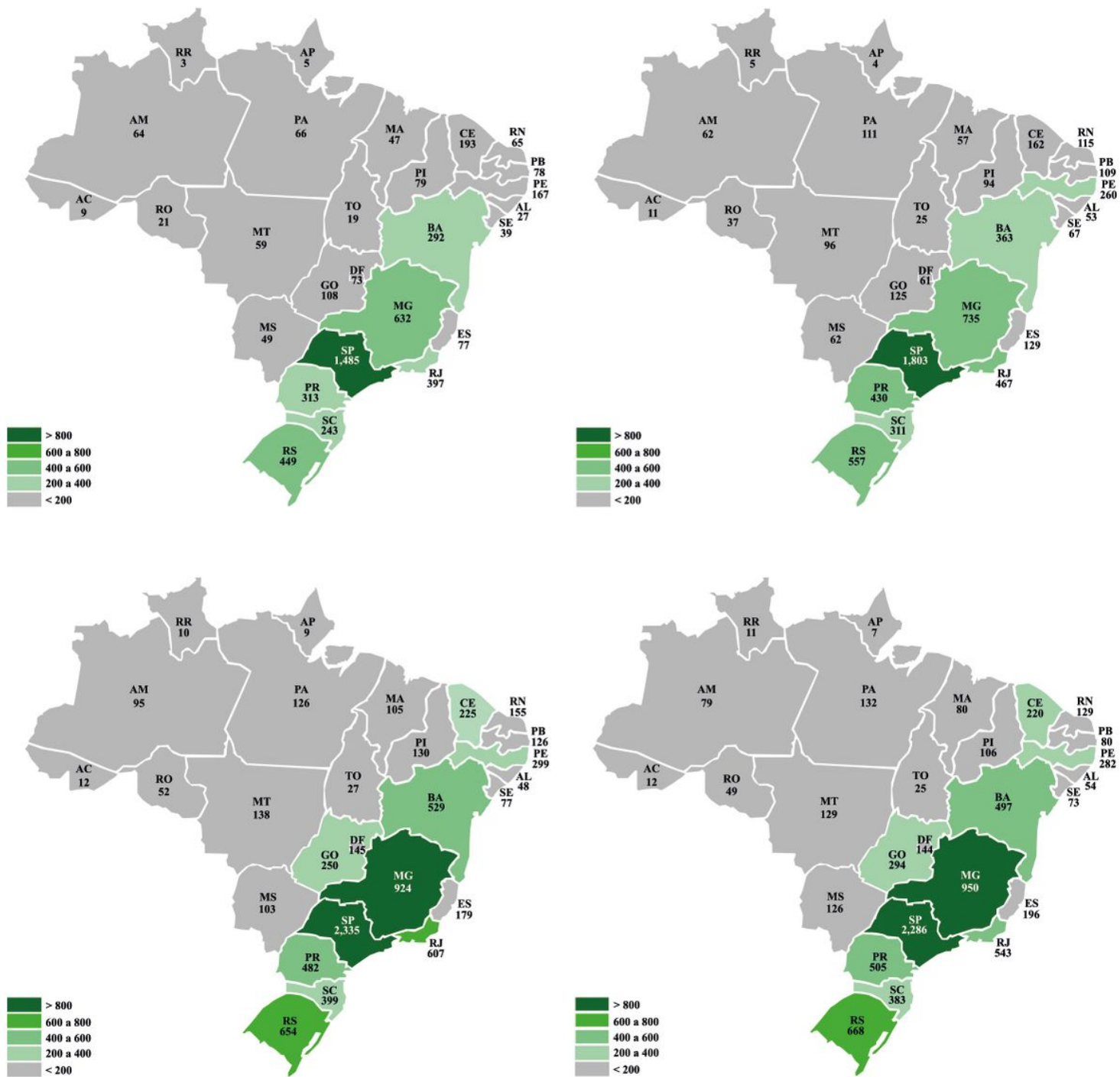
Figure 1

Map of Brazil with the number of hospital admissions of IAM per 100,000 inhabitants in 2011, 2015, 2019, and 2020.
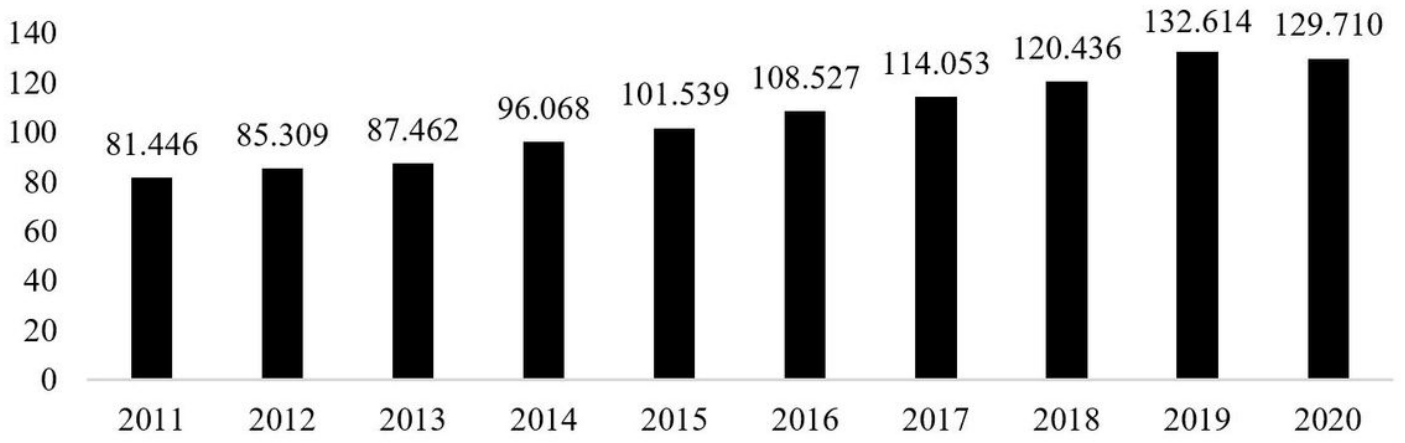
Figure 2

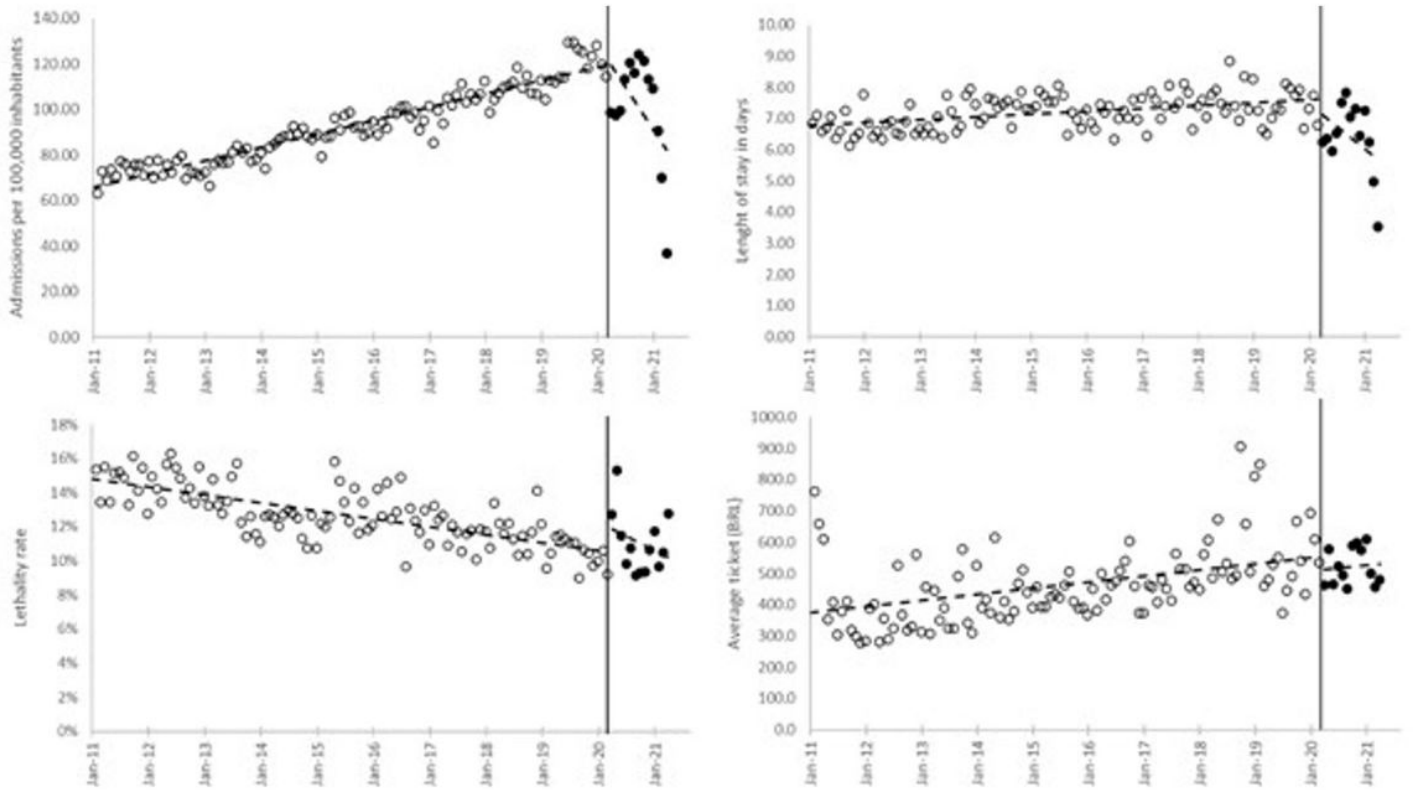Historical series of IAM hospitalizations (2011 to April 2021)

Figure 3
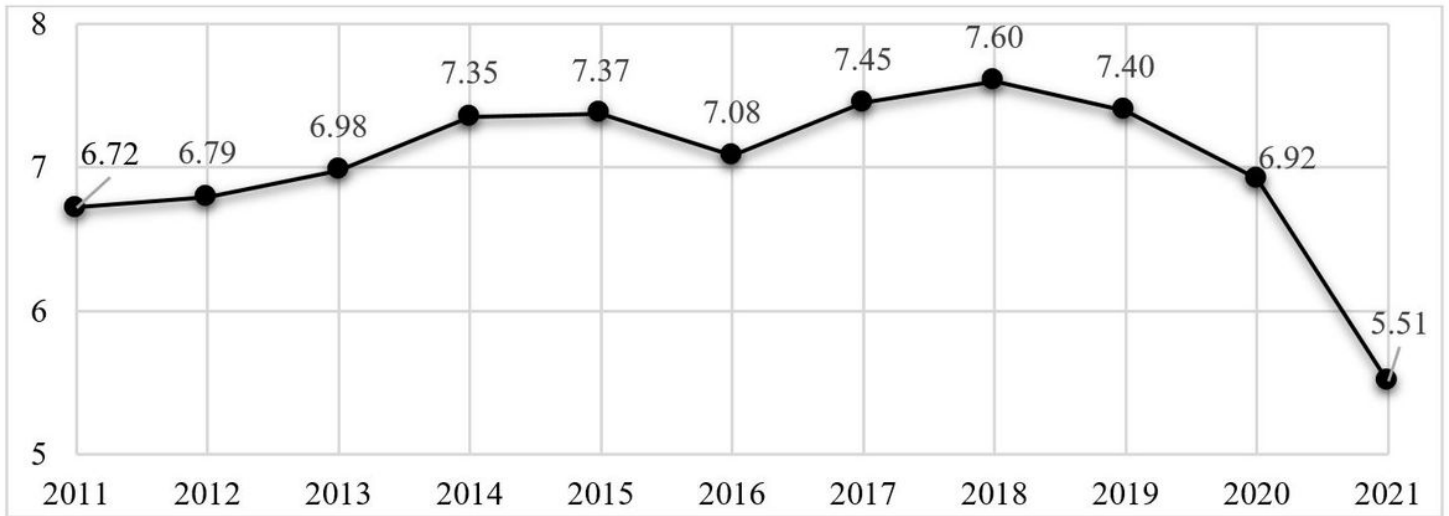
Monthly time series.

Figure 4

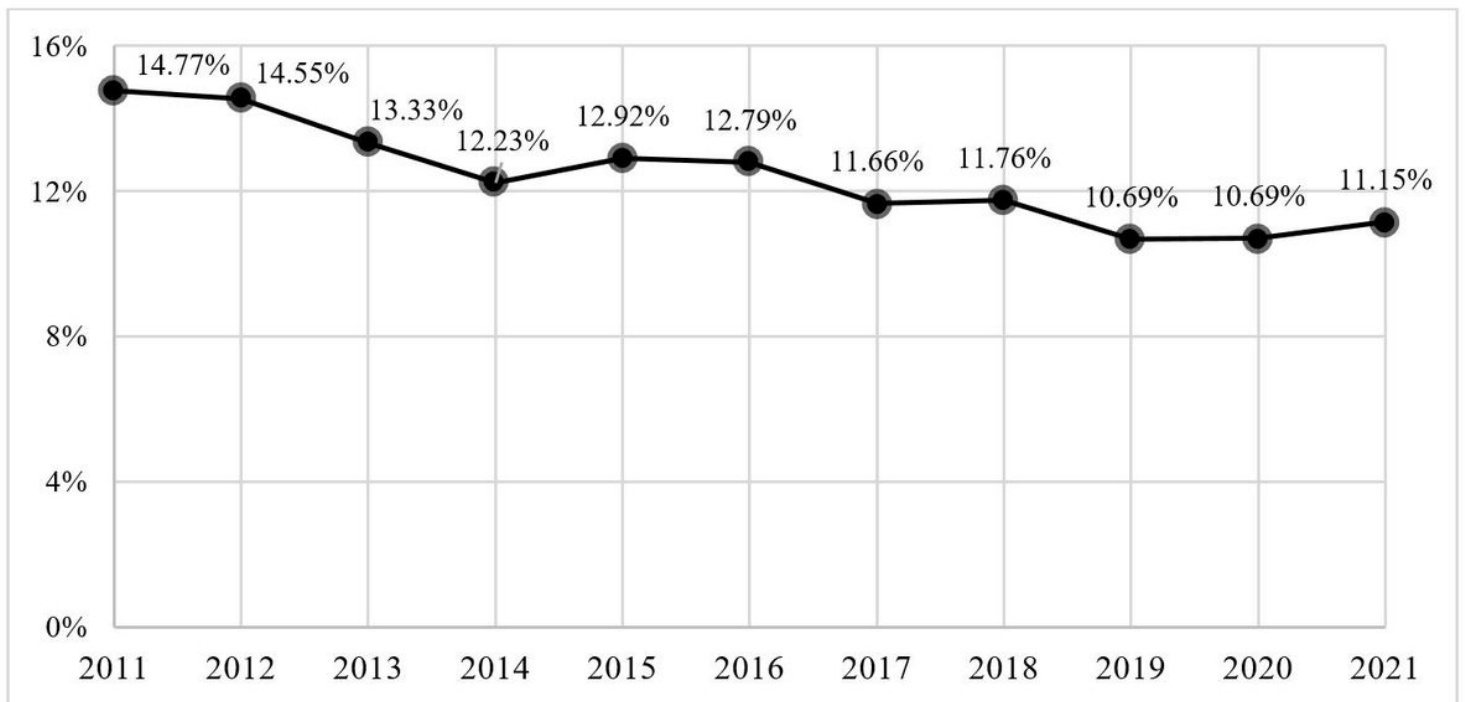Historical series of average stay (year) from January 2011 to April 2021.

Figure 5

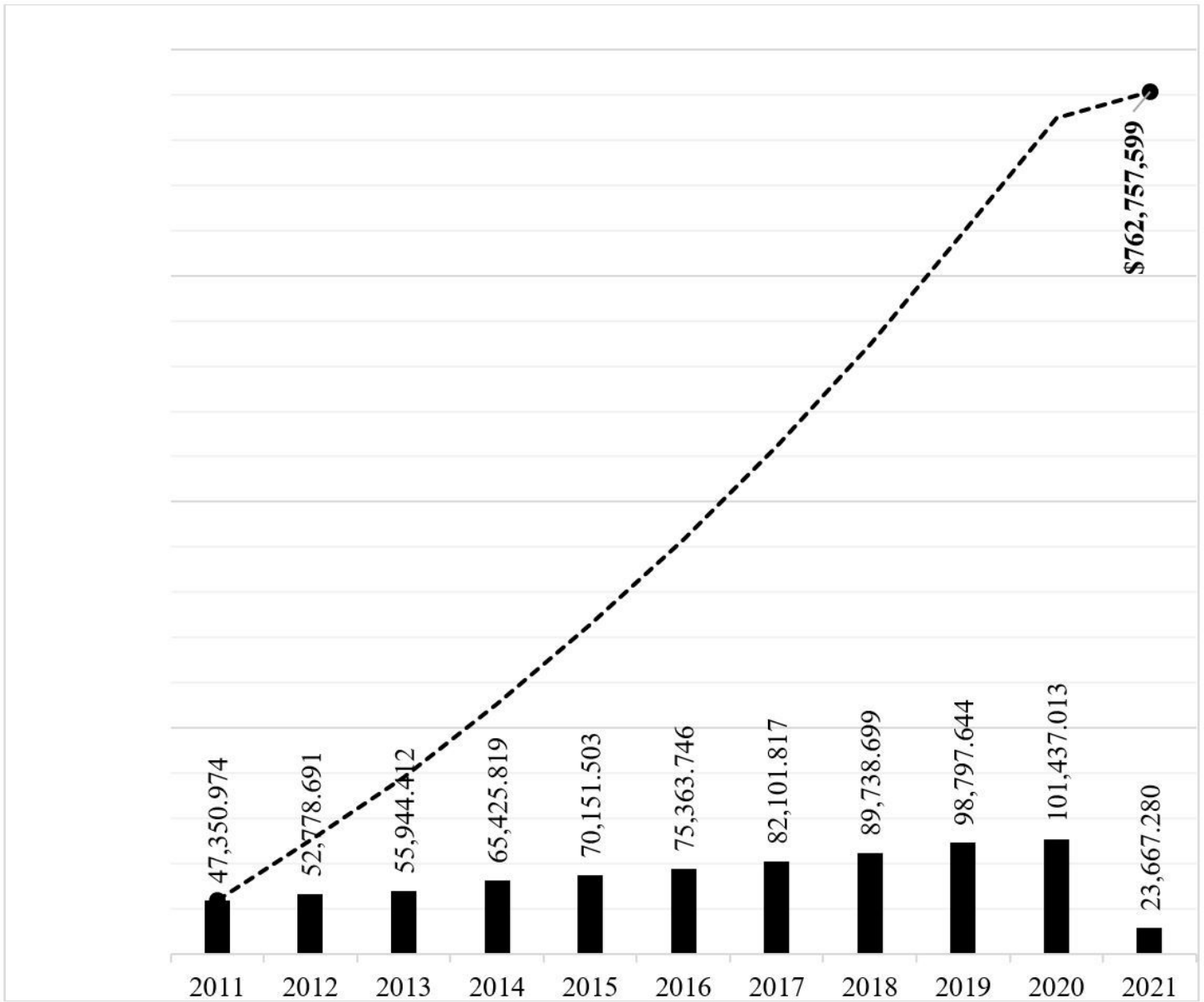Historical series of IAM mortality from 2011 to April 2021

Figure 6

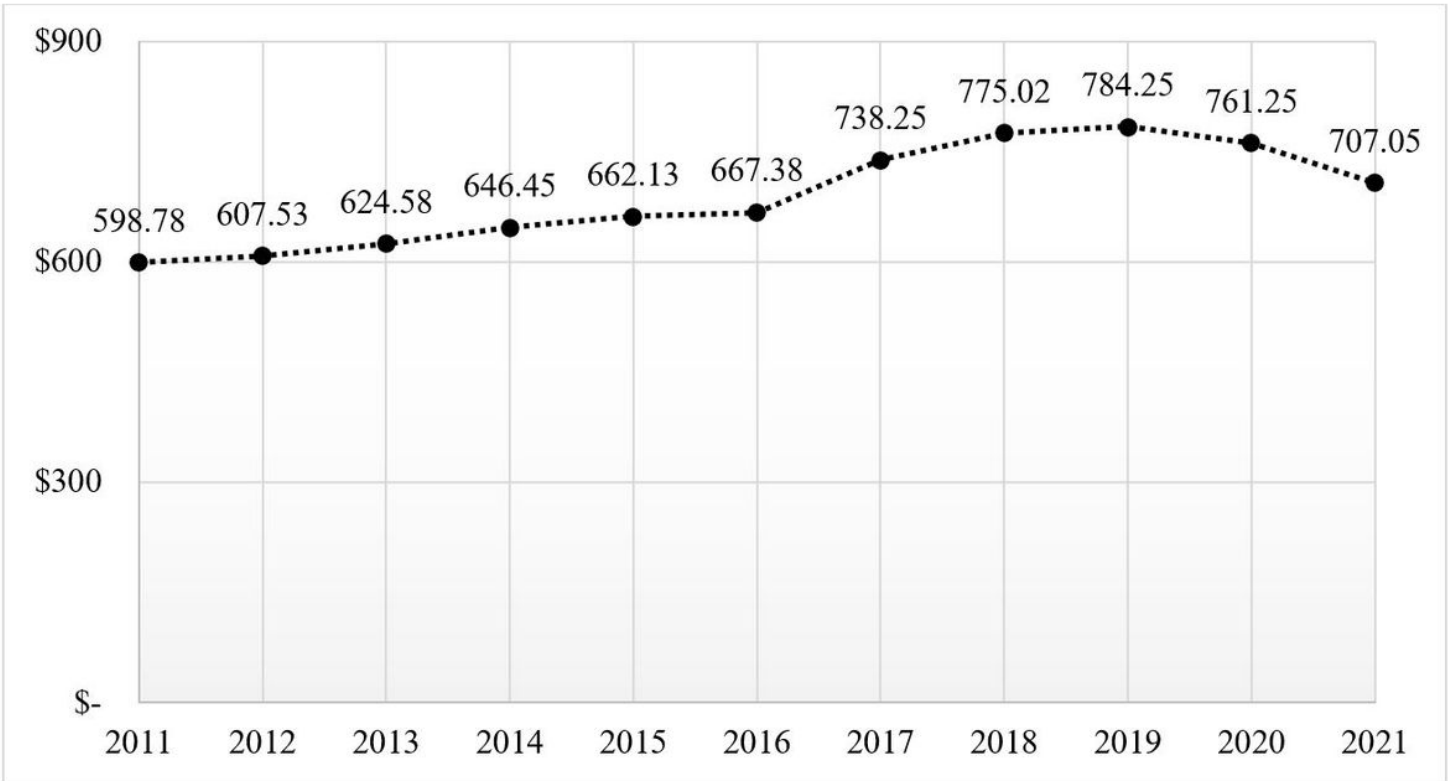Historical series of payments linked to IAM from 2011 to April 2021.

Figure 7

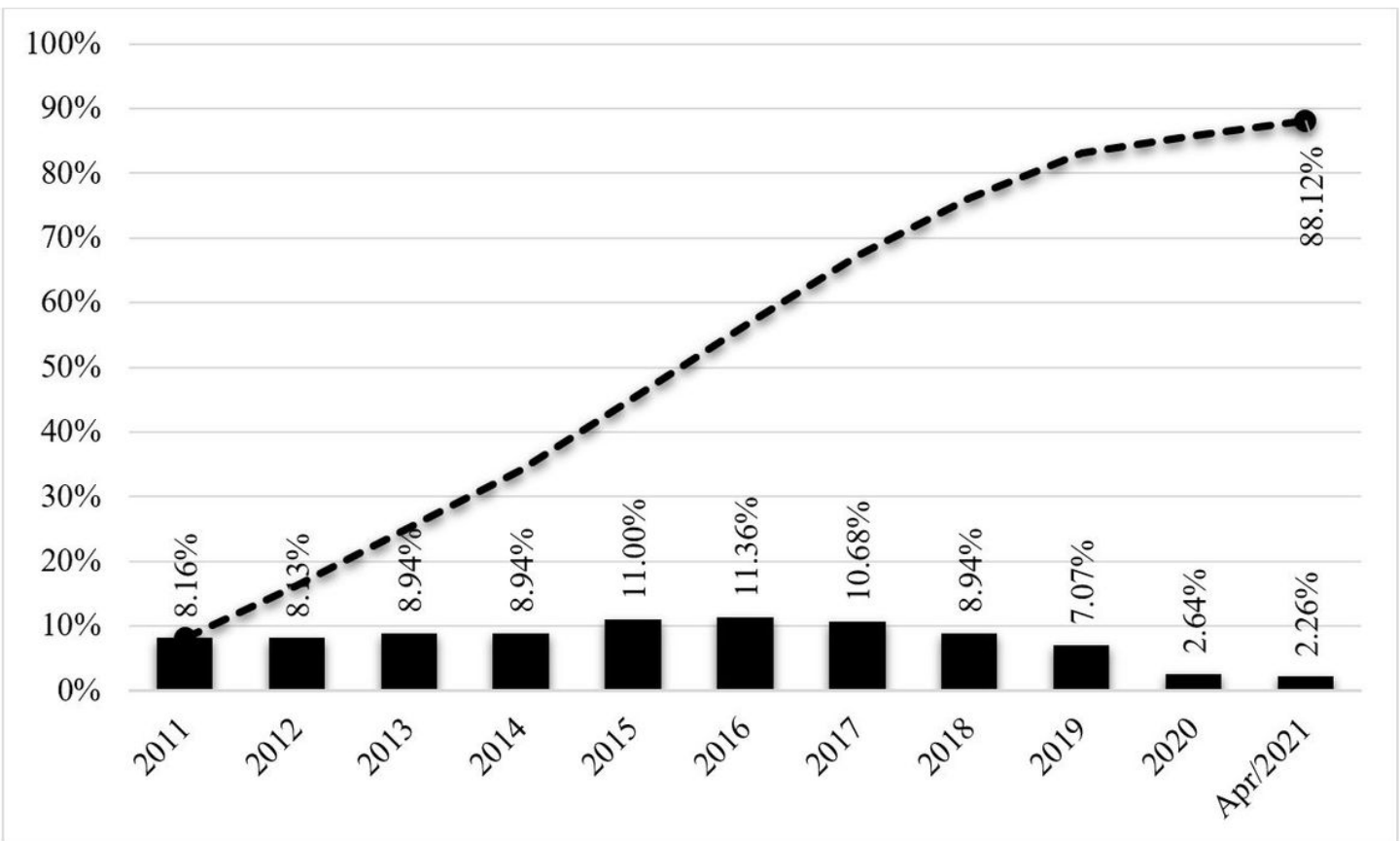Historical series of average ticket linked to IAM from 2011 to April 2021.

Figure 8

Historical series of price adjustment in Brazilian health (IPCA Saúde) from 2011 to April 2021

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AMIDataBaseFiguresTablesandGraphics.xlsx