Original Article

Epidemiological and Financial Aspects of Hospitalizations for Bacterial Meningitis in Brazil

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Abstract

Introduction: Understanding the epidemiology and cost implications of acute bacterial meningitis is crucial for effective health planning, timely treatment implementation, and comprehensive patient support measures, as well as for determining appropriate hospital expenses. Therefore, we conducted an analysis of hospitalization cases for bacterial meningitis in Brazil from January 2008 to December 2019. **Methods:** This is a descriptive ecological study that utilized the Hospital Information System of Brazil's National Unified Health System (SIH/SUS) database. The variables included sex, region, age group, hospitalizations, deaths, lethality rate, and hospital service expenses. The data were tabulated to focus specifically on the epidemiological aspect of bacterial meningitis. **Results:** During the study period, there were 20,207 hospitalizations for bacterial meningitis in Brazil. Men accounted for a higher number of cases, with 11,690 (57.67%), while women had a higher lethality rate of 10.64%. The Southeast region had the highest percentage of both hospitalizations (45.78%) and deaths (46.42%). Bacterial meningitis remains an important cause of morbidity and mortality, particularly in children under 5 years of age. Notably, the elderly and the Northeast region showed higher rates of lethality. The total expenditure on hospital services exceeded 43 million in Brazilian real, with the highest expenditure observed in 2019 and the lowest in 2011. **Conclusion:** A higher prevalence of the disease was observed in males, in children under 1-year-old and in the southeast region. Hospital expenditures were found to be substantial and increasing over time, underscoring the significance of early diagnosis and the promotion of vaccination campaigns.

Keywords: Bacterial meningitis, epidemiology, health expenditures, hospitalization

Introduction

Meningitis is characterized by inflammation of the meninges, primarily affecting the subarachnoid space. This inflammatory condition can be caused by various factors, with viral and bacterial infections being the most common culprits.[1,2] Acute viral meningitis is the most common; however, the bacterial one has a more severe evolution, has a higher mortality rate, and often leaves sequelae.[1] There are several bacterial agents that can cause acute meningitis, such as *Neisseria meningitidis*, *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*, *Streptococcus* sp., *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Enterobacter* sp., *Salmonella* sp., and *Proteus* sp.[1,3,4] The transmission of acute bacterial meningitis (ABM) occurs when the etiological agent is present in the nasopharynx, promoting contamination through droplets from speech, coughing, sneezing, and intimate contact. When the secretions infect a new host, inoculation and inflammation of the leptomeninges occur. In general, the spread starts from an asymptomatic adult carrying the bacteria, causing the spread among children, mainly in day-care centers and schools.[5]

The signs and symptoms of meningitis vary depending on factors such as the immune response, age group, and duration of infection. They can manifest as nonspecific symptoms

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such as fever, vomiting, irritability (in newborns), joint pain, and low blood pressure. Specific symptoms may include the presence of petechiae, headaches, sensitivity to light, alterations in consciousness, seizures, lower back pain, neck stiffness, and bulging fontanelles (in newborns). Kernig's sign and Brudzinski's sign are indicative of meningeal irritation and may be observed.[6] Among the complementary tests for diagnosis, the collection of cerebrospinal fluid (CSF) allows its biochemical analysis, cellularity, evaluation of gram, culture, antigens, and polymerase chain reaction, in addition to culture and sensitivity test to antimicrobials. In addition, blood culture, blood count, C-reactive protein, and skull computed tomography can also be performed when there is a contraindication for CSF collection or in cases of clinical picture of intracranial hypertension.[6,7] Immediate treatment after an early diagnosis is important to reduce morbidity and mortality.[8,9] All contacts who had intimate, prolonged contact and who had contact with oral secretions should be treated prophylactically, preferably within the first 24 h.[6,10]

Important factors in the approach to the patient can modify the course of bacterial meningitis, such as early diagnosis, identification of the etiological agent, and initiation of treatment.[11] Among the complications and sequelae that may arise are empyema, brain abscesses, ventriculitis, extradural and subdural collections, stroke, hernias, paralysis, epilepsy, deafness, hyperactivity syndrome, cognitive impairments, bipolar syndrome, and schizophrenia.[12] After the implementation of antibiotic therapy, mortality from the disease was significantly reduced in the general population; however, the sequelae that may develop with the infection remained frequent.[13]

According to the World Health Organization, each year, there are more than 1.2 million cases of bacterial meningitis in the world, with a death toll of nearly 200,000.[14] Bacterial meningitis is a disease that, if left untreated, can lead to a 70% mortality rate.[5] Like several other infectious-parasitic diseases, it is prevalent in underdeveloped countries, as they have greater means of contamination.[2] The morbidity and mortality rates of the disease are concentrated in children, especially in the youngest age groups (under 1 year old, followed by those aged 1–4 years), as they have an immature immune system and are exposed to people in day-care centers or early school years.[5,14] In Brazil, it is classified as an endemic disease, and may present sporadic outbreaks and, when they do occur, they have a varied prevalence, and may appear more in young people.[2,6,15] The mortality rate can vary from 3%–20%, depending on the etiological agent.[10,16] Among early complications, it is possible to observe cerebral edema, mental confusion, seizures, endocarditis, pericarditis, myocarditis, and hyponatremia. There is also the possibility of the patient presenting late complications such as cerebral palsy, mental retardation, hearing deficit, subdural empyema, and encephalitis.[6,10]

Meningitis is among the 10 main causes of mortality in children under 5 years old in Brazil.[17] Alongside other neurological disorders, it places a substantial financial burden on the public health system.[18-21] It affects all age groups, in addition to being an important clinical presentation that should be well-known by health professionals. The study of the epidemiology of ABM is relevant for health planning, generating better prevention, treatment, and patient support measures, in addition to determining the necessary hospital costs. Thus, the present study aimed to analyze the epidemiological profile of hospitalizations for bacterial meningitis in Brazil from January 2008 to December 2019.

Methods

This is a descriptive ecological study that evaluated hospital admissions for bacterial meningitis in Brazil between January 2008 and December 2019. Data were obtained in May 2020 through Brazil's National Unified Health System (SUS) Hospital Information System (SIH/SUS) made available by the SUS Department of Informatics (DATASUS) at https://datasus.saude.gov.br. This platform is freely accessible to anyone with Internet connectivity, enabling seamless access, integration, and management of health service-related information. The SIH/SUS is a system that registers all attendances resulting from hospital admissions by the SUS.

The distribution of frequencies in relation to hospitalizations, deaths, and lethality rate was analyzed considering sex, age group (up to 1 year, 1–4 years, 5–9 years, 10–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years, and from 60 years old), and the Brazilian region (North, Northeast, Midwest, Southeast, and South) for the entire analyzed period (2008–2019). In order to evaluate the distribution of frequencies by region, and the total and average costs of hospitalization, data by region and by year were described.

The observed values were arranged in graphs and tables. Prevalence and percentages were calculated, and the results were organized for Brazil as a whole, for sexes, different ages, and for each region and year. Microsoft Excel 2016 (Microsoft Corporation, Redmond, Washington, U.S.), and Jamovi version 2.3 (The jamovi project, Sydney, Australia) version 2.3.12 were used for data storage, management, and analysis.

Ethical analysis was not required for this study, as it solely involves the collection of publicly available data from the described database. This ensures the impossibility of identifying individual subjects, aligning with Resolution 466/12 of the National Health Council.

Results

Data analyzed from 2008–2019 show that there were 20,267 hospitalizations for ABM in Brazil. The highest number of hospitalizations was in 2015 (20.1%) and the lowest was in 2009 (0.38%). From 2008–2013, there was no noteworthy increase in cases, with an important rise from 2013 to 2015, from 86–3,216 cases, respectively.

Table 1 shows that the Southeast region had the highest percentage of hospitalizations, with 9279 (45.78%), being the year 2019 with the highest incidence, with 1769 cases. The North had the lowest percentage, with 1415 (6.98%) hospitalizations. There was a predominance of males in all regions of Brazil. Table 2 shows a higher occurrence of hospitalizations for ABM in children, with ages up to 9 years accounting for 37.49% of cases. Of this public, most cases occurred among children under 1 year of age (16%). The age group between 10 and 19 years comprises 2807 (13.85%) hospitalizations, making it the second group with the highest number of hospitalizations. The minority of cases occurred between 50 and 59 years old (8.44%).

Table 1: Hospitalizations and deaths due to acute bacterial meningitis, by region of the country, according to sex, between 2008 and 2019

Variables	Region	Sex		Total (100%)
		Male, *n* (%)	Female, *n* (%)	
Admissions	North	824 (58.23)	591 (41.76)	1415
	NE	2060 (58.9)	1437 (41.1)	3497
	MW	817 (56.9)	619 (43.1)	1436
	SE	5385 (58)	3894 (42)	9279
	South	2604 (56.1)	2036 (43.9)	4640
	Brazil	11,690 (57.68)	8577 (42.32)	20,267
Deaths	North	87 (58.8)	61 (41.2)	148
	NE	228 (58.3)	163 (41.7)	391
	MW	66 (51.16)	63 (48.83)	129
	SE	569 (58.47)	404 (41.52)	973
	South	233 (51.2)	222 (48.8)	455
	Brazil	1183 (56.44)	913 (43.56)	2096
Fatality rate	North	10.56	10.32	10.46
	NE	11.07	11.34	11.18
	MW	8.08	10.18	8.98
	SE	10.57	10.37	10.49
	South	8.95	10.9	9.81
	Brazil	10.12	10.64	10.34

NE: Northeast, MW: Midwest, SE: Southeast

From all macro regions, most deaths occurred in males [Table 1]. The age group of 60 years or more, shown in Table 2, showed a predominance of deaths in the entire country (27.29%), apart from the North region, which had a higher occurrence in the groups of 20–29 years old. In Tables 1 and 2, it is possible to identify the Southeast region as responsible for most deaths (46.42%) and the Midwest region for the minority (6.15%). The highest fatality rate identified was 11.43% in 2016 and the lowest was 4.65% in 2013. The Northeast region had the highest fatality rate and the Midwest the lowest. Females had a higher rate (10.64%) compared to males, with 10.12% [Table 1]. Mortality was higher in hospitalized patients over 60 years of age in all Brazilian regions [Table 2]. The number of hospital admissions, as well as increasing age groups, was correlated with deaths, using the Pearson correlation coefficient (r). Significance was observed between the number of admissions and deaths ($r = 0.996$; $P < 0.001$), as well as increasing age and deaths ($r = 0.958$; $P < 0.001$).

During the analyzed period, the expenditure in Brazilian real (BRL) for hospital services related to bacterial meningitis amounted to BRL 43,244,302.36. Being the highest expense in 2019 (BRL 8,717,883.93) and the lowest in 2011 (BRL 45,244.60). The variation in expenses was very low between 2008 and 2013, comprising a total of 1.93% of general expenses. There was an increase from 2013–2019, a period responsible for 98.8% of general expenses. The average amount spent on hospital services for each hospitalization in the analyzed period was BRL 2133.72, with the lowest amount in 2011 (BRL 447.96) and the highest in 2016 (BRL 2255.13) [Figure 1]. Therefore, over the years, there has been an increase in total and average costs per hospitalization in the country. In Figure 2, the Southeast region had the highest total cost (BRL 20,861,523.96) and, the South, the highest

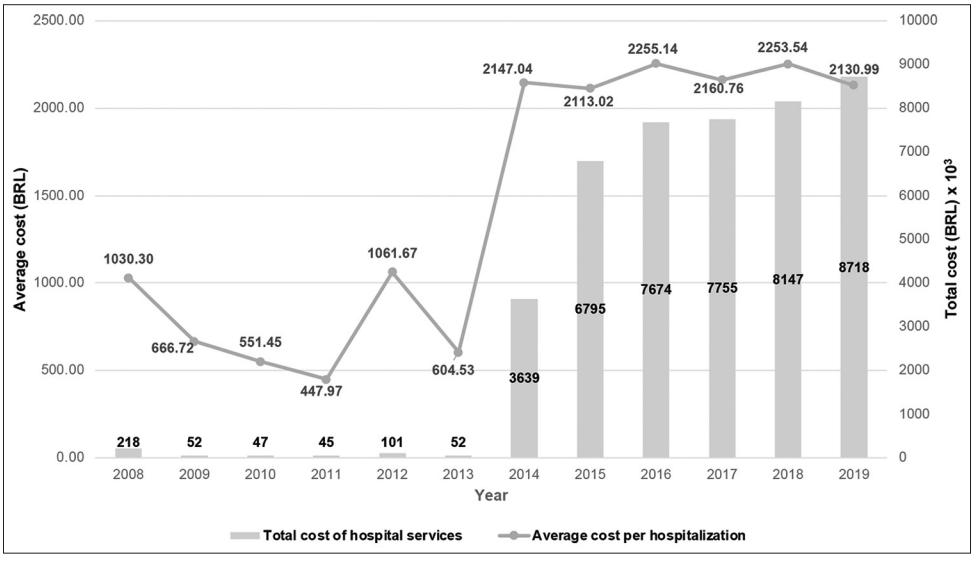

Figure 1: Average and total cost of hospital services for bacterial meningitis in Brazil from 2008 to 2019. BRL: Brazilian real

average cost (BRL 2329.76); the North region had the lowest total (BRL 2,415,564.56) and average (BRL 1707.11) costs. Significant correlations were yielded between costs and the number of cases ($r = 0.995$; $P < 0.001$), as well as costs and deaths ($r = 0.969$; $P = 0.007$), across regions.

Discussion

The collected data highlight the increased occurrence of the disease in the Southeast region, with over 9000 hospitalizations. This higher prevalence of cases is likely due to the region's larger population, which is approximately 50% more populous than the Northeast.[1,11,22] Despite this population difference, according to the tabulated data, the Northeast ranked as the third-most affected region, with 3497 cases. This finding is aligned with previous descriptive work regarding this region.[15] Another important finding is that meningitis did not exhibit seasonality for the period reported, meaning that the incidence and described cases are not influenced by seasonal variations.[16,22]

From the data collected, it was observed that the number of cases was higher in male individuals, which was maintained over the years. Locoregional studies preserve this linearity, such as the one by Ramos *et al*.,[22] which obtained 61% in males, using the Information System for Notifiable Diseases as a database, available as a variation of DATASUS.

Bacterial meningitis can impact individuals of all ages, with the severity of cases varying depending on the age group. In younger children, the symptoms may be nonspecific, including persistent crying, fever, lethargy, and vomiting. The immaturity of the child's immune system plays an important role in both the development of the infection and the susceptibility to

Table 2: Hospitalizations and deaths due to acute bacterial meningitis, by region of the country, according to age, between 2008 and 2019

Variables	Region	Age (years old)								
		<1, *n* (%)	1–4, *n* (%)	5–9, *n* (%)	10–19, *n* (%)	20–29, *n* (%)	30–39, *n* (%)	40–49, *n* (%)	50–59, *n* (%)	≥60, *n* (%)
Admissions	North	209 (14.7)	161 (11.4)	181 (12.8)	293 (20.7)	176 (12.4)	154 (10.9)	99 (7)	71 (5)	71 (5)
	NE	523 (14.96)	346 (9.9)	337 (9.64)	621 (17.76)	434 (12.41)	390 (11.15)	299 (8.55)	275 (7.9)	272 (7.8)
	MW	209 (14.55)	185 (12.9)	152 (10.6)	205 (14.3)	171 (11.9)	166 (11.56)	134 (9.3)	99 (6.9)	115 (8)
	SE	1578 (17.01)	1248 (13.45)	859 (9.26)	1152 (12.42)	959 (10.34)	809 (8.72)	788 (8.49)	821 (8.85)	1065 (11.48)
	South	725 (15.63)	502 (10.8)	384 (8.3)	536 (11.55)	480 (10.34)	451 (9.7)	431 (9.29)	445 (9.6)	686 (14.78)
	Brazil	3244 (16)	2442 (12)	1913 (9.44)	2807 (13.85)	2220 (10.95)	1970 (9.7)	1751 (8.64)	1711 (8.44)	2209 (10.9)
Deaths	North	22 (14.8)	14 (9.4)	12 (8.1)	21 (14.2)	24 (16.2)	19 (12.8)	11 (7.4)	10 (6.7)	15 (10)
	NE	40 (10.2)	20 (5.1)	9 (2.3)	38 (9.7)	48 (12.3)	52 (13.3)	59 (15)	55 (14)	70 (17.9)
	MW	16 (12.4)	12 (9.3)	6 (4.65)	9 (7)	7 (5.43)	17 (13.18)	15 (11.6)	19 (14.7)	28 (21.71)
	SE	74 (7.6)	40 (4.1)	22 (2.26)	56 (5.76)	75 (7.7)	92 (9.46)	132 (13.6)	194 (19.9)	288 (29.6)
	South	32 (7)	16 (3.5)	11 (2.4)	16 (3.5)	32 (7)	44 (9.7)	55 (12)	78 (17.14)	171 (37.6)
	Brazil	184 (8.8)	102 (4.9)	60 (2.8)	140 (6.7)	186 (8.9)	224 (10.7)	272 (13)	356 (17)	572 (27.3)
Fatality rate variables	North	10.53	8.7	6.63	7.17	13.64	12.34	11.11	14.08	21.13
	NE	7.65	5.78	2.67	6.12	11.06	13.33	19.73	20	25.74
	MW	7.66	6.49	3.95	4.86	4.09	10.24	11.19	19.19	27.04
	SE	4.69	3.21	2.56	2.99	7.82	11.37	16.75	23.63	24.93
	South	4.41	3.19	2.86	4.39	6.67	9.76	12.76	17.53	24.35
	Brazil	5.67	4.18	3.14	4.99	8.38	11.37	15.53	20.81	25.89

NE: Northeast, MW: Midwest, SE: Southeast

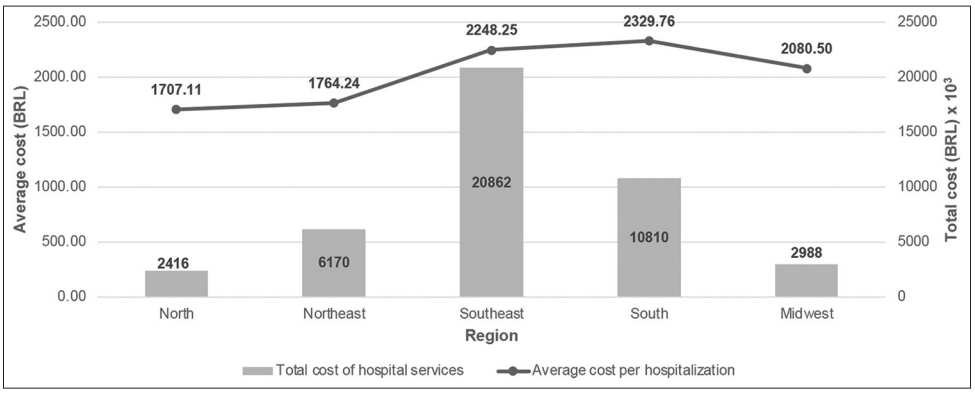

Figure 2: Average and total cost of hospital services for bacterial meningitis by region of Brazil from 2008 to 2019. BRL: Brazilian real

neurological complications.[23] Neonatal meningitis exhibits severe clinical outcomes.[12] Our findings revealed a high number of cases in children under 4 years old, with a notable predominance among those under 1 year old. This underscores the importance of recognizing the significance of the disease and the need for meticulous care in pediatric patients. Bacterial meningitis remains a major public health concern worldwide, as it ranks among the leading causes of morbidity and mortality in children under 5 years old.[24]

In European countries and the United States, adolescents represent the second-most affected group by the disease,[14] which aligns with our study's findings that showed a prevalence of approximately 13.85% among young individuals aged 10–19 years ranking second in terms of proportions. Another population that requires attention is the elderly, as the classic symptoms of headache, fever, and neck stiffness may not be present in all cases, leading to delayed diagnoses.[25] This group is particularly vulnerable due to immunological factors, with cases predominantly attributed to *S. pneumoniae* rather than meningococcus.[26] Our research also revealed notable fatality rates among the elderly population. A study by Lopes *et al*.[27] stresses the significance of pneumococcal vaccination in this population to prevent not only morbimortality by meningitis but also other infectious diseases caused by this bacterium, such as otitis and pneumonia.

In the 20th century, the implementation of meningococcal vaccination effectively prevented infections caused by *N. meningitidis*, the primary agent of ABM. Infant mortality rates from the disease were alarmingly high worldwide. However, countries such as the United States, Canada, and the Netherlands witnessed a remarkable reduction in the incidence of meningitis per 100,000 inhabitants following vaccination.[2] This evidence underscores the significance of vaccination in preventing the disease. In Brazil, the National Vaccination Program introduced meningococcal vaccination in 2010, primarily targeting children under 2 years of age.[28]

Among individuals who succumbed to the disease, males constituted the majority with 56.44%, which, as indicated by Vítor Nunes Sobreira Cruz *et al*.,[29] can be attributed to both higher incidence rates and delayed medical care-seeking among men. Regarding age groups, the elderly aged 60 and above exhibited vulnerability, accounting for 27.3% of total deaths. Notably, the fatality rates for both females and the Northeast region exceeded the national average of 10.34%, with rates of 10.64% and 11.18%, respectively. The Northeast region exhibits a higher lethality rate due to the influence of socioeconomic conditions on meningeal inflammation, extending beyond the etiological agents alone.[29] This study revealed no important disparity in fatality rates, with females at 10.64% and males at 10.12%. Furthermore, the comparison of sexes regarding meningitis warrants further investigation.[22] Bacterial meningitis patients exhibit higher mortality rates than other etiologies, accounting for approximately 50% of all deaths from the disease. The bacteria *H. influenzae* and *N. meningitidis* serve as the primary causative agents responsible for this high mortality, although their incidences vary across different regions.[1]

Hospital expenses for the treatment of ABM can vary depending on factors such as medical complications, the cost of antibiotics, and the management of each patient's clinical condition.[21] The expenses have increased over the years, with 2019 having nearly 40 times higher costs than in 2008. The Southeast region had the highest expenses, followed by the Midwest and North regions. The average costs per hospitalization were lowest in 2010 and 2011, possibly indicating fewer disease complications during those years. The South region had the highest average cost per hospitalization, which can be attributed to the higher prevalence of the disease among the elderly population. The South also had a lower fatality rate compared to other regions.

This study utilized data from the SUS Hospital Information System (SIH/SUS) obtained from DATASUS (https://datasus.saude.gov.br), which provides information on hospitalizations in Brazil. It is important to note that the study focused only on hospitalizations and may not represent all cases of bacterial meningitis in the country. Due to the nature of the data and the heterogeneous population, it is limited in making specific inferences and associations at an individual level. Furthermore, as the data are of secondary origin, there may be variations in data processing before its inclusion in the study. Despite these limitations, the presented dataset includes a substantial number of cases and highlights the substantial investment in health care by the state, emphasizing the need for public health discussions on economic parameters, prevention, and early diagnosis to reduce morbidity and mortality associated with bacterial meningitis.

The data collected highlight the remarkable occurrence of bacterial meningitis in the densely populated Southeast region, leading to a high number of deaths, particularly among children under 1 year old. The region also incurs substantial hospital costs and exhibits the second-highest mortality rate in the country. The Northeast region ranks third in terms of affected cases, primarily among young individuals aged 10–19 years, and experiences a notable lethality rate, especially among those over 60 years old. Males show higher notification and mortality rates across all regions, but only the North and Southeast regions demonstrate elevated lethality rates. Hospitalizations predominantly involve young children, particularly infants, who are more susceptible due to their immunological vulnerability. Conversely, patients aged 60 years or older have the highest mortality rate (25.89%).

Conclusion

This study revealed important hospital costs associated with the treatment of ABM, attributed to the high occurrence of complications, hospitalizations, and fatalities. These findings underscore the importance of early diagnosis and the implementation of robust public policies for ABM prevention and control.

Research quality and ethics statement

As this study is an epidemiologic cross-sectional research project conducted using publicly available databases, and no sensitive information from individuals was exposed, it did not require approval from an ethics committee. The authors followed the applicable guidelines set forth by the EQUATOR Network during the course of this study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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