Evaluation of Reported Meningitis Cases in the Municipality of Governador Valadares, Minas Gerais, Brazil

Avaliação dos casos notificados de meningite no município de Governador Valadares – MG

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Abstract

Meningitis presents high morbidity and mortality rates and is primarily of viral and bacterial origin. This study aimed to conduct a dynamic assessment of meningitis cases in the municipality of Governador Valadares (GV) and to compare these findings with national and state-level data from Minas Gerais (MG). An observational, retrospective study was conducted using data obtained from the Notifiable Diseases Information System (SINAN), covering the period from January 2007 to December 2022. The analysis included information on race/ethnicity, sex, age group, etiology, involved serogroups (*Neisseria meningitidis*), periods of higher case reporting, diagnostic confirmation criteria, and disease outcomes. A total of 286,636 cases were reported nationwide, with 16,541 in MG and 323 in the municipality of GV. Meningitis predominantly affected males aged 20–39 years and had a primarily viral etiology in Brazil (45.6%) and a bacterial etiology in MG (37.9%) and GV (55.4%). Most cases were confirmed through laboratory methods and evolved toward recovery; however, the case-fatality rates attributable to the disease were 8.0%, 13.0%, and 18.9% in Brazil, MG, and GV, respectively. Meningitis showed a significantly lower proportion of cases in GV compared with the national level and a significantly higher proportion compared with MG. These findings highlight the importance of monitoring reported cases to prevent possible sequelae and complications, support disease mapping, and improve both epidemiological surveillance and vaccination coverage.

Keywords: Meningitis; Central Nervous System Infections; Disease Notification.

Resumo

As meningites apresentam altas taxas de morbidade e mortalidade, e têm origem principalmente viral e bacteriana. O objetivo deste trabalho foi realizar um diagnóstico dinâmico dos casos de meningite no município de Governador Valadares (GV) e comparar com os dados nacionais e do estado de Minas Gerais (MG). Foi realizado um estudo observacional, retrospectivo, a partir de dados obtidos do Sistema de Informação de Agravos de Notificação (SINAN), considerando o período de janeiro de 2007 a dezembro de 2022 e informações sobre raça, sexo, faixa etária, etiologia, sorogrupos envolvidos (*Neisseria meningitidis*), período de maior notificação de casos, critério usado para confirmação do diagnóstico e evolução da doença. No total foram notificados 286.636 casos no país, sendo 16.541 em MG e 323 no município de GV. A meningite afetou uma população majoritariamente masculina, com idade entre 20 a 39 anos e tem etiologia predominantemente viral no BR (45,6%) e bacteriana em MG (37,9%) e GV (55,4%). A maioria dos casos apresentou confirmação por técnicas laboratoriais e evolução para cura, entretanto foi possível observar uma taxa de óbitos atribuídos à doença de 8,0%, 13,0% e 18,9% no BR, MG e GV, respectivamente. A meningite apresentou um percentual de casos em GV significativamente mais baixo em relação ao país e significativamente mais alto em relação a MG. Os resultados apontam para a importância do monitoramento dos casos notificados a fim de evitar possíveis sequelas e complicações, auxiliar no mapeamento da doença, bem como no controle epidemiológico e na cobertura vacinal.

Palavras-chave: Meningite, Infecções do Sistema Nervoso Central, Notificação de doenças.

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INTRODUCTION

Meningitis is characterized by an inflammatory process affecting the meninges, the membranes that envelop the brain and spinal cord.[1] They occur worldwide and represent a serious public health concern due to its transmission potential and its association with high morbidity and mortality rates, which may reach up to 50% in cases of bacterial meningitis, even with appropriate treatment.[2] Meningitis may result from infectious causes, such as bacteria, viruses, fungi, protozoa, and helminths, or from noninfectious causes, including drug reactions, tumors, and vasculitis.[1,3] Infectious meningitis is predominantly viral, with enteroviruses being the main agents of viral meningitis. However, bacterial meningitis is of greater public health relevance due to its high lethality, potential to cause sequelae, and ability to trigger outbreaks. They are commonly caused by *Streptococcus pneumoniae, Neisseria meningitidis, Haemophilus influenzae, Streptococcus agalactiae* (Group B *Streptococcus*), *Escherichia coli*, and *Listeria monocytogenes*.[4–6]

The etiology of meningitis may vary seasonally, geographically, and according to the host's age, with bacterial meningitis being more frequent during drier and colder seasons.[4,7] However, the introduction of vaccines into the national immunization schedule, such as the meningococcal C vaccine, the 10-valent pneumococcal vaccine, and the *Haemophilus influenzae* type b vaccine, has led to significant changes in the epidemiological landscape of the disease when caused by bacterial agents.[1,8]

Several host-related factors are associated with an increased risk of developing bacterial meningitis, including immunocompromised status, advanced age, otitis media, mastoiditis, sinusitis, bacterial endocarditis, congenital heart disease, penetrating head trauma, and neurosurgical procedures.[7]

Transmission of the causative agents of this disease occurs through close and direct contact with respiratory droplets and secretions from colonized individuals.[5] Pathogenesis involves nasopharyngeal and oropharyngeal colonization, followed by invasion of the bloodstream or lymphatic system through the mucosa, thereby reaching the central nervous system (CNS) and subsequently crossing the blood–cerebrospinal fluid barrier.[9] The classical clinical triad used for diagnosis consists of fever, neck stiffness, and altered mental status, signs and symptoms that may not be uniformly present in many patients.[3]

Regarding laboratory diagnosis, cerebrospinal fluid (CSF) culture remains the method of choice and the gold standard, as it allows differentiation between viral and bacterial meningitis. Other diagnostic methods include direct bacterioscopy, CSF cytochemical analysis, latex agglutination, and polymerase chain reaction (PCR).[1,3,5]

Early diagnosis and appropriate initial empirical antimicrobial therapy are crucial to minimize complications, such as focal brain deficits and auditory and cognitive impairments, as well as to reduce mortality rates, which can reach up to 54% in low-income countries.[10,11]

In Brazil (BR), meningitis is a notifiable disease and must be reported to the Notifiable Diseases Information System (SINAN) regardless of etiology.[12] The analysis of data available in this system allows for a dynamic assessment of disease occurrence in the population, providing insights into causal explanations for notifiable diseases and indicating potential risks to which individuals are exposed. This contributes to identifying the epidemiological reality of a given geographic area. Its systematic and decentralized use promotes the democratization of information, allowing healthcare professionals and researchers to access and disseminate data to the community. Consequently, SINAN is a relevant tool for health planning, prioritizing interventions, and assessing their impact.[13]

This study aimed to conduct a dynamic assessment of meningitis cases in the municipality of Governador Valadares (GV) and to compare these findings with national data and data from the state of Minas Gerais (MG).

METHODOLOGY

An observational, retrospective study was conducted using secondary data obtained from SINAN, available on the electronic platform of the Department of Informatics of the Unified Health System (DATASUS), accessible at https://datasus.saude.gov.br/acesso-a-informacao/doencas-e-agravos-de-notificacao-de-2007-em-diante-sinan/, with the aim of obtaining information for the period from January 2007 to December 2022. A survey of reported meningitis cases was carried out in GV, at the national level, and in the state of MG, considering age group, race/ethnicity, sex, etiology, involved serogroups, periods of higher case reporting, diagnostic confirmation criteria, and disease outcomes. Governador Valadares has a territorial area of

2,342.376 km², a population of 257,172 inhabitants (2022 Census – IBGE), and a Municipal Human Development Index (MHDI 2010) of 0.727, which is considered high and similar to the national MHDI for Brazil in the same year.[14]

In this study, the research objects were public data obtained remotely through consultation of the SINAN–DATASUS platform. There was no contact between researchers and patients, no biological material was collected from patients, and no patient identification was performed, thus exempting the study from submission to a Research Ethics Committee.

The results obtained in GV were compared with those from other levels, and rate analyses for each evaluated variable were performed using the incidence rate inference test via the BioEstat 5.3 software (Belém-PA, Brazil). Statistical significance was defined as $p \leq 0.05$.

RESULTS

During the evaluated period, a total of 286,636 cases of meningitis were reported nationwide, with 16,541 cases in the state of Minas Gerais (MG) and 323 in the municipality of Governador Valadares (GV), affecting 0.14%, 0.08%, and 0.13% of the population in Brazil (BR), MG, and GV, respectively. The proportion in GV was significantly lower compared with the national level and significantly higher compared with MG.

Individuals aged 20–39 years were the most affected across all levels, accounting for 18.8% of cases in BR, 21.6% in MG, and 21% in GV. Similarly, males were predominantly affected, with rates of 59.1%, 60.3%, and 60.7% in BR, MG, and GV, respectively (Table 1).

Regarding race/ethnicity, white individuals were more frequently affected in BR (45.4%) and MG (35.3%), whereas in GV, mixed-race (brown) individuals were significantly more affected (44.3%) (Table 1).

Although not presented in any table, the distribution of meningitis cases was relatively uniform throughout the year across all levels analyzed, with peaks in November in BR (9.3% of cases), July in MG (9.5%), and October in GV (10.5%).

Most reported cases in BR had a viral etiology (45.6%). However, in MG (37.9%) and GV (55.4%), the majority of cases were of bacterial origin, and in most instances were caused by bacteria other than meningococcus (*Neisseria meningitidis*), pneumococcus (*Streptococcus pneumoniae*), *Haemophilus influenzae*, or *Mycobacterium tuberculosis*. Meningococcus was responsible for 9.5% of cases in both BR and MG, and 15.8% of cases in GV. Serogroup C was the most frequently identified across all three levels, accounting for 3.1% in BR, 3.8% in MG, and 5.9% in GV, with a significantly higher rate in GV compared with the national level (Table 2).

Overall, a downward trend in the absolute number of reported meningitis cases was observed over the evaluated period, with a notable decrease in meningococcal meningitis (Table 3).

According to data obtained from the DATASUS portal, coverage for the meningococcal C vaccine reached 76% in BR, 87.7% in MG, and 95.1% in GV. Pneumococcal vaccine coverage reached 83.6% in BR, 91.5% in MG, and 90% in GV. Coverage for the *Haemophilus influenzae* type b vaccine reached 82.7%, 87.2%, and 86.4% in BR, MG, and GV, respectively.

Most cases were confirmed using laboratory techniques, with CSF cytochemical analysis being the most frequently employed method for diagnostic confirmation in 61.1% of cases nationwide and 46.0% of cases in MG, with significantly higher rates compared with the municipality. In GV, CSF culture was the most commonly used method, accounting for 25.7% of cases (Table 4).

The majority of affected individuals recovered in all three levels analyzed; however, the case-fatality rates attributable to the disease were 8.0%, 13.0%, and 18.9% in BR, MG, and GV, respectively (Table 5). Mortality was mainly observed in bacterial meningitis cases caused by agents other than *Neisseria meningitidis*, *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Mycobacterium tuberculosis* in BR (22.2%) and MG (23.1%), and in pneumococcal meningitis cases in GV (21.3%).

Table 1

Sociodemographic characteristics of reported meningitis cases from January 2007 to December 2022 in Brazil (BR), the state of Minas Gerais (MG), and the municipality of Governador Valadares (GV).

Race/Ethnicity	**BR (n / %)**	**MG (n / %)**	**GV (n / %)**
Not reported / Blank	61,313 (21.4)*	3,936 (23.8)*	108 (33.4)
White	130,100 (45.4)*	5,844 (35.3)*	56 (17.3)
Black	11,280 (3.9)	1,100 (6.6)*	9 (2.8)
Asian	1,452 (0.5)	70 (0.4)	3 (0.9)
Mixed-race (brown)	81,588 (28.5)*	5,563 (33.7)*	143 (44.3)
Indigenous	903 (0.3)	28 (0.2)	4 (1.2)
Total	**286,636**	**16,541**	**323**
Sex	**BR (n / %)**	**MG (n / %)**	**GV (n / %)**
Male	169,443 (59.1)	9,978 (60.3)	196 (60.7)
Female	117,122 (40.8)	6,562 (39.6)	127 (39.3)
Not reported / Blank	71 (0.0)	1 (0.0)	-
Total	**286,636**	**16,541**	**323**
Age Group	**BR (n / %)**	**MG (n / %)**	**GV (n / %)**
Ignored / Blank	238 (0.0)	8 (0.0)	-
<1 year	42,747 (14.9)	2,587 (15.6)	58 (18.0)
1-4 years	52.858 (18.4)*	2,076 (12.5)	42 (13.0)
5-9 years	43,283 (15.1)	1,633 (9.9)	40 (12.4)
10-14 years	22,882 (8.0)	1,059 (6.4)	29 (9.0)
15-19 years	14,623 (5.1)	912 (5.5)	20 (6.2)
20-39 years	53,784 (18.8)	3,569 (21.6)	68 (21.0)
40-59 years	37,850 (13.2)	3,157 (19.0)	47 (14.6)
60-64 years	6,124 (2.1)	554 (3.3)	7 (2.2)
65-69 years	4,547 (1.6)	362 (2.2)	5 (1.5)
70-79 years	5,486 (1.9)	458 (2.8)	6 (1.8)
≥80 years	2,214 (0.7)	166 (1.0)	1 (0.3)
Total	**286,636**	**16,541**	**323**

*P ≤ 0.05 compared with GV. Source: SINAN/DATASUS. Authors, 2024.

Table 2

Reported meningitis cases by etiology and serogroup from January 2007 to December 2022 in Brazil (BR), the state of Minas Gerais (MG), and the municipality of Governador Valadares (GV).

Etiology	**BR (n / %)**	**MG (n / %)**	**GV (n / %)**
Not reported / Blank	2,230 (0.7)	48 (0.3)	-
Meningococcus	11,054 (3.9)*	871 (5.3)	20 (6.2)
Pneumococcus	15,651 (5.5)*	1,404 (8.5)*	51 (15.8)
Viral	130,563 (45.6)*	4,265 (25.8)*	47 (14.5)
Tuberculous	5,615 (2.0)	373 (2.2)	4 (1.2)
Haemophilus	1,923 (0.7)	190 (1.1)	8 (2.5)
Meningococcemia	8,052 (2.8)	388 (2.3)	10 (3.1)
Meningococcal with meningococcemia	8,150 (2.8)*	311 (1.9)*	21 (6.5)
Other bacteria	44,494 (15.5)*	3,131 (18.9)	75 (23.2)
Other etiology	11,743 (4.1)	1,355 (8.2)*	16 (5.0)
Not specified	47,036 (16.4)*	4,203 (25.4)	71 (22.0)
Total	**286,511**	**16,539**	**323**
Serogroups (Neisseria meningitidis)	**BR (n / %)**	**MG (n / %)**	**GV (n / %)**
Not reported / Blank	273,638 (95.5)	15,705 (95.0)	298 (92.3)
A	43 (0.0)	8 (0.0)	-
B	2,807 (1.0)	130 (0.8)	2 (0.6)
C	8,990 (3.1)*	620 (3.8)	19 (5.9)
D	1 (0.0)	-	-
X	9 (0.0)	-	-
Y	284 (0.1)	20 (0.1)	-
Z	4 (0.0)	-	-
W135	835 (0.3)	57 (0.3)	4 (1.2)
29 E	25 (0.0)	1 (0.0)	-
Total	**286,636**	**16,541**	**323**

*P ≤ 0.05 compared with GV. Source: SINAN/DATASUS. Authors, 2024.

Table 3

Reported meningitis cases every four years, according to the most frequent etiological agents, in Brazil (BR), the state of Minas Gerais (MG), and the municipality of Governador Valadares (GV).

Period	2007 to 2010 (n / %)	2011 to 2014 (n / %)	2015 to 2018 (n / %)	2019 to 2022 (n / %)
Brazil				
Meningococcus	7,811 (8.1)	6,768 (8.5)	3,360 (5.1)	1,544 (3.6)
Other bacteria	14,165 (14.6)	12,152 (15.3)	10,970 (16.5)	7,082 (16.5)
Viral	44,098 (45.5)	35,889 (45.1)	31,289 (47.1)	18,929 (44.2)
Haemophilus	506 (0.5)	501 (0.6)	505 (0.8)	415 (1)
Pneumococcus	4,486 (4.6)	4,363 (5.5)	3,945 (5.9)	2,863 (6.7)
Total	96,872	79,550	66,374	42,840
Minas Gerais				
Meningococcus	478 (9.1)	396 (8.4)	202 (5)	123 (4.5)
Other bacteria	821 (15.6)	887 (18.7)	883 (21.7)	577 (21.3)
Viral	1,348 (25.6)	1,211 (25.6)	1,048 (25.7)	740 (27.4)
Haemophilus	59 (1.1)	51 (1.1)	49 (1.2)	36 (1.3)
Pneumococcus	448 (8.5)	402 (8.5)	343 (8.4)	229 (8.5)
Total	5,255	4,735	4,070	2.704
Governador Valadares				
Meningococcus	16 (16.3)	7 (12.5)	1 (2.3)	1 (2.9)
Other bacteria	22 (22.4)	5 (8.9)	12 (27.3)	12 (35.3)
Viral	12 (12.2)	17 (30.4)	9 (20.4)	4 (11.8)
Haemophilus	3 (3.1)	2 (3.6)	0 (0)	1 (2.9)
Pneumococcus	11 (11.2)	10 (17.9)	6 (13.6)	2 (5.9)
Total	98	56	44	34

Source: SINAN/DATASUS. Authors, 2024.

Table 4

Diagnostic methods used to confirm meningitis cases from January 2007 to December 2022 in Brazil (BR), the state of Minas Gerais (MG), and the municipality of Governador Valadares (GV).

Diagnostic Method	BR (n / %)	MG (n / %)	GV (n / %)
Not reported / Blank	856 (0.3)	47 (0.3)	–
Clinical	28,513 (9.9)*	1,933 (11.7)*	71 (21.9)
Culture	36,893 (12.9)*	3,771 (22.8)	83 (25.7)
Latex agglutination	9,.546 (3.3)*	1,111 (6.7)*	48 (14.9)
Counterimmunoelectrophoresis	1,097 (0.4)	40 (0.2)	7 (2.2)
Bacterioscopy	7.378 (2.6)*	381 (2.3)*	16 (5.0)
Cytochemical analysis	175,128 (61.1)*	7,603 (46.0)*	78 (24.1)
Clinical-epidemiological	5,461 (1.9)	436 (2.6)	3 (0.9)
Viral isolation	740 (0.3)	35 (0.2)	–
Viral PCR	14,455 (5.0)	502 (3.0)	11 (3.4)
Other	6,568 (2.3)	682 (4.1)	6 (1.9)
Total	**286,635**	**16,541**	**323**

*P ≤ 0.05 compared with GV. Source: SINAN/DATASUS. Authors, 2024.

Table 5

Outcomes of reported meningitis cases from January 2007 to December 2022 in Brazil (BR), the state of Minas Gerais (MG), and the municipality of Governador Valadares (GV).

Outcome	BR (n / %)	MG (n / %)	GV (n / %)
Not reported / Blank	22,069 (7.7)*	756 (4.6)*	3 (0.9)
Discharged	227,870 (79.5)	12,732 (77.0)	246 (76.2)
Death due to meningitis	23,066 (8.0)*	2,160 (13.0)*	61 (18.9)
Death due to other cause	10,631 (3.7)	893 (5.4)	13 (4.0)
Total	**286,636**	**16,541**	**323**

*P ≤ 0.05 compared with GV. Source: SINAN/DATASUS. Authors, 2024.

Meningitis affected 1,184 pregnant women nationwide and 71 in MG; however, no cases were reported in GV. The majority of cases occurred between the 14th and 27th weeks of gestation, i.e., during the second trimester, both in BR (42.2%) and MG (38%). The etiology was viral in BR (36.6%) and unspecified in MG (35.2%), and mortality rates reached 12.7% and 22.5% in BR and MG, respectively.

DISCUSSION

The analysis of the sociodemographic characteristics of individuals affected by meningitis showed that those aged 20–39 years and males were the most affected across all levels. Similar findings were reported in studies by Cruz, Bernardo, and Gusmão[15] (2021) and Roller et al. [16] (2023), conducted in the states of Alagoas and Goiás, respectively, where the 20–39-year age group was also the most affected, and males accounted for 59.2% and 61% of infection cases.

Immunity against tuberculous meningitis, obtained through BCG vaccination, lasts approximately 15 to 20 years for individuals vaccinated within the first hours after birth, whereas the immunizing effect of meningococcal vaccines administered to children older than 18 months lasts between 1 and 4 years, leaving adults more susceptible to infection. Furthermore, most vaccines are not available through the public health system for the most affected age group, which includes many economically active individuals who are frequently exposed to respiratory droplets from sneezing or coughing in public transportation and crowded workplaces. This may explain the higher incidence of cases in this age group.[17-19]

Regarding race/ethnicity, white individuals were the most affected in Brazil and in the state of Minas Gerais; however, in Governador Valadares (GV), cases predominantly occurred among mixed-race (brown) individuals. According to data from the Cidades Portal of the Brazilian Institute of Geography and Statistics (IBGE), the population of GV is predominantly mixed-race, which explains the higher number of cases in this group. A similar situation was observed in the study by Amorim et al.[20] (2022), conducted in Tocantins, a state where the majority of the population self-identifies as mixed-race and where 82.2% of individuals affected by meningitis belonged to this group.

In this study, a higher frequency of meningitis cases was observed in November in Brazil (9.3%) and in October in GV (10.5%), both during spring. In contrast, in MG, the highest frequency occurred in July (9.5%), during winter. According to Dando et al.[21] (2014), severe and dry winds, common in spring, can irritate mucous membranes and facilitate the penetration of *Neisseria meningitidis* into the epithelium. In the study by Marinho[22] (2023), conducted in a city in northwestern São Paulo, similar to GV, the highest number of notifications occurred in October, accounting for 14.6% of cases. Nevertheless, cases were generally well distributed throughout the year across all regions, regardless of season.

During the period evaluated in this study, viral meningitis accounted for a substantial proportion of cases in both Brazil (45.6%) and MG (25.8%), values similar to those reported by Andrade et al.[23] (2023), who analyzed data from the pre-pandemic and pandemic periods of COVID-19 in Brazil and MG, finding viral meningitis rates of 46.9% and 27.5%, respectively. In Iraq, Khaleel et al.[24] (2024), analyzing data from the country's Center for Communicable Disease Control, also observed a higher incidence of viral meningitis from 2018 to 2023 compared with bacterial meningitis. Viral etiology is highly prevalent because viruses have a higher contagion

factor than bacteria and spread more easily through contact and respiratory routes.[1]

According to Sabbi et al.[25] (2021), the reduction in reported cases of meningitis caused by the main bacterial agents is attributed to the implementation of vaccines through the National Immunization Program (PNI), which led to a shift in the etiological profile, favoring a higher occurrence of viral meningitis. Notable viral families include *Flaviviridae*, *Orthomyxoviridae*, *Togaviridae*, *Peribunyaviridae*, *Herpesviridae*, and *Picornaviridae*.[26] Within the *Picornaviridae* family, enteroviruses are particularly relevant, along with *Coxsackievirus* B5 and *Echovirus* strains 6, 9, and 30, which are commonly associated with outbreaks and epidemics.[27]

The primary concern regarding enteroviruses lies in their mode of transmission. These viruses are transmitted via the fecal–oral route, through the consumption of food and water contaminated with feces. Therefore, the higher number of infections may be associated with socioeconomic factors and inadequate sanitation infrastructure.[28]

In GV, most cases (23.2%) were caused by bacteria other than *Neisseria meningitidis, Streptococcus pneumoniae, Haemophilus influenzae*, and *Mycobacterium tuberculosis*, similar to the findings of Silva et al.[29] (2022), who conducted a study in Piauí between 2011 and 2020, where 49.6% of meningitis cases also had this same etiology.

Among other bacterial agents capable of crossing the blood–brain barrier and causing meningitis, notable examples include *Streptococcus agalactiae, Listeria monocytogenes, Escherichia coli,* and *Streptococcus suis*. These organisms possess a capsular polysaccharide that induces electrostatic repulsion and masks bacterial surface structures, allowing them to evade host defense mechanisms and facilitating invasion.[30] Another predisposing factor is neurosurgical intervention, in which infections are typically caused by Staphylococcus aureus, coagulase-negative staphylococci, and aerobic Gram-negative bacilli, including Pseudomonas aeruginosa.[31]

It is well established that one of the primary agents of bacterial meningitis is *Neisseria meningitidis*. In this study, it accounted for 9.5% of meningococcal disease cases in both BR and MG, and 15.8% of cases in GV, with serogroup C being the most frequently identified across all three levels. The rate was significantly higher in GV compared with the national level, despite GV having higher vaccination coverage than MG and BR. Ferro et al.[32] (2023), in their analysis of meningitis cases in Brazil from 2010 to 2020, also found serogroup C to be the most prevalent, accounting for 38.6% of cases. Similarly, Camargo[33] (2021), in a study conducted at the Central Public Health Laboratory of Minas Gerais in Belo Horizonte between 2017 and 2019, reported a rate of 58.6% for *N. meningitidis* serogroup C in the state.

According to Santayana et al.[34] (2023), serogroups B and C were the main contributors to meningococcal disease cases in Brazil from 2010 to 2019. Infants and children under five years of age were more frequently affected by serogroup B, whereas serogroup C predominantly affected individuals aged 15 to 29 years and those over 60. Vaccination is essential for reducing meningococcal meningitis cases; however, the development of a vaccine against serogroup B is hindered by its complexity and the potential to induce autoimmunity.[35]

Among the most commonly used diagnostic confirmation methods in this study, CSF cytochemical analysis was employed in 61.1% of cases in BR and 46.0% in MG. This method was also the most frequently used in 59.2% of cases in BR in the study by Gonçalves, Silva, and Mezzaroba[36] (2018). Cytochemical analysis enables total and differential cell counts, as well as glucose and protein measurements in the CSF. In general, meningitis presents with pleocytosis and elevated protein levels; bacterial meningitis, in particular, is characterized by a high number of polymorphonuclear neutrophils and hypoglycorrhachia. However, etiological diagnosis is confirmed through CSF culture.[37,38]

In GV, CSF culture was the most frequently used method (25.7%), as also observed in the study by Ramos et al.[39] (2019), conducted in MG from 2007 to 2017, which found culture to be the most commonly used diagnostic confirmation method in the eastern region of the state and the second most used across MG. No information or references were found to explain why cytochemical analysis was the most commonly used method for diagnostic confirmation in BR and MG, whereas culture was more frequently employed in GV.

CSF culture is considered the gold standard for diagnosing bacterial meningitis due to its high specificity. It can be performed using various types of body fluids, primarily cerebrospinal fluid, blood, and even scrapings from petechial lesions.[38] According to Olcén and Fredlund[40] (2001), microorganism isolation through culture allows for identification and susceptibility testing, enabling the implementation of prophylactic measures such as vaccination or isolation, with significant impact on public health and epidemiological surveillance.

Regarding the outcomes of reported cases**,** most individuals recovered across all three levels; however, disease-attributable mortality rates were 8.0%, 13.0%, and 18.9% in

Brazil (BR), Minas Gerais (MG), and Governador Valadares (GV), respectively. Similar findings were observed in the studies by Viana et al.[2] (2024), conducted in the state of Piauí, where 71.5% of individuals recovered and 14.2% died, and Lima et al.[41] (2024), who analyzed national data and found recovery and mortality rates of 75.8% and 9.6%, respectively. According to Viana et al.[2] (2024), this situation may be explained by more effective and resolutive medical care, resulting in improved patient prognosis. Deaths are primarily attributable to the severity of the clinical condition and delays in seeking medical attention.[2]

The etiology of meningitis and its associated mortality rates have undergone substantial changes in recent years following the introduction of vaccines against *Neisseria meningitidis*, *Haemophilus influenzae*, and *Streptococcus pneumoniae*.[42] In the present study, a downward trend in the absolute number of reported meningitis cases was observed over the evaluated period, particularly for meningococcal meningitis, coinciding with the introduction of the meningococcal C vaccine in 2010.[43] Moreover, bacterial meningitis caused by agents other than *N. meningitidis, S. pneumoniae, H. influenzae*, and *Mycobacterium tuberculosis* showed the highest mortality rates in the country and state, at 22.2% and 23.1%, respectively. Similar results were reported by Akaishi et al.[42] (2023), who identified *Staphylococcus aureus* and *Pseudomonas aeruginosa* as the bacterial agents most associated with fatal outcomes in Japan.

In GV, pneumococcal meningitis was significantly more frequent than in BR and MG, despite higher vaccination coverage than the national level and similar coverage to MG. It was also the most lethal (21.3%), as observed in the study by Wunrow et al.[44] (2023), conducted between 1990 and 2019 across 204 countries, which identified S. pneumoniae as the leading cause of death (18.1%). According to Barichello et al.[45] (2012), meningitis caused by *S. pneumoniae* has a higher mortality rate (16%–37%) and poorer prognosis compared with *N. meningitidis* (5%) and *H. influenzae* (3%). Viral meningitis is generally less aggressive and typically follows a self-limiting course.[2]

Nationwide, meningitis affected 1,184 pregnant women, including 71 in MG, with mortality rates of 12.7% and 22.5%, respectively. No cases were reported in GV. However, no information or references were found to explain the differences in case numbers and mortality rates across the three levels. Regarding etiology, 36.6% of cases in BR were viral, while 35.2% in MG were unspecified. During pregnancy, underlying changes in maternal immune function occur, with reduced adaptive immune responses, increasing susceptibility to certain infections.[46,47]

Pardin et al.[48] (2023) emphasize that the effects of meningitis in pregnant women extend beyond maternal health, considering the possibility of fetal invasion. Depending on the etiologic agent, complications may include miscarriage, preterm birth, and impaired fetal development. Listeria monocytogenes is capable of spreading to the central nervous system (CNS) and causing meningitis, as well as invading the placenta and fetus. Pregnant women are more frequently affected than non-pregnant women, with an incidence of 17% during pregnancy.[46,48,49]

Lima and Patriota[50] (2020) analyzed the epidemiological profile of meningitis in the capitals and states of Brazil's Northeast Region and found that most cases during pregnancy occurred in the second trimester (51.3%), as observed in the present study, and resulted in death in 23.6% of cases. This yielded a higher mortality rate in this group compared with the general population, consistent with the findings of the present study.

This study presents some limitations, such as the use of secondary notification data. Additionally, it is evident that the meningitis reporting system remains flawed, with many fields left blank or ignored, highlighting the need for improved training of healthcare professionals to ensure accurate completion of notification forms.

CONCLUSION

The proportion of reported cases, relative to the population of each level, was significantly lower in GV compared with the national level and significantly higher compared with MG. Meningitis predominantly affects a male population aged 20–39 years, with a primarily viral etiology in BR and MG and a bacterial etiology in GV. Most cases were confirmed through laboratory techniques and progressed toward recovery; however, a notable mortality rate attributable to the disease was observed.

The findings of this study highlight meningitis as a serious public health problem and demonstrate the importance of monitoring reported cases to prevent potential sequelae and complications, as well as to support disease mapping, given the geographic and seasonal variability of its etiology.

This study also underscores inefficiencies in completing SINAN notification forms, which may contribute to underreporting, compromise health planning, and affect epidemiological control and vaccination coverage.

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