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Epidemiological Study of Meningitis Outbreak of Children in Halabjah City and Sulaymaniyah Governorate, Kurdistan region, Iraq

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Abstract

Meningitis is a very dangerous and deadly infection that is linked to a high rate of morbidity and mortality in children. Since April 2023, the Kurdistan Region of Iraq has been plagued by an alarming meningitis outbreak, so this study was conducted to look at meningitis in children. Epidemiology has been done using test results from suspected cases at Wafaa Hospital in Halabja City and Dr. Jamal Ahmad Rashid's Pediatric Teaching Hospital in Sulaymaniyah Governorate between March and July 2023. 256 children <15 years old who were admitted with meningitis. Medical records, clinical information and Cerebrospinal fluid (CSF) analysis were obtained. A further classification of meningitis into aseptic and septic forms was made based on laboratory results. A total of 256 children were confirmed to have meningitis, 55 (21.5%) of whom had septic meningitis and 201 (78.5%) had aseptic meningitis. The statistical analysis revealed that almost 118 (46.1%) of patients who had septic or aseptic meningitis occurred in children < 5 years old, and the most common cause was aseptic meningitis. Infection was significantly higher in boys than in girls ($p < 0.05$). There was a significant association ($p < 0.05$) between the cause of meningitis and C-reactive protein (CRP), white blood cells (WBC) count, Cerebrospinal fluid (CSF) protein and CSF glucose. A statistically significant difference (p-value= 0.02) in the prevalence of male preponderance between older and younger age groups among children with meningitis. Meningitis was shown to be greatly influenced by seasonal change; most cases were observed in May. The seasonal associations between meningitis infection and age were not statistically significant ($p > 0.05$). Most cases of meningitis were caused by viral infections. Meningitis has a major impact on children <5 years old, with males predominating. In our community meningitis occurs mainly in May. Seasonality was not influenced by the patients' ages.

Keywords: Meningitis, Children, Septic, Aseptic, Outbreak.

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دراسة وبائية لتفشي مرض التهاب السحايا لدى الأطفال في مدينة حلبجة ومحافظة السليمانية في إقليم كردستان العراق

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الخلاصة

التهاب السحايا هو مرض معدٍ ومميت ومعدل الإصابة والوفيات بين الأطفال مرتفعة. منذ شهر نيسان 2023، وان تفشي مرض التهاب السحايا في مدينتي الحلبجة والسليمانية في منطقة كردستان العراق بشكل مثير للقلق، لذلك تم اجراء هذه الدراسة الوبائية للنظر في نسبة التهاب السحايا عند الأطفال. حيث اجريت الدراسة منذ شهر اذار ولغايه شهرتموز 2023 وذلك من خلال جمع نتائج الفحوصات من الحالات المشتبه بها في مستشفى الوفاء في مدينة حلبجة ومستشفى الدكتور جمال أحمد رشيد التعليمي للأطفال في محافظة السليمانية. شملت الدراسة على 256 طفلاً دون سن 15 عامًا الراقدين في المستشفى بسبب إصابتهم بالتهاب السحايا. تم الحصول على النتائج من خلال السجلات الطبية والمعلومات السريرية وتحليل سائل النخاع الشوكي. حيث صنفت مرض التهاب السحايا بناءً على نتائج المختبر الى مرض التهاب السحايا البكتيري والفايروسي. واظهرت النتائج ان 256 طفلاً مصابا بالتهاب السحايا، منهم 55 (21.5%) مصابون بالتهاب السحايا البكتيري و201 (78.5%) مصابون بالتهاب السحايا الفايروسي. ومن خلال كشف التحليل الإحصائي، لوحظت أن ما يقرب من 118 (46.1%) من المرضى الذين أصيبوا بالتهاب السحايا البكتيري او الفايروسي يحدثون عند الأطفال الذين تقل أعمارهم عن 5 سنوات، وأكثرالاصابه شيوعًا هو التهاب السحايا الفايروسي. اضافه الى ذلك الإصابة بالتهاب السحايا كانت أعلى بشكل ملحوظ عند الأولاد مقارنة بالبنات. وايظا اظهرت النتائج ان هناك علاقه بين سبب التهاب السحايا و CRP, WBC count, ($p < 0.05$). CSF protein and CSF glucoseومن نتائج الإحصاء تم الاستدلال ان الأطفال المصابين بالتهاب السحايا غالبيتهم ذكور وخاصة بين الفئات العمرية الأكبر سنا و الفئات العمرية الأصغر سنا. لقد ثبت النتائج أن التهاب السحايا يتأثر بشكل كبير بالتغيرات الموسمية، حيث لوحظت ان معظم الحالات كانت في شهر أيار. ولا يوجد علاقة بين التغيرات الموسمية وعمر الأطفال المصابين بالتهاب السحايا. واستنتج من هذه الدراسة ان أغلب حالات التهاب السحايا كانت ناجمة عن عدوى فيروسية. وان الإصابة بالتهاب السحايا يؤثر بشكل رئيسي على الأطفال الذين تقل أعمارهم عن 5 سنوات، وغالبتهم الذكور، ولوحظت ان تفشي التهاب السحايا بشكل رئيسي كانت في شهر ايار.

1. Introduction

An inflammation of the meninges, the membranes that surround the brain and spinal cord, is referred to as meningitis. It may result from infectious agents such as bacteria, mycobacteria, viruses, fungi, or parasites, as well as from autoimmune, malignancy, or drug responses [1].

Numerous types of bacteria can cause bacterial meningitis, which has serious long-term consequences and a high case fatality rate. *Streptococcus pneumoniae, Haemophilus* *influenzae, Neisseria meningitidis,* and *Streptococcus agalactiae* (group B *streptococcus*) are some of these bacteria. Other bacteria, including nontyphoidal *Salmonella*, *Listeria monocytogenes, Streptococcus suis*, and pathogens like *Staphylococcus aureus* or *Staphylococcus epidermidis* can also cause meningitis; however, it happens less frequently [2]. The most typical central nervous system infection (CNS) is viral meningitis, which is brought on by meningeal viral invasion. Enteroviruses are one of them [3]. Immunocompromised individuals, such as young children and the elderly, frequently experience it [4]. However, there aren't many reports of these issues. The severity of viral meningitis is typically lower than that caused by bacterial infections [5]. In order to effectively treat meningitis, it is crucial to distinguish between pyogenic (bacterial) and aseptic meningitis [6]. Similar signs of bacterial and viral infections include fatigue, fever, muscle discomfort, and others. For the best treatment and prognosis, it is crucial to differentiate between these 2 forms of infections as soon as possible. Antibiotics are frequently used to treat bacterial infections; however, treating viral infections with them is ineffective and may contribute to antibiotic resistance [7].

Although the clinical signs and symptoms of meningitis are frequently nonspecific and can overlap with those of other illnesses, acute bacterial meningitis continues to be a major cause of neurological sequelae and death in children [6]. The most crucial management steps might be early diagnosis and effective treatment. Meningococcal meningitis typically takes 4 days to incubate; however, it can take anywhere between 2 and 10 days. The most typical signs of meningitis include stiff neck, high temperature, light sensitivity, dizziness, headaches, and vomiting [8]. A less frequent but significantly more serious and frequently fatal version of the illness is meningococcal septicemia, which is marked by a hemorrhagic rash and rapid circulatory collapse [9]. Even with early detection and effective treatment, 5% – 10% of patients still perish away, often 24/48 hours after their symptoms start. 10–20% of meningitis survivors may also develop hearing loss, learning disabilities, or brain damage [7].

Meningitis affects 2.8 million people annually, mostly children under the age of five, who are more susceptible to the disease [10]. Acute bacterial meningitis affects 15–18% of children who present with status epilepticus and fever [10]. Although viral meningitis is not rare, it is generally less dangerous and self-limiting. Children under one month old and those with impaired immune systems are more severely affected. To rule out significant causes and inform management strategy, it is crucial to identify viral meningitis [3]. In both industrialized and developing nations, bacterial meningitis is a substantial cause of morbidity and mortality in children. Patients with suspected bacterial meningitis require immediate medical attention; however, there is a substantial risk of poor outcome due to delayed and inadequate diagnosis [11].

Meningitis in humans has seasonal variations, which vary from nation to country. In hot climates, it usually strikes in the late winter or early spring [12]. Meningitis risk factors include: gender, age of infancy, history of head injury and brain surgery, bottle-feeding, recent upper respiratory infection, mumps, tuberculosis and otitis media, crowded living conditions, low socioeconomic status, passive smoking, compromised immune system, splenectomy and sickle cell disease [12].

Meningitis is diagnosed using a combination of clinical examination, laboratory tests, and the patient's medical history. Clinical indicators of meningitis in the patient include the Brudzinski sign. A lumber puncture and cerebrospinal fluid analysis are needed if meningitis is suspected to be present [13].

Meningitis is a deadly illness that leaves survivors with major long-term damage. It is still a serious global problem with outbreaks occurring in many different countries [14]. Meningitis outbreaks can have particularly severe impacts on lower-income areas because of inadequate resources for prompt diagnosis and treatment as well as poor immunization rates [12].

In developing nations, pediatric meningitis continues to be a leading cause of child morbidity and mortality. Understanding the organisms that cause meningitis can support us to create empirical antibiotic regimens and suggest the essential vaccinations for primary healthcare [15]. The majority of cases of bacterial meningitis occur in children under the age of one year. The late winter and early spring months have the highest incidence rates [16]. Meningitis disease epidemiological data are essential for characterizing the more often circulating strains and directing future preventative and control measures [17].
Since mid-April, the Kurdistan Region of Iraq (KRI) has been plagued by an alarming meningitis outbreak, so this study was conducted independently to look at meningitis in children. Data on the prevalence of bacterial and viral meningitis were obtained from the current investigation of meningitis cases in Halabja City and Sulaymaniyah governorate. The study focuses on the frequency meningitis in children. The epidemiology will be done according to the laboratory results of suspected cases.

2. Patients and Methods

A prospective hospital-based surveillance study was conducted to determine the incidence and cause of meningitis in children. In the Kurdistan Region of Iraq, pediatric patients from newborns to 15 years old who were admitted to Wafaa Hospital in Halabja City and Dr. Jamal Ahmad Rashid's Pediatric Teaching Hospital in Sulaymaniyah governorate were the subjects of this study between March and July 2023. Senior physicians who were monitoring the patients suspected of having meningitis took CSF samples. A total of 256 cases were registered.

2.1 Inclusion Criteria

Clinical symptoms and indicators of meningitis, such as fever, a severe headache, extreme irritability, photophobia, vomiting, drowsiness, stiff neck, and the Kernig and Brudzinski signs, were the diagnostic inclusion criteria for acute bacterial and viral meningitis. Demographic information (Age, gender, length of hospital stays). Based on laboratory test results (CSF cells, glucose, a CRP test, total, differential WBC, and protein levels, for the purpose of diagnosing bacterial meningitis, CSF Gram staining and culture were carried out), all were included in the data. Additionally, data on the causal agent (for cases with verified causation) were gathered.

Meningitis diagnosis depends on CSF analysis, culture, and laboratory investigations such as complete blood count, blood culture, and CSF culture and sensitivity (Gram stain, analysis) (Normal value of CSF sugar is 45–80 mg/dl, CSF protein is 20–40 mg/1dl, and CSF cell count is 0–5 WBC and no RBC).
Isolation of bacteria from CSF culture was defined as bacterial meningitis. If other CSF characteristics such as cellularity, leukocytes >10 with neutrophilic predominance >20%, protein >40 mg/dl, and sugar <40 mg/dl were observed in cases where a culture was negative, pyogenic meningitis was assumed to be the cause.
Aseptic meningitis: CSF WBC 50 to 500 cells/ mm3 are counted with lymphocytic predominance (>50%), mildly raised protein (>40 mg/dl), normal or slightly decreased sugar content with negative CSF bacterial culture and Gram stain. Slide agglutination for CRP Qualitative was performed in CSF. Positive CRP levels are defined in this qualitative investigation as those more than 6 mg/dl.

2.2 Exclusion Criteria

Children who had received antibiotics more than 24 hours prior to the CSF testing, those with congenital abnormalities of the central nervous system, those with any chronic illnesses, children older than 15 years old, the existence of a recognized immunodeficiency and additional creatures present in the CNS culture were excluded.

2.3 Ethical Approval

Permission was given by the ethics committee to carry out this study on March 1, 2023, according to administrative order number (ETC. Ref No. 5/7/26). The research was conducted under strict confidentiality guidelines, and the data were used only for that reason.

2.4 Statistical Analysis

Frequency analysis was performed on the data using Stata software, version 21 (Stata Corp, College Station, TX, USA). The Chi-squared test was performed to examine the relationship between qualitative variables; a *P*- value < 0.05 was deemed significant.

3. Results

Between March and July 2023, 256 patients between the ages of 1 day and 15 years with clinical signs and symptoms of meningitis were involved in the current study. The study comprised 55 (21.5%) children who had a clinical suspicion of having septic meningitis (Bacterial), and 201 (78.5%) individuals were found to have aseptic meningitis (Viral) (Figure 1).

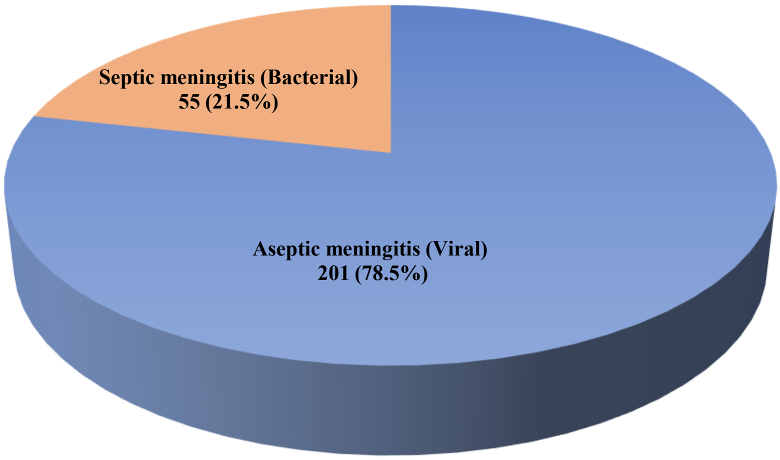

Figure 1: Distribution of patients according to septic and a septic meningitis infection

Table 1 displays the correlation between the cause of meningitis and the overall characteristics of the study participants. Furthermore, the statistical analysis revealed that almost 118 (46.1%) of patients who had septic or aseptic meningitis occurred in children under the age of five, and the study showed that aseptic meningitis is more common, 82 (32.0%), whereas 36 (14.1%) were septic meningitis. 115 (44.9%) cases with 99 (38.7%) of aseptic meningitis and 16 (6.3%) of septic meningitis occurring in the age group of (6–10), remain 23 (9%) of cases with 20 (7.8%), 3 (1.2%) of aseptic meningitis and septic meningitis, respectively, occurred in the age group (11–15 years old) ($p < 0.05$). According to the gender distribution in the current study, males 190 (74.2%), are more likely than females, 66 (25.8%), to get meningitis ($p < 0.05$). Whereas 155 patients (60.5%) had positive CRP and 101 patients (39.5%) had negative CRP ($p < 0.05$). There were a significant association ($p < 0.05$) between the cause of meningitis and WBC count, CSF protein and CSF glucose.

Table 1: The demographic and laboratory characteristics of CSF in the studied patients

Variables		Total (No. & %)	Septic meningitis (No. & %)	Aseptic meningitis (No. & %)	*P*-value
Age/years	<1-5	118 (46.1%)	36 (14.1%)	82 (32.0%)	< 0.05
	6-10	115 (44.9%)	16 (6.3%)	99 (38.7%)	
	11-15	23 (9%)	3 (1.2%)	20 (7.8%)	
Gender of patients	Male	190 (74.2%)	46 (18.0%)	144 (56.3%)	< 0.05
	Female	66 (25.8%)	9 (3.5%)	57 (22.3%)	
CRP Test	Positive	155 (60.5%)	109 (42.6%)	46 (18.0%)	< 0.05
	Negative	101 (39.5%)	9 (3.5%)	92 (35.9%)	
WBC (6-7 WBC/mm^3)	Normal	84 (32.8%)	4 (1.6%)	80 (31.3%)	< 0.05
	Increased	166 (64.8%)	49 (19.1%)	117 (45.7%)	
	Decreased	6 (2.3%)	2 (0.8%)	4 (1.6%)	
CSF Protein (mg/dl)	Normal (20-40)	102 (39.8%)	3(1.2%)	199 (38.7%)	< 0.05
	Increased (>20-40)	153(59.8%)	102 (39.8%)	51 (19.9%)	
	Decreased (<20-40)	1(0.4%)	0 (0.0%)	1 (0.4%)	
CSF glucose (mg/dl)	Normal 45-80	208 (81.3%)	8 (3.1%)	200 (78.1%)	< 0.05
	Increased >45-80	5 (17.2%)	1 (0.4%)	4 (1.6%)	
	Decreased <45-80	43 (17.2%)	43 (16.8.4%)	0 (0.0%)	
Total		256 (100%)	55 (21.5%)	201 (78.5%)	< 0.05

The study revealed a statistically significant difference (*P*-value = 0.02) in the prevalence of male preponderance between older and younger age groups among children with meningitis (Figure 2).

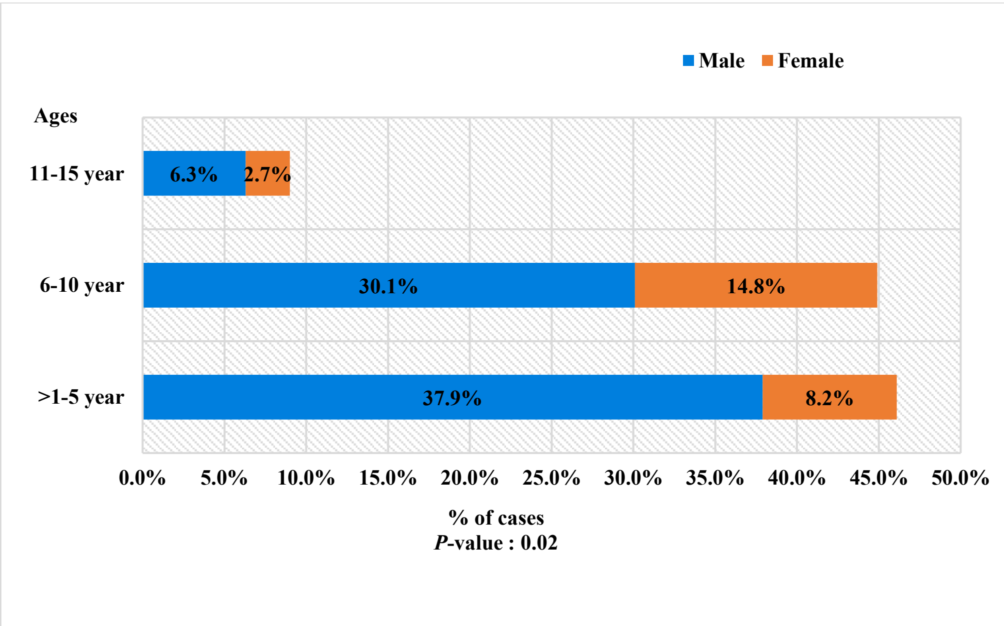

Figure 2: Distribution of patients according to age and gender

Meningitis was shown to be greatly influenced ($p < 0.05$) by seasonal change, with most cases observed in May. There were 3 cases in March after the peak number of cases (n = 129) was recorded in May (Figure 3).

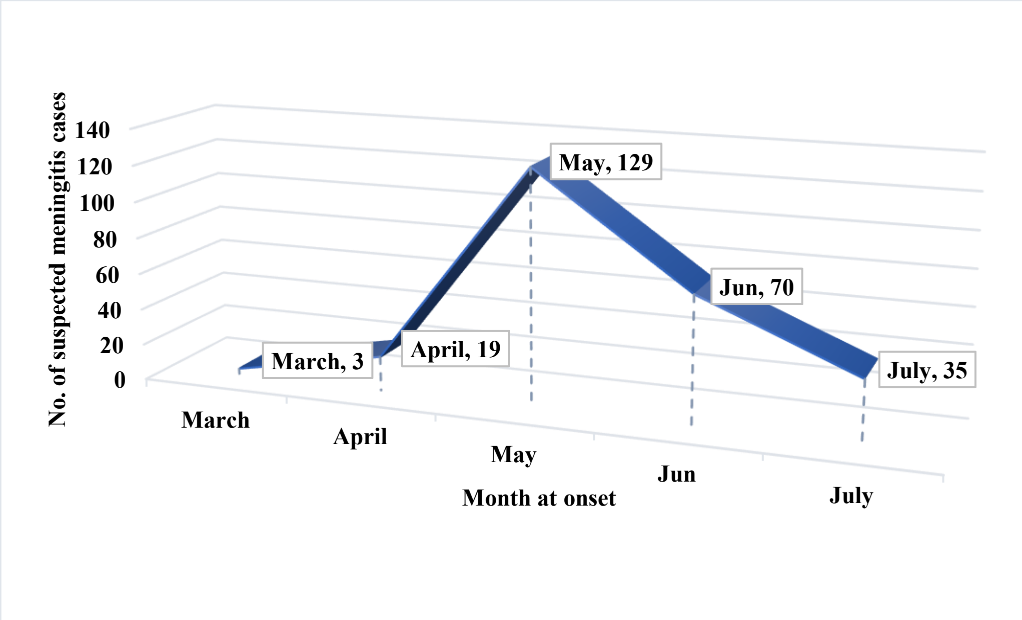

Figure 3: Frequency of meningitis patients by month of onset, March to July 2023

Figure 4 illustrates how the percentage of meningitis cases in all age groups increased over the May, followed by individuals who were mainly infected in the June and July, whereas in patients of all age groups fall of in the March, so that the seasonal associations between meningitis infection and age were not statistically significant ($p > 0.05$).

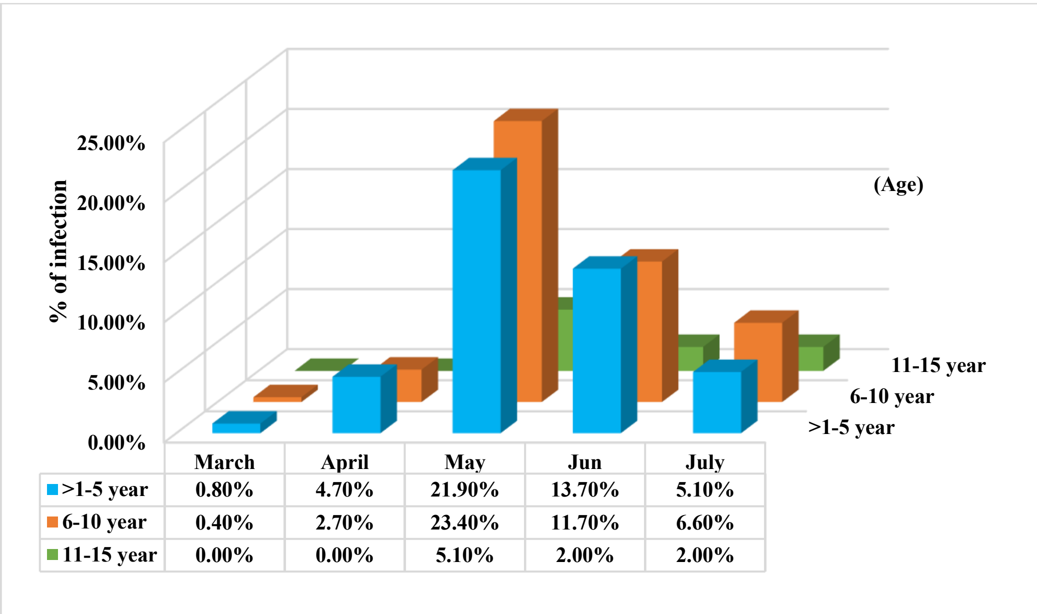

Figure 4: The study group data for the seasonality of meningitis infection according to age

4. Discussion

Meningitis is still a leading cause of morbidity and death [18]. A prominent causal agent for all patients in the current investigation was aseptic meningitis, which was present in 201

(78.5%) of the patients. This agrees with another study conducted in Diyala, Iraq, which found the largest percentage of cases with aseptic meningitis diagnosis (74.3%) [19].

A study investigated that the meningitis is frequently caused by *enterovirus* and indicated that the most frequent pathogen in children with confirmed meningitis in their study was *enterovirus* [10]. It's critical to differentiate between pyogenic and aseptic meningitis based on clinical signs and symptoms to prevent antibiotic overuse and avoidable hospital stays [10].

In the current investigation septic meningitis in children made up 55 (21.5%) of all admissions. Similar to the previous study in a tertiary care hospital in Vietnam, about clinical and laboratory manifestations of bacterial meningitis , and reported that the bacterial meningitis etiology is only found in 24.2% of cases, and the most prevalent infection was *Streptococcus pneumonia* [10]. Banseria *et al.,* found that *pneumococcus* (*Streptococcus pneumoniae*) was the most frequently isolated organism among those cultivated in CSF culture, accounting for 46.55% of the 58 CSF culture-positive cases, and this can be linked to the absence of pneumococcal vaccination coverage [1].

On the basis of clinical criteria, it is not always easy to differentiate between pyogenic and aseptic meningitis. Therefore, many medical professionals advise starting antibiotics as soon as a child exhibits clinical signs of acute bacterial meningitis and continuing them for up to 72 hours after receiving a bacterial culture report. A quick and precise diagnostic test is required since failing to diagnose bacterial meningitis can have potentially fatal effects [20].

A team of experts from the Ministry of Health and the World Health Organization (WHO) was sent to the impacted regions to conduct a collaborative epidemiological analysis of the documented cases and create an expedient response strategy aimed at halting the disease's spread. After a preliminary examination of 24 samples, it was determined that *Enterovirus* and *Streptococcus pneumonia* were the two microorganisms causing meningitis [2].

After analyzing the patients' ages and gender, it was discovered that meningitis is more common in boys and younger children (<5 years old). Comparable findings about gender and age were discovered by other studies [10, 16, 21].

The differential expression of genes encoded on a host's X and Y chromosomes could be the cause of gender variations in how they react to infections. The immunological advantage of females appears to be related to X chromosome-associated biological processes and X-linked genes because of X-linked micro-RNA-related processes. It has been suggested that the immune disadvantage experienced by males and the increased survival of females after immunological challenges are caused by the phenomenon of X chromosome inheritance and expression [22]. According to certain theories, the phenomenon of X chromosome inheritance and expression is responsible for the immune disadvantage that males face and the higher survival rate that females experience following immunological challenges [22].

A study investigated variations in the age distribution of meningitis patients. Meningitis incidence declined markedly in children over five years old (36.67%); but it somewhat rose in children under five years old (63.33%) ($p < 0.001$) [10].

A study reported that meningitis was shown to have a significant correlation with the male gender, who tended to be between the ages of 22 and 44 and younger than 9 years old [5].

Jarad research produced the same findings and found that meningitis is more common in males' gender and children under one year old. This could be attributed to their developing immune systems, which lead to more serious infections [17].

In the current investigation, viral meningitis was the major causal agent in all patients aged between 6 and 10 years, accounting for 99 (38.7%) of the patient presentations. This agrees with a study carried out in Diyala government/Iraq in 2019 [19]. According to published research, *enteroviruses* are associated with elevated rates of morbidity and mortality in pediatric age groups, particularly in neonates and infants under one year of age. However, these morbidities and fatalities have decreased recently. Similar to prior research, *enterovirus* can manifest at any age. Severe infections are prevalent in neonates, especially those under two weeks old [3].

The World Health Organization, in their report about the outbreak of meningitis in the center of Halabja and nearby Sirwan City, in Kurdistan, Iraq 2023, clarified that boys were afflicted twice as frequently as females, and school-aged youngsters made up the majority of the cases [2]. The cause could be that these age groups have cerebral shunts, immunocompromised factors, or predisposing factors [23].

In a number of clinical contexts, CRP levels have been employed as a quick diagnostic method to distinguish between aseptic and pyogenic meningitis [24]. Patients with bacterial and aseptic meningitis showed significant differences in the distribution of all biological parameters found in the blood and cerebrospinal fluid. In the current study, more than 60.5% of patients had elevated CRP. These findings are in line with a previous study by J. Lee *et al.*[10]. Of the 58 meningitis patients with a positive culture, 53 (91.37%) had positive CSF CRP values [1].
Largman-Chalamish *et al*. showed that individuals upon admission, bacterial patients had higher CRP levels (133 mg/L) than viral patients (23.31 mg/L) ($p < 0.001$). Their CRP velocity median value was four times more than that of the viral patients, indicating that the use of CRP findings and time from symptom start could benefit clinicians in discriminating between viral and bacterial infections [7]. According to a study, 39 patients (33.3%) had negative CRP and 78 patients (66,7%) had positive CRP [17]. Before being discharged, a small number of individuals had slightly elevated CRP levels exceeding 5mg/dl. Despite the literature's claim that *enteroviruses* are momentarily present in the CSF during acute infection, only 32% of the samples had positive PCR results [3]. When compared to aseptic meningitis, the CSF–CRP level was considerably higher in septic infections ($p = 0.0$) in research by Javadinia *et al.* to quantitatively assess the CSF-CRP level in meningitis-affected children [25]. So, the measurement of CRP in CSF has recently been proposed as a simple, sensitive, and reliable diagnostic for meningitis. Additionally, the determination of CSF–CRP aids in selecting the right antibiotic and the length of treatment [25]. The majority of inflammatory illnesses can result in measurable CRP levels in blood or other bodily fluids that are strongly related to the tissues that are afflicted [20]

In the present study, the total white blood cell count differed based on age. Additionally, 64.8% of patients had a significantly high WBC count (45.7% had aseptic meningitis, whereas 19.1% had septic meningitis). This result agrees with another study that found that all of the patients under a year old had either high or normal lymphocyte levels when they first arrived [3]. These results may provide information about viral infection [3]. A study by Huu *et al*., found that 50% of the patients had a CSF leucocyte count exceeding 500 cells/mm_3. Leucocyte counts > 500 cells/mm3 were detected in every dead subject. The CSF of the deceased group had larger levels of WBC and neutrophils than that of the living group, and

this difference was statistically significant [20]. Raheem *et al.,* reported that leukocytosis was present in 78.6% of study subjects, of which 70.9 % of patients were infected with viral meningitis and 29.1% of them had bacterial meningitis [19].
Jarad explained that among the patients with CSF cell counts indicative of bacterial meningitis, an important predictive factor was the CSF cell count (>1000 cells) [17]. Nadeem *et al.* in their study recorded that the patients in the aseptic group had a mean total leukocyte count (TLC) level of 253.78 ± 269.95, while those in the bacterial group had a mean of 3689.09±2113.65. In both groups, the mean TLC level was statistically significant ($p < 0.001$) [21].

In the current study, when bacterial meningitis 102 (39.8%) was compared to viral meningitis 51(19.9%), there was a considerable increase in cerebrospinal fluid protein. Another study noted similar findings [1]. A study by Nadeem *et al.,* in 2018 identified that the average CSF protein of the patients in the aseptic group was 56.72 ± 27.53, while the bacterial group's mean was 72.79 ± 28.68 [21]. Another study reported that in bacterial meningitis, the mean CSF protein was substantially higher than in viral meningitis [19]. Huu *et al.,* demonstrated that since high protein and WBC were frequently seen in severe patients, it is imperative that these findings be closely monitored during the CSF test [20].
Many factors could have contributed to the disparities, including the size of the sample, the time of the lumber punctures, whether they were performed early in the disease or later and the use of antibiotics [20].

The present results showed that younger children with meningitis had a higher prevalence of males than older age groups; this difference was statistically significant (*P*-value: 0.02). These findings are comparable to the previous studies [12, 18, 21]. The age range of the patients was 1 month to 12 years, with a mean age of 28.30 ± 1.23 months. The bulk of the children (46.15%) belonged to the 1 month to 1 year age group, and there was a statistically significant finding that male was impacted more than females [1]. In a study by Garg *et al.,* which involved children in Shimla from 1 month to 5 years of age, 57 instances were identified as acute bacterial meningitis, with 59.6% of the cases falling into the 3–12 months age category, and the majority of the patients were male [27]. Al-Sanouri e*t al.* was noted in 33.1% of the suspected cases were younger than 1-year-old when they arrived at the hospital, followed by 27.8% of cases that were between 1 and 4 years old and 21.7% of cases that were between 5 and 14 years old and predominantly males (62.9%) [12].

It was found that there was a significant association ($p < 0.05$) between the cause of meningitis and CSF glucose. A study represented those patients suffering from bacterial meningitis had an average glucose level of 38.65 ± 13.88, while those with viral meningitis had an average glucose level of 49.26 ± 152.20. In both groups, the mean glucose level was statistically significant (p-value < 0.001) [21]. Children in the study group had mean CSF sugar levels of 58.2% mg and mean protein levels of 74.22% mg [1]. Raj *et al.* discovered that, in comparison to aseptic meningitis, the CSF results of patients with bacterial meningitis showed statistically greater WBC counts, protein levels, and lower glucose levels ($p < 0.01$ for all) [26].

Many factors influence the course of acute meningitis. The following variables have an impact: age at diagnosis, degree of awareness at admission, protracted or complex seizures, disease progression prior to antibiotic therapy, etiologic agent, and delayed CSF sterilization [27]. Meningitis, in general, has several variables that can raise the chance of infection. For example, compared to other age groups, newborns and children pose more risks [5].

The results of the current study showed that the lowest prevalence of meningitides infection was observed in March, with May seeing the highest number of instances. A similar finding was also reported in various other studies [5, 12, 27-29]. Neamah *et al.,* discovered that there was a high correlation between the incidence of meningococcal meningitis and the dry seasons (summer and fall). The seasonal relationship was impacted by variations in the patients' ages and genders, and it was added that in all seasons, meningitis infection was observed to occur more frequently in men than in women [5]. Abdelrahim *et al.,* found that the summer, which runs from March to June, is when most admissions of patients with meningitis occur [30].

The study observed that one of the diseases sensitive to climate change that is impacted by global warming is cerebrospinal meningitis, and this finding indicated that there was a statistically significant correlation between climate factors and cerebrospinal meningitis, also added that cerebrospinal meningitis outbreaks were substantially correlated with high temperatures, lots of sunshine, little precipitation, and low relative and absolute humidity, as well as according to the participants, the beginning of meningitis is driven by high temperatures, sunshine, low relative humidity, and dusty, dry winds. They held that sunlight and temperature cause dehydration, which makes people more susceptible to cerebrospinal meningitis. Additional significant risks linked to cerebrospinal meningitis included living in cramped, poorly ventilated rooms, unsanitary surroundings, deforestation, undernourishment, and compromised immune systems. It is thought that warm conditions are ideal for the growth of meningitis. It was also discovered that unventilated rooms generate heat at night, which puts people at risk for meningitis. It gets worse because heat is released by the body at night, which could make the environment feel even warmer. Additionally, when breathing, more carbon dioxide is exhaled, warming rooms with inadequate ventilation and perhaps leading to an epidemic of meningitis [31], Furthermore, we discovered that patients from the age range of 6 -10 years old had a considerably higher percentage of meningitis occurrence during the May, while patients of all ages tend to fall off in March, in terms of statistics, these relationships between age and seasons and meningitis illness were not significant. These results are consistent with other studies [5, 12, 28, 30].

Meningitis risk factors include recent colonization with pathogenic microorganisms, lack of immunity to certain infections associated with early age, and intimate contact. Cold nights and dust winds are features of the dry season in several nations, like Iraq. These illnesses may raise the risk of meningococcal disease in addition to upper respiratory tract infections that harm the nasopharyngeal tract. The dry season, which begins in June and lasts until September, is almost always linked to outbreaks of *meningococci* [5].

It was discussed how social and religious events, including marketplaces, marriages, funerals, naming ceremonies, and festivals, could cause a meningitis outbreak. This is due to the fact that cerebrospinal meningitis is an infectious illness that spreads through an affected person's bodily fluids, including their respiratory and throat secretions. The chance of the disease spreading is higher in large groups [30]. Risk factors for bacterial meningitis infection include living in cramped quarters, eating dirty or improperly prepared food, sharing a home with an infected person, and drinking contaminated water [32]. In biofilms, enhanced antibiotic resistance or tolerance is a typical problem. It could result from the environment in which microbes flourish, or it might be linked to the exchange or mutation of genes that cause antibiotic resistance [33].

Above all, the current findings highlight how urgently Iraq needs to strengthen its testing and surveillance capabilities. Nowadays, RT–PCR is essential for diagnosing meningitis regardless of previous antibiotic use or low bacterial load, but developing nations are severely limited by its high cost. To lower the morbidity and mortality of the pediatric age group and to prevent complications, early diagnosis and aggressive care measures are of the utmost importance. In order to describe the more often circulating strains of meningococcal illness and to direct future preventative and control measures, epidemiological data are required. A multidisciplinary meningitis course was arranged by the WHO in Halabja city and Sulaymaniyah governorate for surveillance personnel, medical experts, and laboratory technicians in cooperation with the Ministry of Health. Response tactics could include immunizing children against pneumococcal disease, adhering to infection prevention and control protocols, and improving community education and awareness, depending on the pathogen that has been identified as the cause.

Limitations of the study

Limitations in the current study included a small sample size and its retrospective design, a short study period, and missing data, which are not a reality because the CSF statistics were verified using the computerized lab reports. The lack of RT–PCR estimation.

5. Conclusion

Most cases of meningitis were caused by viral infections. Meningitis has a major impact on children under five years old, with males predominating. In our community, meningitis occurs mainly in May, June, and July. Seasonality was not influenced by the patients' ages. The useful method can assist in distinguishing between aseptic and septic meningitis. In order to control this serious illness, vaccination programs against bacterial and viral agents must be implemented in our nation.

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Conflict of Interest

All authors declare that there is no conflict of interest

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