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A RESEARCH ARTICLE

Clinical, Demographic, and Laboratory Profile of Pediatric Meningitis at Benghazi Pediatric Hospital, Libya: A Retrospective Study

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Abstract

Background: Meningitis affects more than 2.5 million people annually and disproportionately burdens pediatric populations, particularly in low- and middle-income countries. Libya lacks comprehensive, up-to-date clinical data on pediatric meningitis, limiting evidence-based interventions. To characterize the demographic, clinical, and laboratory profiles of children diagnosed with meningitis at Benghazi Pediatric Hospital, Libya, in 2024, and to assess disease outcomes, including mortality. **Materials and Methods:** A retrospective descriptive study was conducted involving 101 children aged 0–10 years diagnosed with meningitis during 2024. Data were manually extracted from paper-based medical records and analyzed using descriptive statistics including frequencies, percentages, means, and standard deviations. **Results:** Infants aged 3 to <12 months constituted the largest group (47.5%), with male predominance (62.4%). Fever was present in 84.2% of cases and vomiting in 51.5%. Elevated CSF WBC counts were observed in 68.3% of cases. CRP >50 mg/L, indicating likely bacterial infection, was found in 20.8% of patients. CSF bacterial culture was positive in only 2.0% of cases, attributed to prior antibiotic use. The overall mortality rate was 5.9%. Comorbidities were present in 51.5% of cases.
Conclusion: Pediatric meningitis in Benghazi predominantly affects infants under one year, with significant inflammatory markers and moderate mortality. These findings underscore the need for enhanced vaccination coverage, improved molecular diagnostics, early empirical treatment, and structured survivor follow-up in Libyan pediatric hospitals.

1. Introduction

Meningitis is an inflammation of the meninges surrounding the brain and spinal cord, which affects more than 2.5 million individuals annually worldwide and ranks among the most life-threatening infections in childhood [1]. Epidemiological data consistently demonstrate that infants under one year bear the greatest burden, a pattern attributed to immunological immaturity, waning maternal antibodies, and incomplete vaccination schedules during this developmental window [2]. Low- and middle-income countries account for the highest case loads, compounded by delays in diagnosis, restricted access to antimicrobial therapy, and inadequate intensive care capacity [3]. The World Health Organization has designated meningitis a priority disease for urgent global action, particularly in settings with limited healthcare infrastructure [4].

The three principal pathogens responsible for bacterial meningitis, Neisseria meningitidis, Streptococcus pneumoniae, and Haemophilus influenzae type b, collectively cause approximately 70% of bacterial cases globally [5,6]. Despite advances in conjugate vaccination, these organisms continue to drive substantial morbidity and mortality wherever immunization coverage remains suboptimal. Clinical presentation in young children is typically nonspecific: infants rarely exhibit the textbook triad of fever, neck stiffness, and altered consciousness, and may present instead with irritability, bulging fontanelle, or high-pitched cry. Delayed diagnosis carries severe consequences, including hearing loss, cognitive impairment, motor deficits, and death [7].

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Libya presents a particularly challenging environment for studying and managing pediatric meningitis. Prolonged political instability, armed conflict, and chronic healthcare system fragmentation have disrupted immunization programs, disabled disease surveillance networks, and severely limited research infrastructure [8,9]. Hospital-based data on pediatric meningitis are consequently rare, outdated, or incomplete, leaving clinicians without the local epidemiological context needed for evidence-based management [10].

The most recent comparable local study, by Al-Ojali et al. (2022), retrospectively analyzed 400 clinically diagnosed bacterial meningitis cases at Benghazi Pediatric Hospital (January 2018–December 2019), of which 103 (25.75%) were culture-confirmed [11]. Predominant pathogens included Staphylococcus aureus (14.6%), Streptococcus pneumoniae (11.7%), and Klebsiella pneumoniae (9.7%), with 75.5% of cases in children under one year and an overall mortality rate of 6.9%. The present study expands on this work by encompassing all meningitis types, employing broader laboratory profiling, and providing updated 2024 epidemiological data.

This study aimed to characterize the demographic, clinical, and laboratory profiles of children diagnosed with meningitis at Benghazi Pediatric Hospital in 2024, and to assess disease outcomes, including in-hospital mortality.

2. Materials and Methods

2.1. Study design and setting

A retrospective descriptive study was conducted at Benghazi Pediatric Hospital, the principal tertiary pediatric referral center in eastern Libya, serving a catchment population of approximately 1.5 million. The hospital provides specialized pediatric care across infectious diseases, intensive care, neurology, and emergency services.

2.2. Study population and eligibility criteria

All children aged 0–10 years admitted with a diagnosis of meningitis during 2024 were eligible. Meningitis was diagnosed when clinical features (fever, vomiting, altered consciousness, seizures, or meningeal signs) were supported by laboratory evidence of CNS inflammation: elevated CSF white blood cell count, elevated CSF protein, or decreased CSF glucose relative to age-specific reference ranges. Cases with incomplete CSF data were excluded. A total of 101 cases met the inclusion criteria.

2.3. Data collection

Trained medical laboratory technicians manually extracted data from paper-based medical records using a standardized extraction form. Variables included: demographic data (age, sex, nationality, admission and discharge dates); clinical data (presenting symptoms and comorbid conditions); laboratory data (complete blood count, CRP, and CSF analysis); and outcome data (discharge status, length of hospital stay).

2.4. Laboratory methods

Venous blood was collected and analyzed using automated hematology analyzers (Sysmex XN-1000, Sysmex Corporation, Kobe, Japan). CRP was quantified by immunoturbidimetric assay (Cobas c501, Roche Diagnostics, Basel, Switzerland). CSF samples were collected by trained pediatric physicians through lumbar puncture performed under strict aseptic conditions. CSF analysis included manual microscopic cell counting, biochemical measurement of protein and glucose, Gram staining, and bacterial culture. Bacterial culture was performed on blood agar and chocolate agar, with plates incubated at 35–37°C in 5% CO_2 for up to 72 hours.

2.5. Data analysis

Data were entered into Microsoft Excel 2019 and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as absolute frequencies and percentages. Continuous variables were tested for normality using the Shapiro–Wilk test and reported as means ± standard deviations for normally distributed data or as medians with interquartile ranges otherwise. Age was stratified into five clinically relevant groups: <1 month, 1 to <3 months, 3 to <12 months, 1 to <5 years, and 6 to 10 years. All laboratory parameters were interpreted against age-specific pediatric reference ranges. Subgroup distributions across age and sex were examined descriptively. Given the descriptive nature of the study and unequal subgroup sizes, no formal inferential hypothesis testing was performed.

2.6. Ethical considerations

Ethical approval/administrative permission for this retrospective anonymized record review was obtained from the relevant authorities at Benghazi Pediatric Hospital. As the study used existing paper-based medical records, no direct patient contact was involved. No names, registration numbers, or other personal identifiers were extracted. All data were anonymized before analysis and handled confidentially in accordance with applicable institutional standards.

3. Results and Discussion

3.1. Demographic characteristics

A total of 101 children were enrolled. Infants aged 3 to <12 months constituted the largest subgroup (n = 48, 47.5%), followed by early infants aged 1 to <3 months (n = 17, 16.8%) and neonates aged <1 month (n = 16, 15.8%). Collectively, children under one year of age accounted for 80.2% of all cases (Table 1, Figure 1). This distribution closely parallels the 75.5% under-one-year predominance reported by Al-Ojali et al. (2022) from the same institution [11] and aligns with global epidemiological surveillance data [2,6]. The consistency across two independent studies conducted five years apart reflects the structural vulnerability of infancy [12], including waning maternal antibody protection, functional immunological immaturity, and vaccination schedules that leave the 2–6-month window particularly exposed to invasive pathogens.

Table 1. Demographic Characteristics of Children with Meningitis (N = 101)

Characteristic	n	%
Age group		
<1 month (neonates)	16	15.8
1 to <3 months (early infants)	17	16.8
3 to <12 months (late infants)	48	47.5
1 to <5 years (toddlers)	13	12.9
6 to 10 years (school-age)	7	6.9
Total	101	100.0
Sex		
Male	63	62.4
Female	38	37.6
Nationality		
Libyan	94	93.1
Other	7	6.9

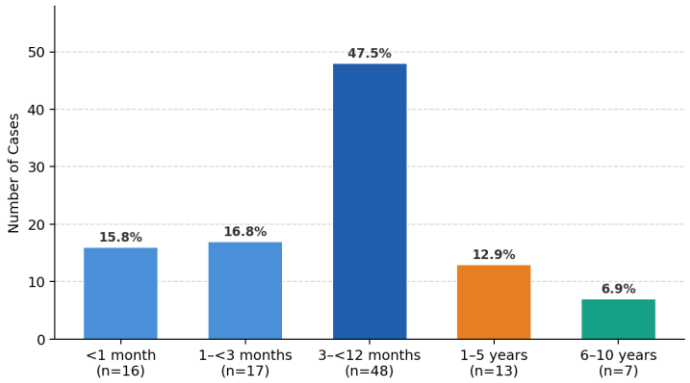

Figure 1. Age distribution of pediatric meningitis cases (N = 101). Infants aged 3 to <12 months accounted for 47.5% of the cohort; children under 1 year collectively accounted for 80.2% of all cases.

Male children predominated (n = 63, 62.4%), yielding a male-to-female ratio of 1.66:1 (Figure 2). This sex disparity is consistent with prior reports from Libya [11, 13] and global pediatric infectious disease literature [14,15]. Proposed mechanisms include X-linked differences in innate immune gene expression and sex-hormone-modulated inflammatory responses. Libyan nationals comprised 93.1% (n = 94) of the cohort, reflecting the hospital's primary service population. The small non-Libyan

minority (6.9%) consisted predominantly of children of regional migrant and displaced populations residing in Benghazi, who access the hospital under the same public-service framework as Libyan nationals; this distribution mirrors the demographic composition of the wider Benghazi catchment area [9].

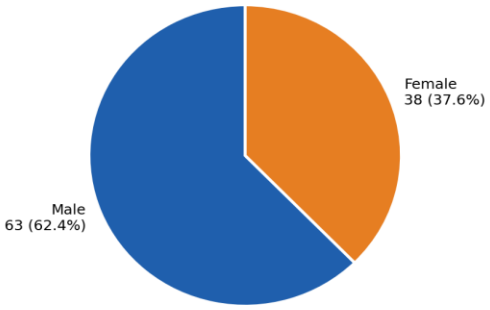

Figure 2. Sex distribution of patients (N = 101). Male predominance (62.4%) is consistent with patterns reported from Libya and the wider North African region.

3.2. Clinical presentation and comorbidities

Fever was the most prevalent presenting symptom (84.2%, n = 85), followed by vomiting (51.5%, n = 52), irritability (23.8%, n = 24), seizures (15.8%, n = 16), and altered consciousness (12.9%, n = 13). Comorbid conditions were documented in 51.5% (n = 52) of cases, with pneumonia (28.7%, n = 29) and sepsis (18.8%, n = 19) the most frequent (Table 2, Figure 3). These frequencies parallel those reported by Al-Ojali et al. (2022), who found fever in 90% and vomiting in 60% of bacterial meningitis cases [11]; the modestly lower rates in the present study likely reflect the inclusion of viral and aseptic cases.

Table 2. Clinical Features of Children with Meningitis (N = 101)

Clinical feature	n	%
Presenting symptoms		
Fever	85	84.2
Vomiting	52	51.5
Irritability	24	23.8
Seizures	16	15.8
Altered consciousness	13	12.9
Comorbid conditions		
Any comorbidity	52	51.5
Pneumonia	29	28.7
Sepsis	19	18.8
Congenital anomalies	4	4.0

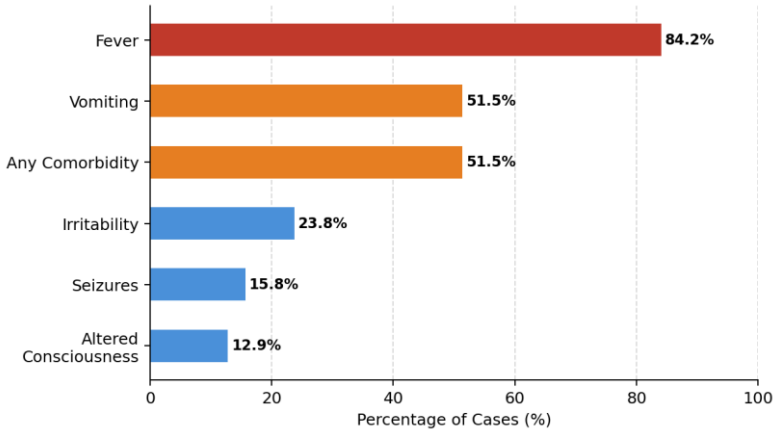

Figure 3. Prevalence of clinical symptoms and comorbidities (N = 101). Fever was the predominant presenting feature (84.2%); comorbid conditions were present in 51.5% of patients.

The high frequency of fever and vomiting as dominant presenting features, combined with low rates of classic meningeal signs, underscores a fundamental diagnostic challenge in this age group. The complete meningeal triad (fever, neck stiffness, photophobia) is rarely present in infants; bulging fontanelle, paradoxical irritability, and high-pitched cry may be the only early indicators [16] of CNS involvement. The high co-occurrence of meningitis with pneumonia (28.7%) and sepsis (18.8%) reflects the immature blood-brain barrier in early infancy, which facilitates hematogenous CNS seeding from systemic infection. Clinicians must maintain a low threshold for lumbar puncture in febrile infants, even when a concurrent systemic infection appears to explain the presentation.

3.3. Hematological and inflammatory markers

Mean hemoglobin was 10.8 ± 1.9 g/dL; anemia (below age-specific reference range) was present in 42.6% (n = 43) of patients, with the distribution across age groups shown in (Figure 5). Leukocytosis (WBC >15 × 10^3/µL) was found in 23.8% (n = 24) and thrombocytopenia (<150 × 10^3/µL) in 7.9% (n = 8) [17]. CRP was elevated (>10 mg/L) in 50.5% (n = 51) of cases; critically, CRP >50 mg/L, indicating likely bacterial etiology, was found in 20.8% (n = 21) (Figure 4). This elevation reflects the hepatic acute-phase response driven by pro-inflammatory cytokines, primarily interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and interleukin-1 (IL-1), released by activated macrophages and endothelial cells during invasive bacterial infection [17]. The remaining 49.5% (n = 50) had normal or mildly elevated CRP (<10 mg/L), consistent with viral or aseptic meningitis (Table 3).

Table 3. Hematological Parameters in Children with Meningitis (N = 101)

Parameter	Mean ± SD	Abnormal values n (%)
Hemoglobin (g/dL)	10.8 ± 1.9	43 (42.6%) below the age-specific reference
WBC (× 10^3/µL)	11.2 ± 5.3	24 (23.8%) > 15 × 10^3/µL
Platelets (× 10^3/µL)	285 ± 98	8 (7.9%) < 150 × 10^3/µL
CRP (mg/L)	28.5 ± 35.2	51 (50.5%) > 10 mg/L; 21 (20.8%) > 50 mg/L

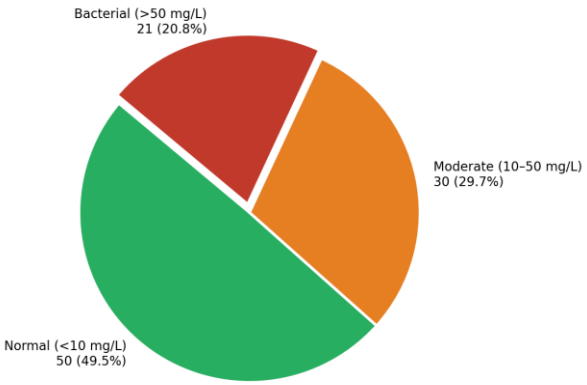

Figure 4. CRP distribution across the study cohort (N = 101). CRP >50 mg/L, indicating likely bacterial etiology, was found in 20.8% of patients and served as the primary surrogate marker of bacterial meningitis in the absence of positive culture results.

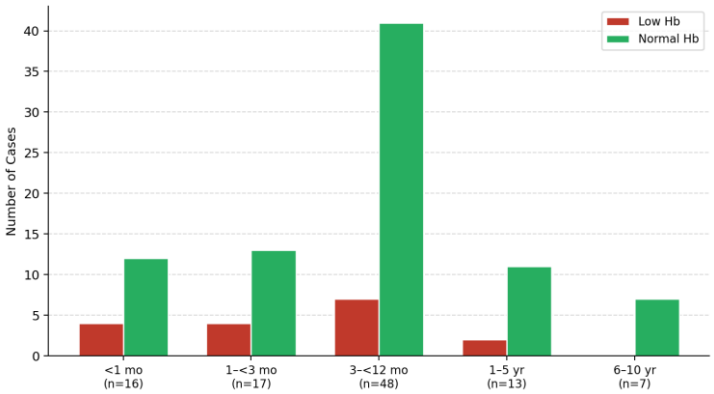

Figure 5. Hemoglobin levels stratified by age group (N = 101). Anemia was most prevalent in the 3 to <12-month age group, reflecting nutritional vulnerability in the period of peak disease burden.

A level of C-reactive protein (CRP) greater than 50 mg/L is a significant biochemical indicator that is highly suggestive of bacterial infection. This encourages clinicians to apply strong empirical antibiotic stewardship in the early stages, particularly in settings with limited resources where a distinct causative organism is not yet identified [15,18]. Anemia in 42.6% of patients is unlikely to be caused solely by acute infection-related hemolysis and may reflect underlying nutritional vulnerability common in this pediatric population [19], highlighting the importance of nutritional assessment during hospitalization.

3.4. Cerebrospinal fluid analysis

CSF appeared turbid or cloudy in 31.7% (n = 32) of cases, a finding strongly associated with bacterial etiology, while 68.3% (n = 69) had clear CSF, consistent with viral, aseptic, or partially treated bacterial meningitis. Elevated CSF WBC above the age-specific upper limit was found in 68.3% of cases (n = 69), with the age-group distribution shown in Figure 6; RBCs were absent in 44.6%, present in small numbers in 41.6%, and moderate to high in 13.8% of samples. CSF protein was elevated in a subset of patients when assessed against age-specific thresholds (up to 100 mg/dL for neonates, 80 mg/dL for 1–3 months, 60 mg/dL for older children). CSF glucose was normal in 84.2% (n = 85), elevated in 13.9% (n = 14), and low (<40 mg/dL) in 2.0% (n = 2). CSF bacterial culture was positive in only 2.0% (n = 2) of cases (Table 4, Figure 7).

Table 4. Cerebrospinal Fluid (CSF) Findings (N = 101)

CSF parameter	Category	n (%)
Appearance		
CSF appearance	Clear	69 (68.3%)
CSF appearance	Turbid / Cloudy	32 (31.7%)
WBC count		
CSF WBC (above age-specific upper limit)	Elevated	69 (68.3%)
RBC		
RBC in CSF	None	45 (44.6%)
RBC in CSF	Few	42 (41.6%)
RBC in CSF	Moderate	8 (7.9%)
RBC in CSF	High	6 (5.9%)
Glucose		
CSF Glucose	Normal	85 (84.2%)
CSF Glucose	Elevated	14 (13.9%)
CSF Glucose	Low (<40 mg/dL)	2 (2.0%)
Bacterial Culture		
CSF Culture	Positive growth	2 (2.0%)
CSF Culture	No growth	99 (98.0%)

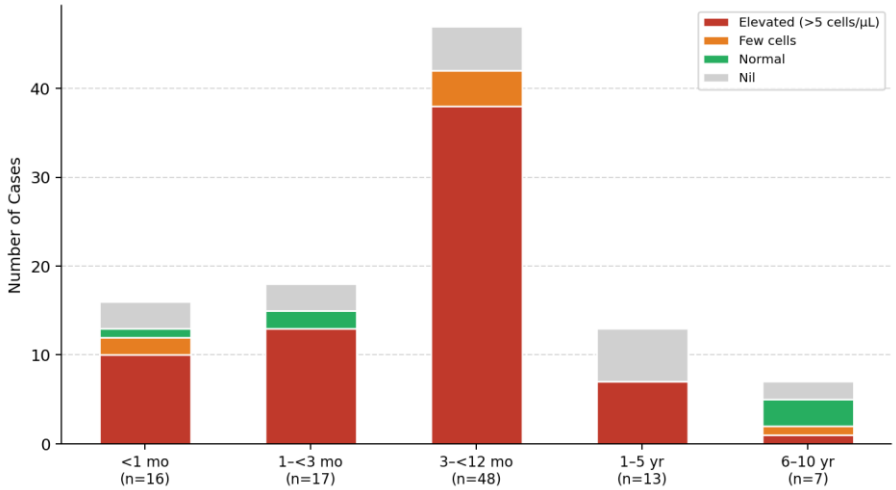

Figure 6. CSF white blood cell count by age group (N = 101). Elevated CSF WBC was most prevalent in the 3 to <12-month group, accounting for the largest proportion of inflammatory CSF findings, consistent with the peak disease burden in late infancy.

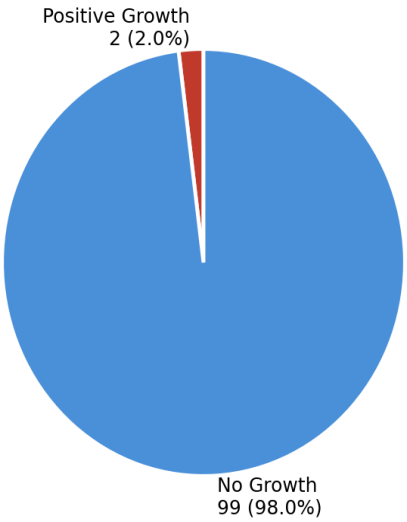

Figure 7. CSF bacterial culture results (N = 101). Only 2.0% of cultures yielded bacterial growth, attributed to near-universal empirical antibiotic administration prior to lumbar puncture.

The positive cultures yielded Streptococcus pneumoniae and Escherichia coli, respectively. The contrast between the 2.0% culture positivity in the present study and the 25.75% reported by Al-Ojali et al. (2022) [11] is not evidence of declining bacterial incidence; rather, it is the direct microbiological consequence of empirical antibiotic administration before lumbar puncture, a practice observed to be nearly universal at referring facilities in this setting. Viable bacterial load in CSF falls precipitously within hours of the first antibiotic dose, rendering conventional culture insensitive [15, 18, 20]. The introduction of multiplex PCR-based CSF assays, which retain sensitivity 48–72 hours after antibiotic initiation, is the most impactful single diagnostic investment this institution could make.

3.5. Patient outcomes

The in-hospital mortality rate was 5.9% (n = 6), with all six deaths occurring in infants under one year. Mean length of hospital stay was 8.5 ± 4.2 days (range 2–21 days). Among the 95 survivors (94.1%), 88 patients (87.1% of the total) were discharged in stable condition, while 7 survivors (6.9% of the total) were discharged with documented neurological sequelae, including seizures or developmental delay (Table 5, Figure 8). Long-term follow-up beyond the index hospitalization was not available for most patients.

Table 5. Patient Outcomes (N = 101)

Outcome	n	%
In-hospital mortality	6	5.9
Survival — total	95	94.1
Discharged in stable condition	88	87.1
Discharged with neurological sequelae	7	6.9
Mean hospital stay (days)	8.5 ± 4.2 (range 2–21)	—

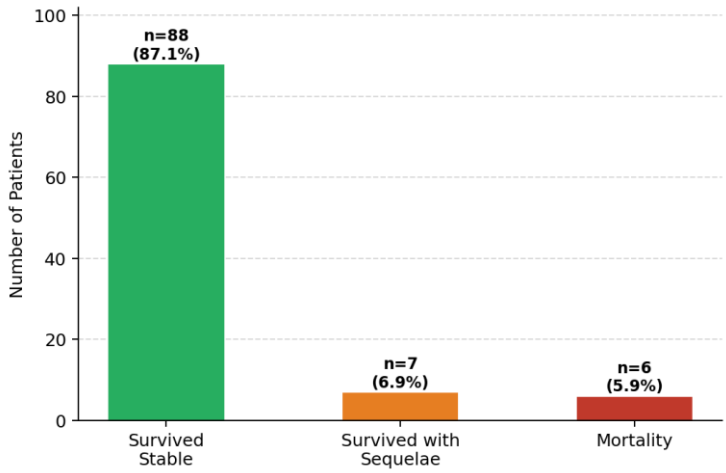

Figure 8. Patient outcomes (N = 101). Overall survival was 94.1%; 87.1% were discharged stable. Neurological sequelae at discharge (6.9%) likely underestimate the true burden of post-meningitis morbidity.

The 5.9% mortality rate is marginally lower than the 6.9% reported by Al-Ojali et al. (2022) [11], suggesting modest clinical improvement over the five-year interval, though it remains substantially above the 2–5% range seen in high-income countries with advanced pediatric intensive care [18, 21, 22]. All deaths occurred in infants under one year, identifying this group as the primary target for mortality-reduction strategies. Contributing factors include delayed referral, sub-optimal empirical antibiotic regimens, and limited access to intensive care resources. Neurological sequelae in 6.9% of survivors almost certainly underestimates the true neurological morbidity burden; international prospective studies consistently report that 20–30% of meningitis survivors develop at least one long-term complication, most commonly sensorineural hearing loss [7, 22, 23]. Establishing systematic audiological and neurodevelopmental follow-up at this institution is an immediately actionable, low-cost intervention.

3.6. Comparison with regional and global data and public health implications

The findings are broadly consistent with published data from North Africa and the wider Middle East, where similar infant-predominant age distributions, male excess, fever-dominant presentations, and moderate mortality rates have been described [14, 15, 24]. Globally, conjugate vaccines have reduced vaccine-preventable meningitis incidence by more than 90% in countries with sustained high immunization coverage [21, 25]. Libya's vaccination programs have suffered severe disruption from political conflict and healthcare fragmentation [8, 9]; the persistence of high infant meningitis rates at this institution between 2018–2019 and 2024 is itself evidence that coverage in the eastern Libyan catchment area remains insufficiently protective. Closing immunization gaps and implementing PCR-based diagnostics are the two highest-yield interventions available for reducing pediatric meningitis burden in this setting. In parallel, rational antibiotic-use policies should be strengthened, including discouraging unsupervised antibiotic dispensing in community pharmacies, as pre-lumbar-puncture antibiotic exposure substantially reduces CSF culture yield and limits pathogen identification.

3.7. Study strengths and limitations

This study provides the first comprehensive hospital-based clinical dataset on pediatric meningitis in eastern Libya for 2024, with systematic data extraction across a full calendar year and age-specific laboratory interpretation. Limitations include: retrospective design with paper-based records; near-zero CSF culture positivity precluding pathogen characterization; single-center design that may overrepresent referred severe cases; absence of long-term follow-up; and lack of molecular diagnostics.

4. Conclusions

Pediatric meningitis at Benghazi Pediatric Hospital in 2024 predominantly affects infants under one year, with male predominance, fever and vomiting as dominant presenting features, and a 5.9% in-hospital mortality rate. The near-universal CSF culture negativity (2.0%), attributable to pre-lumbar-

puncture antibiotic administration, is the most operationally significant finding, rendering microbiological characterization impossible in the vast majority of cases. Four immediate priorities are identified: (1) accelerating vaccination coverage against leading bacterial pathogens in the first year of life; (2) implementing PCR-based molecular CSF diagnostics to recover etiological data lost to pre-treatment; (3) standardizing institutional protocols for lumbar puncture timing and empirical antimicrobial regimens; and (4) establishing structured audiological and neurodevelopmental follow-up for all meningitis survivors. Future research should include prospective, multicenter studies with molecular diagnostics and long-term follow-up [26].

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Author Contributions

Abdelnaser O. Busba (A.O.B.) and Abdelmuhsen M. Abusneina (A.M.A.) conceived and designed the study. Mohammed A. Aldrsy (M.A.A.), Ahmed M. Alfaitory (A.M.Al.), and Moath F. Alsaity (M.F.A.) were responsible for data collection and manual extraction from medical records. Abdelmuhsen M. Abusneina (A.M.A.), Abdelnaser O. Busba (A.O.B.), and Muna N. Albadry (M.N.A.) performed the statistical analysis and interpretation. Abdelmuhsen M. Abusneina (A.M.A.) and Abdelnaser O. Busba (A.O.B.) drafted and critically revised the manuscript. All authors reviewed and approved the final version of the manuscript for submission.

Disclosure of Conflict Of Interest

The authors declare no conflicts of interest.

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التوصيف الديموغرافي والسريري والمخبري للتهاب السحايا لدى الأطفال في مستشفى بنغازي للأطفال، ليبيا: دراسة استعادية

الملخص

الخلفية: يُعدّ التهاب السحايا من الأمراض التي تُشكّل خطرًا صحيًا عامًا بالغ الأهمية، إذ يصيب ما يزيد على 2.5 مليون شخص سنويًا على مستوى العالم، مع تحمّل الفئات العمرية الصغيرة العبء الأكبر من هذا المرض. ولا تزال ليبيا تفتقر إلى بيانات سريرية شاملة ومحدّثة حول التهاب السحايا لدى الأطفال، مما يُعيق تطوير تدخّلات طبية قائمة على الأدلة. هذه الدراسة صممت لوصف الملامح الديموغرافية والسريرية والمخبرية للأطفال المشخَّصين بالتهاب السحايا في مستشفى بنغازي للأطفال، ليبيا، خلال عام 2024، وتقييم مآلات المرض بما فيها معدلات الوفيات.

المنهجية: أُجريت دراسة وصفية استعادية شملت 101 طفلًا تتراوح أعمارهم بين 0 و10 سنوات، شُخِّصوا بالتهاب السحايا خلال عام 2024. استُخرجت البيانات يدويًا من السجلات الطبية الورقية، وحُلّلت باستخدام الإحصاء الوصفي.

النتائج: شكّل الرضع في الفئة العمرية من 3 أشهر إلى أقل من 12 شهرًا أكبر المجموعات (47.5%)، فيما مثّل الذكور 62.4% من الحالات. سُجّلت الحمى لدى 84.2% من المرضى، والقيء لدى 51.5%. تجاوزت أعداد كريات الدم البيضاء في السائل الدماغي الشوكي الحدود المرجعية لدى 68.3% من الحالات. بلغ مستوى CRP أكثر من 50 ملغ/ل لدى 20.8% من المرضى. أسفرت مزارع السائل الدماغي الشوكي عن نتائج إيجابية في 2.0% فقط من الحالات. بلغت نسبة الوفيات 5.9%، وكانت جميع حالات الوفاة في رضع دون سنة واحدة.

الاستنتاج: يُصيب التهاب السحايا في بنغازي في المقام الأول الرضع دون سنة واحدة، ويرتبط بمؤشرات التهابية مرتفعة ومعدل وفيات معتدل. تُبرز هذه النتائج الحاجة إلى تعزيز برامج التطعيم، وتطوير التشخيص الجزيئي، وتحسين بروتوكولات الإدارة السريرية، وإنشاء برامج متابعة منظّمة للناجين.

الكلمات المفتاحية: التهاب السحايا؛ طب الأطفال؛ السائل الدماغي الشوكي؛ ليبيا؛ معدل الوفيات؛ العدوى البكتيرية