



ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCES
SCHOOL OF NURSING AND MIDWIFERY
DEPARTMENT OF EMERGENCY AND CRITICAL CARE NURSING

**TITLE: TREATMENT OUTCOMES AND ASSOCIATED FACTORS OF
ACUTE BACTERIAL MENINGITIS AMONG CHILDREN ADMITTED TO
PEDIATRIC EMERGENCIES OF SELECTED PUBLIC HOSPITALS IN
ADDIS ABABA, ETHIOPIA.**

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This is to certify that the thesis entitled “treatment outcomes and associated factors of acute bacterial meningitis among children admitted to pediatric emergencies of selected public hospitals in Addis Ababa, Ethiopia, 2025” is submitted in partial fulfillment of the MSC with specialization in Emergency Medicine and critical care nursing to the Graduate program of the college of health sciences of Addis Ababa University and was done by Mekrez Tadesse under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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I thus declare this MSc thesis is my original work, that it has not been submitted for a degree at any other university, and that all sources of material used in this thesis have been properly acknowledged.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABM	Acute Bacterial Meningitis
AFB	Acid-Fast Bacilli
AOR	Adjusted Odds Ratio
BBB	Blood-Brain Barrier
CABM	Community Acquired Bacterial Meningitis
CNS	Central Nervous System
COR	Crude Odds Ratio
CSF	Cerebrospinal Fluid
CT	Computed Tomography
ETB	Ethiopian Birr
GBS	Group B Streptococcus
Hib	Haemophilus Influenzae Type B
LP	Lumbar Puncture
MRI	Magnetic Resonance Imaging
PCV-10	pneumococcal conjugate
TASH	Tikur Anbessa Specialized Hospital
WBC	White Blood Cell
WHO	World Health Organization

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ABSTRACT

Background: Acute bacterial meningitis remains a major health challenge among children under five in sub-Saharan Africa, including Ethiopia, where mortality ranges from 15% to 32.65%. Despite expanded immunization programs, delayed treatment, limited diagnostic capacity, and resource constraints contribute to poor outcomes. This study assessed treatment outcomes and associated factors of acute bacterial meningitis among children in public hospitals in Addis Ababa, highlighting gaps in treatment protocols and resource allocation.

Objective: Evaluate treatment outcomes and associated factors of acute bacterial meningitis among children admitted to pediatric emergencies in selected public hospitals in Addis Ababa from January 1, 2024, to December 31, 2024.

Methods: A multicenter retrospective study was conducted across five public hospitals. All children aged 0–12 years diagnosed with ABM during the study period were eligible. A total of 303 patient charts were selected through simple random sampling. Data on demographics, clinical presentation, treatment, and outcomes were collected using a structured questionnaire. Used SPSS 30 to do logistic regression to identify factors associated with treatment outcomes, with findings summarized in tables and figures.

Results: Of the 303 children with Acute bacterial meningitis, 71% had good outcome, while 29% had poor outcomes: 11% mortality, 14% complications, and 4% self-discharge. Significant factors associated with poor outcomes included rural residence (AOR = 5.61; 95% CI: 1.60–19.67), seizures (AOR = 0.17; 95% CI: 0.04–0.73), altered consciousness (AOR = 0.02; 95% CI: 0.003–0.10), delayed hospital presentation ≥ 72 hours (AOR = 0.05; 95% CI: 0.01–0.21), comorbidities (AOR = 0.19; 95% CI: 0.05–0.66), and hospital stay < 7 days (AOR = 12.75; 95% CI: 1.00–162.42). Diagnostic limitations were noted: CSF analysis was performed in 56% of cases, CSF culture in 33% (8% positive). Ceftriaxone was the most prescribed antibiotic (51%), and corticosteroids were used in only 31% of cases.

Conclusions: Most patients had good outcomes, but a considerable amount experienced poor outcomes, including death, complications, or leaving the hospital before completing treatment. The findings of this study suggest the need to improve early access to care, especially for rural patients, enhance diagnostic practices, and ensure consistent use of evidence-based treatments to improve outcomes for children with bacterial meningitis.

Key Words: Acute bacterial meningitis, pediatric, treatment outcome, Ethiopia, public hospitals.

INTRODUCTION

1.1. BACKGROUND

Meningitis is an inflammation of the meninges, the membranes covering the brain and spinal cord (1). It remains a critical global neurological emergency, posing significant risks of mortality and long-term complications, necessitating prompt diagnosis and treatment (2). Newborns and young infants are particularly vulnerable due to their immature immune systems (3).

Meningitis can be caused by various infectious agents, including bacteria, viruses, fungi, and parasites, as well as non-infectious factors such as autoimmune conditions, cancer, or drug reactions. Among children, bacterial meningitis is primarily caused by *Neisseria meningitidis*, *Haemophilus influenzae* type b (Hib), and *Streptococcus pneumoniae* (4). Viral meningitis, the most common form of aseptic meningitis, frequently affects young children but generally has a better prognosis than bacterial meningitis (1).

Despite significant advances in vaccination programs, including the global implementation of Hib and pneumococcal vaccines, meningitis remains a major public health threat. In 2019, the disease had an estimated 2.5 million new cases and caused approximately 250,000 deaths worldwide (5,6). One in five survivors suffers long-term disabilities such as cognitive impairment, hearing loss, or motor dysfunction. Between 1990 and 2016, the incidence of meningitis increased by 12.8%, with the highest burden observed in the African meningitis belt, spanning from Senegal to Ethiopia (7).

The pathogenesis of meningitis involves pathogens entering the cerebrospinal fluid (CSF) either through infected immune cells or by breaching the blood-brain barrier (BBB) (8). The ensuing neuro-inflammatory response is a primary cause of morbidity and mortality rather than the infection itself. The immune system's activation, particularly microglial and neutrophil involvement, leads to cytokine release, increased vascular permeability, and subsequent brain edema, which may result in neurological damage (9).

Meningitis presents with similar clinical symptoms regardless of etiology. Historically, signs such as Brudzinski's and Kernig's have been used for diagnosis, but their sensitivity is low, with some studies indicating detection rates as low as 5% (10,11). Common symptoms include fever, headache, neck stiffness, nausea, photophobia, and cognitive impairment. In bacterial cases, symptoms may progress to include seizures, respiratory distress, and skin rashes. Diagnosing

meningitis in infants is particularly challenging, as they often present with nonspecific symptoms such as bulging fontanel, irritability, lethargy, vomiting, and poor feeding (12).

Effective management of bacterial meningitis requires timely recognition, antibiotic administration, and supportive care. Treatment strategies differ by age group. Neonates are most susceptible to Group B Streptococcus, Escherichia coli, and Listeria monocytogenes infections (7). Empirical treatment typically includes ampicillin combined with either Gentamicin or Cefotaxime (2). For infants older than two months, common causative agents include Streptococcus pneumoniae and Neisseria meningitis, with ceftriaxone or cefotaxime as first-line treatments. In regions with high antibiotic resistance, vancomycin may be added to target resistant strains of Streptococcus pneumoniae. Corticosteroids such as dexamethasone may be beneficial in reducing inflammatory complications, particularly in cases of Hib meningitis (2,12). In Ethiopia, research indicates persistent challenges in managing meningitis in children, despite the introduction of the PCV-10 vaccine. While vaccination has led to a decline in hospitalizations and mortality rates associated with community-acquired bacterial meningitis (CABM), Streptococcus pneumoniae remains a leading cause of infection (13). Poor treatment outcomes, ranging between 15% and 32.65%, are linked to factors such as comorbidities, lack of corticosteroid use, absence of oxygen therapy, altered mental status at admission, delayed presentation, malnutrition, and inadequate access to timely medical intervention (4,14,15).

1.2. STATEMENT OF THE PROBLEM

Bacterial meningitis is a life-threatening infection, particularly among children under five years of age, with high mortality and long-term disability rates. Globally, despite the availability of effective vaccines, the disease caused an estimated 250,000 deaths in 2019. One in five children suffers from lasting complications such as hearing loss, cognitive delays, or motor impairments (6). The burden more in low-resource settings, where there is limited diagnosis and treatment.

Children in regions with poor healthcare infrastructure, low immunization coverage, and limited diagnostic capacity face a higher risk of poor outcomes. In many parts of Africa, including Ethiopia, outbreaks of bacterial meningitis occur frequently. Factors such as delayed healthcare-seeking, malnutrition, comorbidities, and empirical antibiotic use without pathogen identification further increase the likelihood of death or long-term complications (7).

Although vaccines such as PCV-10 and Hib have been introduced in Ethiopia, bacterial meningitis continues to be a major pediatric health concern. Reported mortality rates range from 15% to over 30% (4,14,15). Gaps remain in early diagnosis, consistent treatment protocols, and the use of supportive therapies such as corticosteroids and oxygen. Resource limitations, overcrowded public hospitals, and variations in clinical management further hinder optimal outcomes (14,15).

Ethiopia has implemented immunization programs aimed at reducing vaccine-preventable meningitis. The introduction of PCV-10 and Hib vaccines into the national schedule has led to some improvements in disease prevention (13). However, these efforts have not fully addressed gaps in clinical management or the factors contributing to poor treatment outcomes in hospitalized children. The WHO's global roadmap to defeat meningitis by 2030 emphasizes the need for improved surveillance, diagnostics, and clinical care, areas where significant challenges remain in Ethiopia (39).

This study was conducted to assess treatment outcomes and associated factors among children with bacterial meningitis in selected public hospitals in Addis Ababa. Through retrospective analysis of patient records, the study provides evidence on current clinical practices, gaps in diagnosis and treatment, and predictors of poor outcomes. These findings aim to inform policies

and clinical practices to enhance patient care, reduce mortality, and support Ethiopia's progress toward the 2030 global targets for meningitis control.

1.3. SIGNIFICANCE OF THE STUDY

This study holds significant to addressing the ongoing challenges of managing acute meningitis in children in Ethiopia, particularly within the public hospital setting of Addis Ababa. By investigating treatment outcomes and associated factors, the research aims to provide valuable insights into the clinical, demographic, and institutional determinants that influence patient recovery and prognosis.

The findings contributes to an understanding of the gaps in current diagnostic and treatment practices, which is essential for improving targeted interventions. Specifically, the study will help identify modifiable risk factors, such as delayed presentation and lack of corticosteroid use, and emphasize the role of vaccination and early diagnosis in improving outcomes.

For healthcare providers and policymakers, this research serves as evidence to refine treatment protocols, strengthen diagnostic capabilities, and promote adherence to best practices, ultimately reducing morbidity and mortality rates associated with acute meningitis.

By shedding light on these critical aspects, this study not only benefits the population of children at risk of meningitis but also contribute to the broader goal of improving child health outcomes in resource-limited settings. It also serves as a foundation for future research, bridging gaps in knowledge and guiding policy changes to enhance the quality of healthcare in Ethiopia.

2. LITERATURE REVIEW

Acute bacterial meningitis (ABM) is a critical and potentially fatal condition, especially among children, where timely and effective management can significantly impact outcomes. Various studies have explored the treatment outcomes and factors associated with ABM in children, offering insights into clinical features, treatment approaches, and outcomes across diverse settings.

A comprehensive literature review was conducted using trustworthy databases to gather relevant studies on bacterial meningitis in children. Studies published in English between 2010 and 2024 were included, focusing on bacterial meningitis in children, treatment outcomes, and regional epidemiology. Data on incidence, treatment approaches, and outcomes were selected and categorized into key themes: sociodemographic factors, diagnostic challenges, comorbidities, time of presentation and treatment initiation, treatment approaches and outcomes, and system-level barriers. The findings provide a foundation for understanding current treatment practices and identifying gaps requiring further investigation.

2.1 Socio-demographic Factors

Infants under one year old are much more likely to experience neurological complications from bacterial meningitis than older children (3). In a prospective study conducted in Germany involving 77 children with bacterial meningitis, 33 (43%) experienced neurological complications, while two (2.6%) succumbed to the illness. Key factors linked to poor outcomes included being under 12 months of age, showing altered mental status, experiencing seizures before admission, receiving initial treatment with two antibiotics, using dexamethasone, having focal neurological deficits at the time of admission, and having elevated protein levels in cerebrospinal fluid ($p < 0.05$).

A study by Peltola et al. (2021) analyzed the outcomes of childhood bacterial meningitis across three continents: Finland, Latin America, and Angola. The researchers conducted a secondary analysis of five clinical trials involving 2,123 children to assess death, severe neurological sequelae, and deafness as dismal outcomes. Tools used included mental status, cerebrospinal fluid (CSF) analysis, and audiological assessments. The findings revealed significant regional differences, with Angola reporting the highest rate of poor outcomes (54%) compared to Latin America (31%) and Finland (5%). Factors independently associated with poor outcomes included

delayed hospital arrival, seizures, GCS scores below 13, pneumococcal meningitis, and malnutrition. The study highlighted that although advancements in antibiotics and vaccinations have improved meningitis management, the disease continues to be a major health challenge in resource-limited settings. The authors concluded that improving nutritional status, preventing anemia, and ensuring timely treatment could mitigate these adverse outcomes, stressing the importance of continued efforts to enhance healthcare access and treatment in low-resource regions (24).

2.2 Diagnostic Challenges

Effective diagnosis of ABM is essential for successful treatment, yet several studies show that diagnostic limitations persist, especially in low-resource settings. In Ethiopia, a study on the challenges of ABM management in teaching hospitals reported that lumbar puncture was only performed in 55.5% of cases, and causative organisms were identified in just 3.3% of patients. No blood cultures were taken, and diagnosis often relied on CSF appearance or basic parameters. Treatment varied, with ceftriaxone as the most common antibiotic, and dexamethasone used in 50% of cases despite unclear benefit (21).

In Addis Ababa, a study on bacterial culture-negative meningitis found that human enteroviruses (HEVs) were responsible for 26.7% of cases, mostly in children, emphasizing the need to include viral testing in meningitis workups (20). This study highlighted the importance of investigating a broader spectrum of pathogens, as excluding other viral etiologies limited the ability to assess the full range of causative agents.

In Egypt, Sameh et al. (2021) highlighted the importance of identifying predictive factors, including clinical and laboratory markers. They found a 22.7% mortality rate among hospitalized febrile patients with ABM, and poor outcomes were associated with delayed treatment, older age, neurological issues, and specific CSF abnormalities (19). These findings underline the importance of timely, accurate diagnosis to initiate early targeted therapy and improve survival.

2.3 Comorbidities

Underlying health conditions significantly affect ABM outcomes. Bekele et al. (2021) found that the presence of comorbidities increased the likelihood of poor outcomes by more than threefold (AOR = 3.64). In addition, lack of corticosteroid use (AOR = 2.37) and unavailability of oxygen therapy (AOR = 3.12) were also associated with adverse results (27). Peltola et al. (2021) and others have noted that malnutrition is a key factor contributing to the severity and mortality of ABM, particularly in low-income countries like Ethiopia and Angola (24, 28, 29).

In Nigeria, a study involving 81 children revealed that 27.2% died during hospitalization, and among those discharged, 32.1% developed neurological deficits (25). These complications reinforce the need for early supportive care and close monitoring of children with comorbidities.

2.4 Time of Presentation and Treatment Initiation

Several studies emphasize that delayed healthcare-seeking and antibiotic initiation are major contributors to poor ABM outcomes. In Denmark, a retrospective cohort study of 173 patients found that delays of over six hours in antibiotic administration increased mortality by 60% and unfavorable outcomes by 50%. Every additional hour of delay in the first six hours increased risks by 10%. Patients diagnosed after admission faced a median delay of 8.5 hours and had a 30% mortality rate compared to 14% for those diagnosed promptly (18). Similarly, a prospective study in Afghanistan revealed that delayed presentation, lack of diagnostics, and reliance on empirical treatment were key obstacles in ABM management in children (17).

In Ethiopia, regional studies further confirmed that delayed presentation and unconsciousness on admission predicted poor outcomes. In Eastern Ethiopia, 23% of pediatric ABM patients had poor outcomes, including 11% mortality. Factors such as delayed care and changing antibiotic regimens during treatment contributed to these adverse outcomes (22). A study from Felege Hiwot Referral Hospital found that the season of admission, lack of corticosteroid use, and poor initial clinical presentation were associated with complications or death in 15% of patients, while vaccination was a strong protective factor (AOR = 20.912) (14).

2.5 Treatment Approaches and Outcomes

Treatment practices significantly influence ABM outcomes. Empirical treatment with ceftriaxone is common, but the lack of microbiological confirmation can lead to antibiotic overuse or mismatches. In Ethiopia, inconsistency in corticosteroid use and poor adherence to treatment guidelines were noted as key challenges (21). In Bahir Dar, corticosteroid use was associated with improved outcomes, while its absence led to poor prognosis (14, 27). Similarly, the inappropriate modification of antibiotics during treatment contributed to worse outcomes in Eastern Ethiopia (22).

Vaccination plays a crucial role in prevention and improved outcomes. Following the introduction of PCV-10 in Gondar, Ethiopia, a 62.7% reduction in community-acquired bacterial meningitis hospitalizations and a 56.1% decline in mortality were observed. Nevertheless, *Streptococcus pneumoniae* remained the leading pathogen, highlighting the need for continuous surveillance (13). Immunized children were shown to have up to 20 times greater odds of achieving favorable outcomes (14).

A systematic review was conducted to investigate the risk factors that contribute to poor clinical outcomes in children diagnosed with bacterial meningitis. The review included 17 studies with a total of 9,581 patients aged between 0 and 18 years. The rate of unfavorable outcomes, such as complications or fatalities, ranged from 3% to 44%, yielding an average of 17.6%. Several important prognostic factors linked to negative outcomes were identified. Late diagnosis, *Streptococcus pneumoniae* infection, and poor access to care as primary risk factors for poor outcomes (25).

2.6 System-Level Barriers

Health system limitations present persistent barriers to effective ABM management in Ethiopia. These include inadequate diagnostic infrastructure, reliance on empirical treatment, absence of standard guidelines, and inconsistent documentation (21, 27, 28). Over-diagnosis, antibiotic overuse, and treatment inconsistencies, combined with poor laboratory capacity, highlight the urgent need for context-specific treatment protocols and improved laboratory support.

Poor death registration and incomplete records further complicate efforts to accurately measure the burden of disease and monitor outcomes (5). A review of health system studies in Ethiopia showed that malnutrition, poor pre-hospital care, and delayed facility visits were common factors behind high mortality (28, 29). Furthermore, rising antimicrobial resistance poses an emerging threat, limiting the effectiveness of standard antibiotics (32).

A critical knowledge gap exists regarding the optimal duration of parenteral antibiotic therapy in infants with ABM, which remains unaddressed in current clinical guidelines (33). Improving healthcare infrastructure, training, and surveillance is essential to ensure evidence-based and equitable care for children in Ethiopia.

In summary, existing literature demonstrates that age, delayed treatment, diagnostic limitations, comorbidities, and weak health systems all contribute to poor outcomes in children with acute bacterial meningitis. While vaccination and improved awareness have led to some progress, large gaps remain in diagnostic capacity, treatment consistency, and follow-up care. Targeted interventions, including the development of standardized, evidence-based guidelines, expansion of diagnostic capacity, and health system strengthening, are necessary to improve treatment outcomes and reduce mortality from this preventable and treatable disease in Ethiopia and other low-resource settings.

3. CONCEPTUAL FRAMEWORK

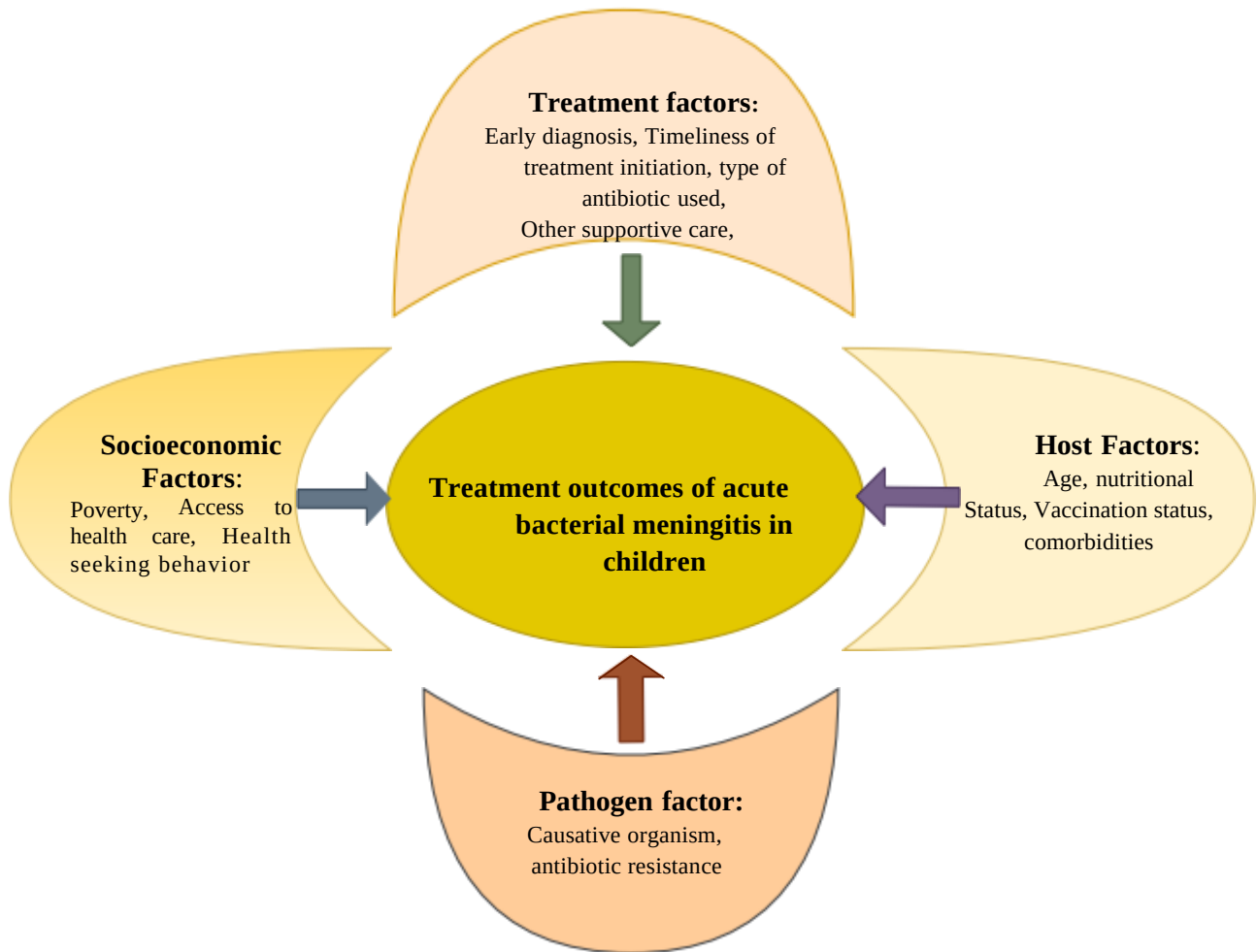


Figure 1: Conceptual framework of treatment outcomes of acute bacterial (2, 3, 24)

The conceptual framework in this study represents the interplay of various factors influencing the treatment outcomes of acute bacterial meningitis in children. It visually and structurally organizes how different independent variables contribute to or affect the dependent variable. This framework was developed using previous literature on this specific topic and guides data collection and analysis, ensuring all relevant factors are considered (2, 3, and 24).

4. OBJECTIVES

4.1. GENERAL OBJECTIVES

To assess the treatment outcomes and associated factors of acute bacterial meningitis among children admitted to the pediatric emergency units in 5 selected public hospitals in Addis Ababa, Ethiopia, from January 1 to December 31, 2024.

4.2. SPECIFIC OBJECTIVES:

- To evaluate the treatment outcomes of acute bacterial meningitis among children admitted to the pediatric emergency of 5 selected public hospitals in Addis Ababa, Ethiopia, between January 1 and December 31, 2024.
- To identify the associated factors affecting the treatment outcomes of acute bacterial meningitis in children admitted to pediatric emergency units of 5 selected public hospitals in Addis Ababa, Ethiopia, between January 1 and December 31, 2024.

5. METHODS AND MATERIALS

5.1. STUDY AREA AND STUDY PERIOD

The study was conducted on five public hospitals located in Addis Ababa, Ethiopia from March 24, 2025, to April 25, 2025. These hospitals include Tikur Anbessa Specialized Hospital, Zewditu Memorial Hospital, Yekatit 12 Hospital Medical College, St. Paul's Hospital Millennium Medical College, and Ras Desta Damtew Memorial Hospital which serve as primary referral centers for pediatric care in the region.

The selection of these Hospitals for this study was based on their leading role as public referral hospitals in Addis Ababa, Ethiopia (33). They provide comprehensive care to a diverse range of pediatric patients, including those with acute meningitis. By including hospitals with varying patient populations and expertise in pediatric infectious disease, the study has produced findings that are relevant to the broader healthcare context in Addis Ababa. Furthermore, these hospitals' advanced diagnostic and treatment resources ensure high-quality and accurate data for studying treatment outcomes and associated factors of acute meningitis in children.

Tikur Anbessa Specialized Hospital (TASH), established in 1972, is Ethiopia's largest referral and teaching hospital with a 700-bed capacity. Transferred to the School of Medicine in 1998, TASH became the primary university teaching hospital, offering clinical and preclinical training across most medical disciplines. It provides specialized services unavailable in other institutions nationwide, supported by 200 doctors, 379 nurses, and 115 other health professionals, alongside 950 administrative staff. Faculty members and residents contribute to patient care, and the hospital is affiliated with nearly all regional and federal hospitals in Addis Ababa, serving as clinical and training sites (34).

Zewditu Memorial Hospital, originally established and operated by the Seventh-day Adventist Church, was nationalized in 1976 during the Derg regime and is named after Empress Zewditu. Currently managed by the Ministry of Health, the hospital is a leading center for antiretroviral therapy in Ethiopia, serving over 6,000 patients monthly and managing approximately 14,000 HIV patients (35).

Yekatit 12 Hospital Medical College, established in 1923 by Dr. Ayiner, is one of Ethiopia's oldest healthcare institutions. Originally named "Bete Saida Be Tefferi Mekonnen Hospital," it was later renamed during the Derg regime. The hospital pioneered blood donation programs and nursing education in Ethiopia and now offers specialized services such as burn management, gynecology, and dental care. It continues to provide medical care to over 14,000 outpatients and 19,000 emergency cases annually, while celebrating its 100th anniversary with various community-focused events (36).

St. Paul's Hospital Millennium Medical College, founded in 1968 and transformed into a teaching hospital in 2008, is a leading healthcare and educational institution in Ethiopia. It provides advanced medical services, including Ethiopia's first kidney transplant center, burn care, and fertility treatment. The college offers a wide range of academic programs, training nearly 2,000 students annually in medicine, nursing, and specialized fields. SPHMMC addresses public health challenges through research, innovative technology, and international collaborations, positioning itself as Ethiopia's premier institution for integrated clinical services, education, and research, serving over 2,000 patients daily (37).

Ras Desta Damtew Memorial Hospital is a healthcare facility located in Addis Ababa, Ethiopia. It offers a range of medical services, including laboratory diagnostics. The hospital's laboratory is accredited by the Ethiopian Accreditation Service for disciplines such as Molecular Biology and GeneXpert testing (38).

5.2. STUDY DESIGN

This study used a multicenter retrospective study design to assess the treatment outcome and associated factors of bacterial meningitis among children admitted to pediatric emergency departments from January 1, 2024, to December 31, 2024 of selected public hospitals in Addis Ababa, Ethiopia.

5.3. SOURCE POPULATION

All children admitted to pediatric emergency departments in selected public hospitals in Addis Ababa from January 1, 2024 to December 31, 2024.

5.4. STUDY POPULATION

The study population included all pediatric patients aged 0–12 years diagnosed with acute bacterial meningitis and admitted to the emergency departments of the selected hospitals from January 1, 2024 to December 31, 2024.

5.5. ELIGIBILITY CRITERIA

5.5.1. INCLUSION CRITERIA

This study included pediatric patients aged 0 to 12 diagnosed with acute bacterial meningitis. Eligible participants were those admitted to the emergency department of the selected hospitals during the study period, from January 1, 2024, to December 31, 2024. Furthermore, only patients with accessible medical records and no restrictions on accessing their health data for research purposes were included in the study.

5.5.2. EXCLUSION CRITERIA

Patients diagnosed with non-bacterial meningitis and, any patients with incomplete medical records were excluded.

5.6. SAMPLE SIZE DETERMINATION

The sample size for this study was determined using a standard population proportion formula for estimating proportions in cross-sectional studies. The proportion of 0.77 (77%) was taken from a previous study on treatment outcomes of acute bacterial meningitis (21). The formula used for the calculation is:

$$n = \frac{(Z_{\alpha/2})^2 \cdot p \cdot (1-p)}{d^2}$$

Where:

n: Required initial sample size.

Z_{α/2}: Z-score corresponding to the confidence level 1.96 for 95% confidence.

p: 0.77 proportion of acute bacterial meningitis cases based on previous literature with the outcome of interest (22).

d: Margin of error 0.05.

$$n = \frac{(1.96)^2 * 0.77 * (1 - 0.77)}{(0.05)^2}$$

$$n = \frac{3.8416 * 0.77 * 0.23}{0.0025}$$

n=271.429 Thus, the sample size is **272**.

To account for a potential 10% incomplete patient chart, the sample size is adjusted

$$n_{\text{adjusted}} = n_{\text{final}} * \frac{1}{1 - 0.1} = 272 * 1.1 \approx 303$$

Thus, the final sample size was **303**.

A proportional allocation method distributed the final sample size among the five selected hospitals according to the total number of cases recorded at each hospital. Finally Simple Random Sampling was used with lottery method to select patient records from each hospital.

Proportional sample size for each hospital was calculated as follows: $n_i = \frac{N_i}{N} * n$ where

N

N_i is number of eligible cases in each hospital,

Tikur Anbessa Specialized Hospital: 72

Zewditu Memorial Hospital: 84

Yekatit 12 Hospital Medical College: 56

St. Paul's Hospital Millennium Medical College: 74

Ras Desta Damtew Memorial Hospital: 38

N is total number of eligible cases across all hospitals ($N=324$) and

n is the sample size ($n=303$)

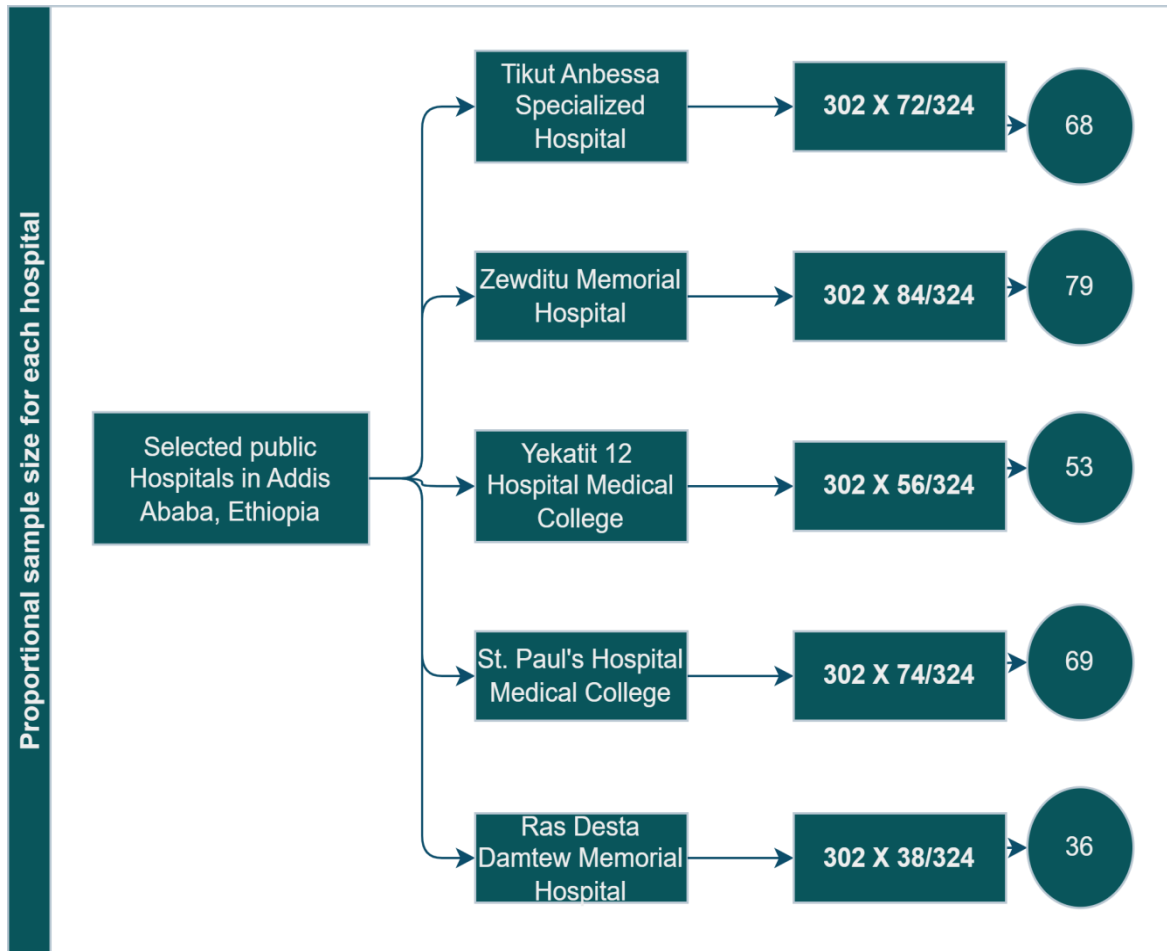


Figure 2: Proportional sample size for each selected public Hospitals in Addis Ababa, Ethiopia

5.7. DATA COLLECTION TOOLS AND MATERIALS

Data collection was conducted at each selected hospital by reviewing patient records and extracting relevant information through semi-structured questionnaires. The questionnaire was constructed based on literature review (4, 13, 14, 15, and 22) and consultations with seniors, ensuring content validity. The tool was also be pretested on 5% of the sample size, which was not included in the final result, to identify and correct any discrepancies. Additionally, double data entry was utilized to identify and rectify transcription errors.

The checklist captured the following key variables:

Dependent Variable:

Treatment Outcome: represents the clinical result following medical intervention, classified as recovery, complications, or mortality. It served as the central focus of the study, indicating the effectiveness of treatment and the overall influence of various contributing factors.

Independent Variables:

Host Factors: influence the body's ability to fight infection and respond to treatment. For example, younger children or those with malnutrition may have poorer immune responses, leading to prolonged recovery or higher mortality rates (3).

Treatment Factors: Early initiation of appropriate antibiotics and supportive care significantly improves outcomes. Delayed treatment or ineffective antibiotics can lead to severe complications or death (2).

Socioeconomic Factors: Socioeconomic constraints may delay hospital visits, limit access to medication, or reduce follow-up adherence, increasing adverse outcomes (24).

Pathogen Factors: The pathogen type and its resistance profile determine the effectiveness of antibiotics. Resistant strains may lead to treatment failure or prolonged hospitalization (2).

5.8. DATA COLLECTION PROCEDURES

The data collection for this study was carried out by two trained nurses with BSc qualifications under the guidance of an MSc nurse supervisor. Before the data collection began, both data collectors and the supervisor had undergone training on the study's objectives, the data collection tool, and the necessary procedures to ensure that the process is accurate and consistent across all participating locations.

To maintain the quality of data collection and ensure compliance with the protocol, the supervisor conducted regular monitoring and oversight. Any issues or uncertainties that were raised during the data extraction process were addressed through discussions with the supervisor. Data collection took place from March 24, 2025, to April 25, 2025.

5.9. OPERATIONAL DEFINITIONS

Acute Bacterial Meningitis: In the context of this study, which was conducted in public hospitals where the diagnosis of acute bacterial meningitis was primarily based on clinical presentation and cerebrospinal fluid (CSF) analysis findings. Due to the frequent unavailability or inconclusiveness of culture results, cases are classified according to the World Health Organization 2015, criteria as *suspected*, *probable*, or *confirmed*. All three classifications are considered as acute bacterial meningitis for the purposes of this research, explained as:

A **suspected case** is any person with a sudden onset of fever ($>38.5^{\circ}\text{C}$ rectal or $>38.0^{\circ}\text{C}$ axillary) accompanied by at least one sign of neck stiffness, altered consciousness, or other meningeal signs (40).

A **probable case** includes suspected cases with CSF abnormalities such as turbid appearance, elevated leukocyte count (>10 cells/ mm^3), or bacteria identified by Gram stain (40).

A **confirmed case** is one where a causative organism (*Neisseria meningitis*, *Streptococcus pneumoniae*, or *Haemophilus influenzae* type b) is detected in CSF or blood through culture, PCR, or antigen testing (40).

Good Outcome: will be the patient showing significant clinical improvement such as alleviation of symptoms as fever, headache, neck stiffness, sensitivity to light and sound, changes in mental state, neurological issues, and increased irritability or crying in children. Additionally, there will be noticeable enhancements in appetite, energy levels, and stabilization of vital signs and being discharged without acute complications such as seizures, hearing loss, cognitive or developmental delay or hydrocephalus (15, 22).

Poor outcome will be characterized by:

In-hospital Death: Mortality occurring during the hospital stay, attributed to acute bacterial meningitis or its complications.

Development of Complications: The emergence of new, serious conditions resulting from acute bacterial meningitis, such as hearing loss, seizures, hydrocephalus, or cognitive impairment.

Self-discharge Against Medical Advice: Patients leaving the hospital prematurely, contrary to medical advice, without completing the prescribed antibiotic treatment. This was considered poor

outcome due to the risk of inadequate treatment, which could lead to treatment failure, relapse, or worsening of the symptoms (15, 22).

5.10. DATA QUALITY MANAGEMENT

To ensure the integrity and reliability of the data collected, all data collectors have undergone training. They received instruction on the study's objectives, the procedures for data collection, and the proper use of data collection tools to ensure uniformity across all study locations. A data collection tool was developed that clearly outlines each variable.

Pretesting was carried out on 5% of the total sample size from Tikur Anbessa Specialized Hospital from March 10 to 11, 2025 to assess the tool's clarity, feasibility, and accuracy. Feedback gathered from this pretest was utilized to improve the tool by addressing any inconsistencies, ambiguities, or difficulties encountered during data extraction. Additionally, pretesting helped to identify any gaps or unnecessary variables, ensuring the tool was fully optimized for comprehensive data collection.

After finalizing the tool, routine monitoring and audits were implemented throughout the study to guarantee compliance with protocols and consistency in data gathering. The data entry process involved double entry to identify and correct transcription errors, followed by thorough data cleaning and validation to address any discrepancies and missing information. Periodic evaluations of inter-observer reliability were conducted to ensure consistent interpretation of subjective clinical data.

All collected data were securely stored, with electronic records protected by passwords and physical documents safeguarded in locked cabinets. These precautions guaranteed the collection of high-quality, reliable, and valid data for analysis and conclusions.

5.11. DATA ANALYSIS PROCEDURES

After checking for completeness, the data was transcribed, entered into Excel, and then exported to SPSS 30.0 for further analysis. Descriptive statistics was used to summarize socio-demographic, clinical, and treatment-related variables. Bivariate analysis was performed using

appropriate statistical tests to identify potential associations. Variables with a p-value less than 0.25 were included in the final multivariable logistic regression model. A backward stepwise method was applied to determine the most significant predictors of treatment outcomes. To assess the goodness-of-fit of the final logistic regression model, the Hosmer-Lemeshow test was conducted; a non-significant result ($p > 0.05$) indicated good model fit. Results were reported using odds ratios with 95% confidence intervals and p-values to show the strength and significance of associations. Findings are presented using figures, tables, graphs, and charts to aid interpretation.

5.12. ETHICAL CONSIDERATION

In accordance with ethical guidelines for research, this study was approved by the Institutional Review Board (IRB) of the Department of Emergency and Critical Care Nursing at Addis Ababa University. Ethical clearance was obtained from Addis Ababa Public Health and Emergency management Directorate and from the management of Tikur Anbessa Specialized Hospital and St. Paul's Hospital Millennium Medical College. Since this research involves a retrospective chart review, a waiver of informed consent was requested, as the study presents minimal risk to participants. All data collected were kept confidential and anonymous. All data was handled with care, and patients' identities were protected to uphold their privacy. Additionally, data was securely stored in encrypted files, with access limited to authorized personnel only.

5.13. RESULT DISSEMINATION

Results of the study will be submitted and presented to the department of emergency medicine. It will be disseminated to Addis Ababa Public Health and Emergency management Directorate, Addis Ababa University's College of Health Science, Tikur Anbessa Specialized Hospital, Addis Ababa University College of Health Sciences Library and St. Paul's Hospital Millennium Medical College.

6. RESULTS

6.1. SOCIO-DEMOGRAPHIC INFORMATION

Out of 324 eligible patient charts recorded across the five selected hospitals during the study period, 303 were successfully reviewed and included in the analysis, yielding a response rate of 93.5%. Of the participants, 168 (55.4%) were male. The median age was 3 years, with a range from 15 days to 12 years. The majority of patients, 226 (74.6%), were younger than 5 years old. Most were from urban areas 199 (65.7%). Regarding vaccination status, 275 (89.8%) were fully vaccinated. Exposure to meningitis infection was reported in 44 (14.5%) of cases, primarily due to healthcare setting exposure and overcrowded living conditions.

Table 2: Socio-demographic information of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Variable	Categories	Frequency (n)	Percentage (%)
Age	0–28 days	67	22.1
	29 days- 3 months	75	24.8
	4 months–5 years	84	27.7
	6–12 years	77	25.4
Gender	Male	168	55.4
	Female	135	44.6
Residence	Rural	104	34.3
	Urban	199	65.7
Vaccination Status	Fully vaccinated	272	89.8
	Not fully vaccinated	14	4.6
	Unknown	17	5.6
Exposure to Meningitis Infection	No	259	85.5
	Yes	44	14.5
If Yes, Type of Exposure	Close contact with confirmed case	1	.3
	Exposure in healthcare settings	24	7.9
	Exposure to overcrowded living	11	3.6
	Family member with symptoms	8	2.6

6.2. CLINICAL PRESENTATION AND DIAGNOSIS

6.2.1. CLINICAL PRESENTATION

Among the clinical presentations, fever 252 (83.2%), vomiting 238 (78.5%), and poor feeding (62.7%) were the most common. Symptoms such as seizures 75 (24.8%) and headache 78 (25.7%) were also frequent, while classic meningeal signs like neck stiffness 33 (10.9%) and positive Kernig's sign 12 (4%) were less commonly reported (Table 3). The presence of multiple symptoms per patient contributed to a total of 1,176 reported signs across 303 cases.

Table 3: Signs and Symptoms of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Symptom	Frequency (n)	Percentage (%)
Fever	252	83.2%
Vomiting	238	78.5%
Seizure	75	24.8%
Headache	78	25.7%
Neck stiffness	33	10.9%
Photophobia	57	18.8%
Altered consciousness	67	22.1%
Irritability	143	47.2%
Poor feeding	190	62.7%
Bulging fontanelle	31	10.2%
Positive Kernig's sign	12	4.0%
Total responses	1176	388.1%

Most patients (63.4%) were admitted to the hospital within 72 hours of symptom onset, suggesting timely healthcare-seeking behavior. Nonetheless, a notable portion 111 (36.6%) experienced a delay in admission, presenting after 72 hours.

Nearly one-third of the patients 98 (32.3%) had at least one comorbid condition at the time of admission, while the majority 205 (67.7%) had no documented comorbidities. Among the 98 patients with comorbidities, a total of 108 comorbid conditions were identified (as some patients had more than one). The most common were malnutrition 42 (48.3%).

Table 4: Comorbidities of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Variable	Categories	Frequency (n)	Percentage (%)
Comorbidities present	Yes	98	32.3%
	No	205	67.7%
Specify comorbidities present	Malnutrition	42	48.3%
	HIV/AIDS	24	27.6%
	Tuberculosis	10	11.5%
	Pneumonia	21	24.1%
	Traumatic Brain Injury	11	12.6%
	Total	108	124.1%

6.2.2. DIAGNOSTIC TESTS

Among the 303 pediatric patients, CSF analysis was done in 56.4%. Of those tested, 78.4% had a CSF WBC count > 20 cells/mm³, 70.2% had glucose levels ≤ 40 mg/dL, and 77.8% had protein levels > 100 mg/dL — consistent with typical bacterial meningitis profiles. Gram stain was performed in 57.3% of cases, with 41.8% testing positive. CSF culture was done in 33.3%, yielding a 23.8% positivity rate. Blood cultures were performed in 51.2%, with 36.1% positive results. Imaging was conducted in 35% of patients, primarily using trans fontanelle ultrasound. (Table 5)

Table 5: Diagnostic tests of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Diagnostic Test	Category	Frequency (n)	Percentage (%)
CSF Analysis Done (N= 303)	No	132	43.6
	Yes	171	56.4
CSF WBC Count (N= 171)	> 20 cells/mm ³	134	78.4
	≤ 20 cells/mm ³	37	21.6
CSF Neutrophil % (N= 171)	> 80%	75	43.9
	≤ 80%	96	56.1
CSF Protein Level (N= 171)	> 100 mg/dL	133	77.8
	≤ 100 mg/dL	38	22.2
CSF Glucose Level (N= 171)	≤ 40 mg/dL	120	70.2
	> 40 mg/dL	51	29.8
Gram Stain Done (N= 171)	Yes	98	57.3
	No	73	42.7
Gram Stain Result (N= 98)	Positive	41	41.8
	Negative	57	58.2
AFB Done (N= 171)	Yes	75	56.1
	No	96	43.9
AFB Result (N=75)	Positive	7	9.3
	Negative	68	90.7
CSF Culture Done (N=303)	Yes	101	33.3
	No	202	66.7
CSF Culture Result (N=101)	Positive	24	23.8
	Negative	77	76.2
Blood Culture Done (N=303)	Yes	155	51.2
	No	148	48.8
Blood Culture Result (N=155)	Positive	56	36.1
	Negative	99	63.9
Imaging Done (N=303)	Yes	106	35
	No	197	65
Type of Imaging (N=106)	Brain MRI	25	23.6
	Brain CT	20	18.9
	Transfontanelle Ultrasound	61	57.5

6.3. TREATMENT INFORMATION

In this study 35% of patients received treatment within 3 hours while 13% received treatment after 6 hours (Figure 3). Multiple antibiotics were often prescribed per patient, which explains why the total percentage exceeds 100%. Among the antibiotics used, Ceftriaxone was the most commonly prescribed 156 (51.5%), followed by Vancomycin 140 (46.2%). In this study, adjunctive therapies were frequently given in combination, leading to a total percentage greater than 100%. The most commonly administered supportive treatment was fluid resuscitation, used in 248 (84.6%) of cases, followed by antipyretics 211 (72.0%) (Table 6).

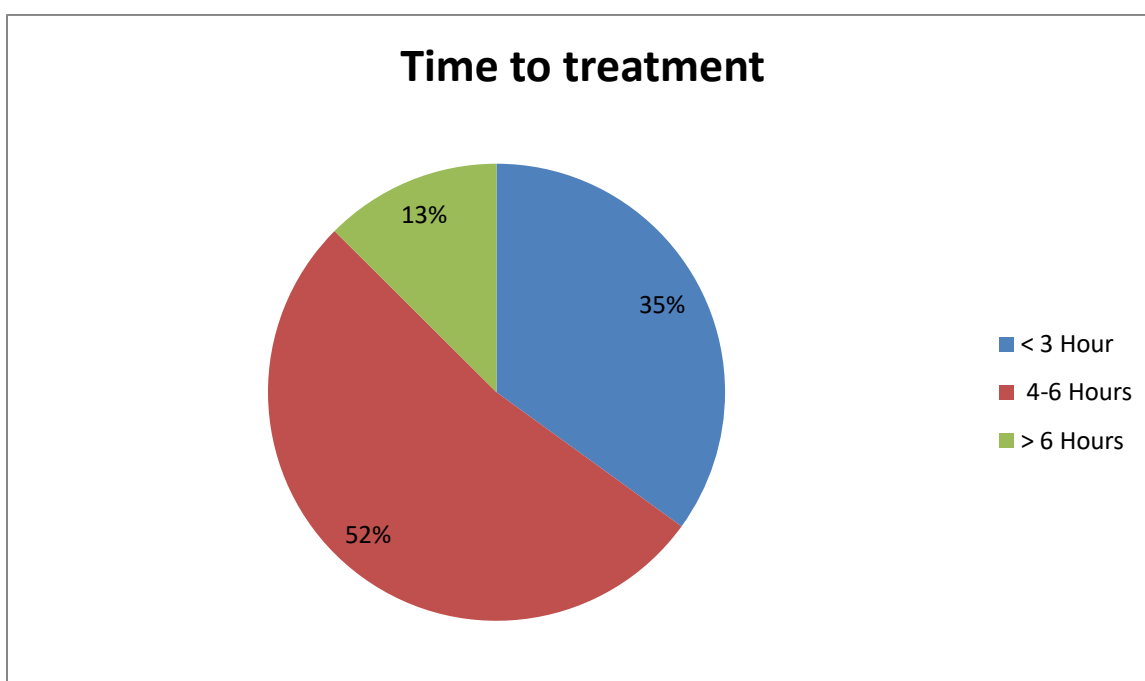


Figure 3: Time to treatment of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Table 6: Antibiotics and Adjunctive Therapies Prescribed to children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Variable	Categories	Frequency (n)	Percentage (%)
Antibiotics Prescribed	Ampicillin	134	44.2%
	Gentamicin	63	20.8%
	Ceftriaxone	156	51.5%
	Cefotaxime	77	25.4%
	Vancomycin	140	46.2%
	Meropenem	25	8.3%
Total		595	196.4%
Adjunctive Therapies	Corticosteroids	92	31.4%
	Oxygen therapy	76	25.9%
	Fluid resuscitation	248	84.6%
	Seizure management	73	24.9%
	Antipyretic	211	72.0%
	Mannitol	17	5.8%
Total		717	244.7%

The relationship between age groups and the duration of hospital stay among 303 patients are shown in the following figure (Figure 4). 47.2% (143 patients) stayed in the hospital for 7–14 days, while 46.9% (142 patients) had a prolonged stay of over 14 days. A majority of neonates aged 0–29 days (79.7%) and infants aged 1–3 months (65.8%) stayed more than 14 days. In contrast, 63.1% of children aged 4 months–5 years and 73.8% of those aged 6–9 years were discharged within 7–14 days. Children aged 10–12 years also mostly stayed 7–14 days (80%). Overall, the data shows that younger age groups had longer hospital stays, while older children were discharged more rapidly.

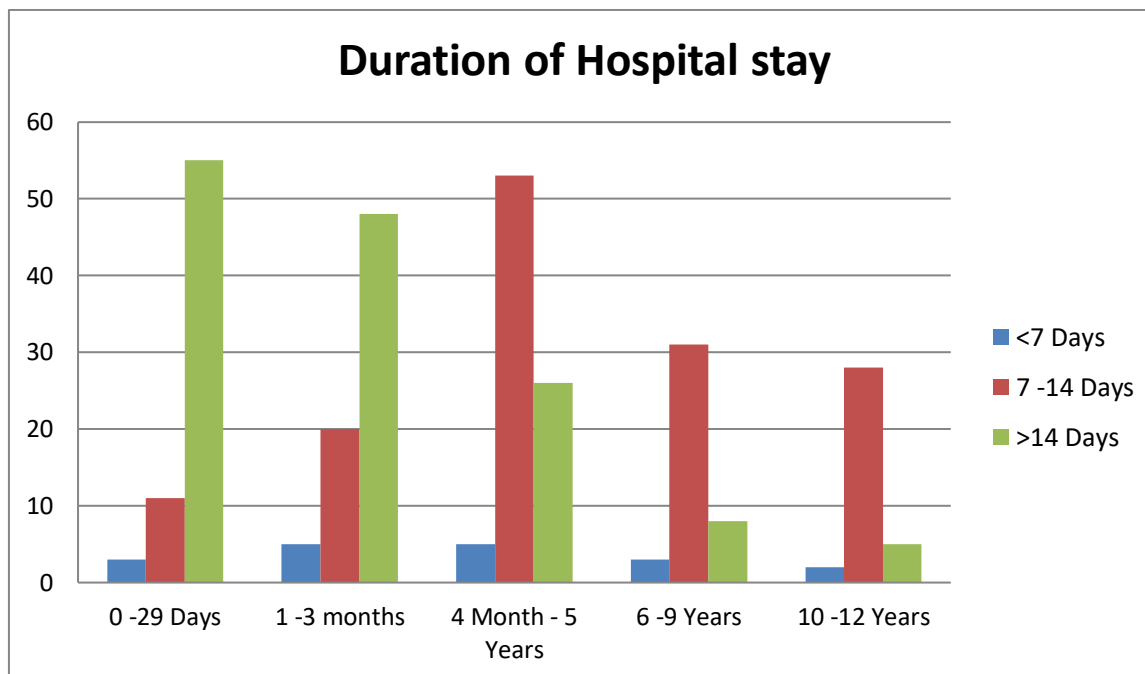


Figure 4: Duration of hospital stay among different ages of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

6.4. TREATMENT OUTCOMES AT DISCHARGE

Out of 303 children admitted with acute bacterial meningitis, the majority (71%) had good treatment outcomes at discharge, while 29% had poor outcomes. Among those with a poor treatment outcome, the majority experienced complications, followed by death and self-discharge. Among patients who developed complications, the most commonly reported was seizures (48.3%), followed by neurological deficits (30.0%), hydrocephalus (26.7%), and hearing loss (16.7%). The total percentage exceeds 100% because some patients experienced more than one type of complication.

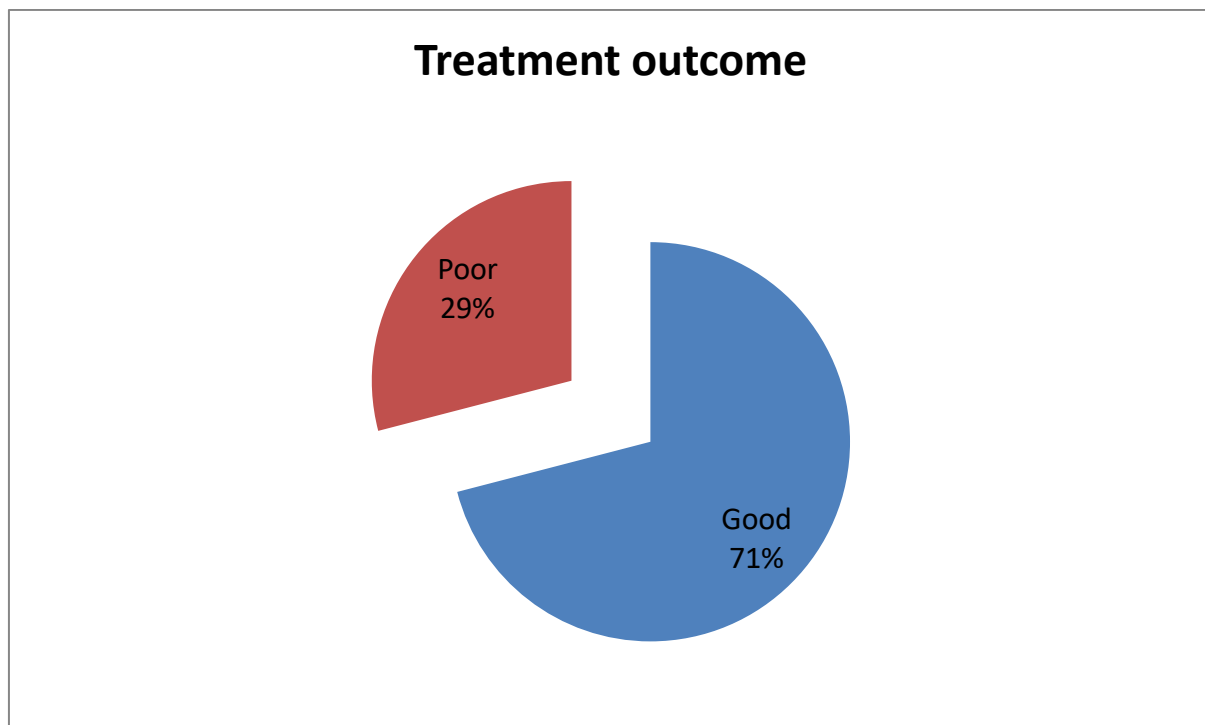


Figure 5: Treatment outcome of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

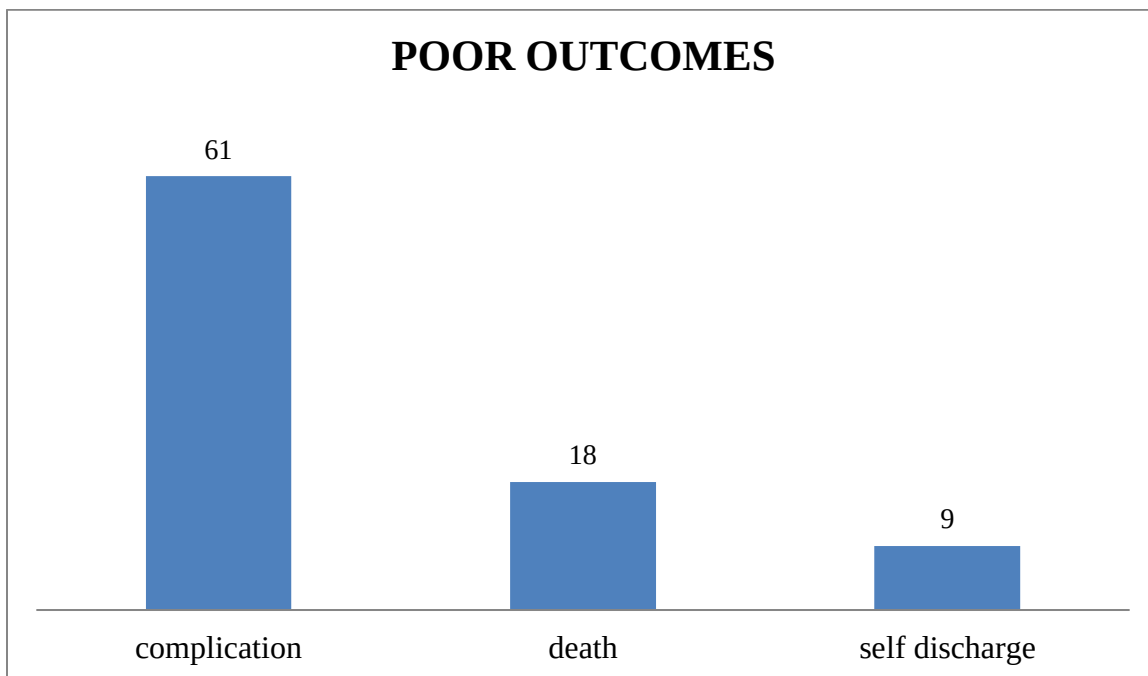


Figure 6: poor outcome of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024

6.5. FACTORS ASSOCIATED WITH TREATMENT OUTCOMES

A total of 303 pediatric patients diagnosed with acute bacterial meningitis were included in the analysis. In the bivariate analysis, several variables were significantly associated with treatment outcomes. Although age, sex, and from sign and symptoms, vomiting and poor feeding were significant in bivariate analysis, they did not retain statistical significance in the multivariable model. After adjusting for potential confounders in the multivariable logistic regression model, six variables remained significantly associated with outcomes.

Significant associations were identified for residence (AOR = 5.605; 95% CI: 1.597–19.667), seizure (AOR = 0.174; 95% CI: 0.041–0.735), altered consciousness (AOR = 0.018; 95% CI: 0.003–0.103), duration of illness before admission (AOR = 0.054; 95% CI: 0.013–0.215), comorbidities (AOR = 0.185; 95% CI: 0.052–0.657), and duration of hospital stay of 7–14 days (AOR = 12.748; 95% CI: 1.001–162.420). The extremely wide 95% CI around the AOR was due to very small number of patients in the reference subgroup. These results were determined after adjusting for other variables in the model.

Table 7: Associated factors with Treatment outcome of children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia from January 1, 2024, to December 31, 2024.

Variables	Category	Treatment Outcome		COR (95% CI)	P- value	AOR (95% CI)	P-value
		Poor	Good				
Residence	Rural	53 (17.5%)	51 (16.8%)	1			
	Urban	35 (11.6%)	164 (54.1%)	4.87 (2.84, 8.36)	<0.001*	5.605 (1.597, 19.667)	0.007**
Sign and symptoms	Vomiting	72 (23.8%)	166 (54.8%)	0.048 (0.004 – 0.559)	0.015*	0.165 (0.025– 1.076)	0.060
	Seizure	59 (19.5%)	16 (5.3%)	0.000 (0.000 – 0.005)	<0.001*	0.174 (0.041, 0.735)	0.017**
	Altered consciousness	65 (21.5%)	2 (0.7%)	0.069 (0.007 – 0.666)	0.021*	0.018 (0.003, 0.103)	<0.001* *
	Poor feeding	49 (16.2%)	141 (46.5%)	0.196 (0.018 – 2.15)	0.182*	0.535 (0.132– 2.163)	0.380
Duration of illness before admission	<72 Hours	9 (3.0%)	183 (60.4%)	1			
	72 hours and above	79 (26.1%)	32 (10.6%)	0.020(0.009 – 0.044)	<0.001*	0.054 (0.013, 0.215)	<0.001* *
Comorbidities present	Yes	65 (21.5%)	33 (10.9%)	0.224 (0.132 – 0.381)	< 0.001*	0.185 (0.052, 0.657)	0.009**
	No	23 (7.6%)	182 (60.1%)	1			
Duration of Stay	<7 Days	15 (5.0%)	3 (1.0%)	1			
	7–14 Days	31 (10.2%)	112 (37.0%)	18.07 (4.9 – 66.4)	<0.001*	12.748 (1.001, 162.420)	0.050**
	>14 Days	42 (13.9%)	100 (33.0%)	11.91 (3.3 – 43.2)	<0.001*	2.47 (0.18, 33.448)	0.496

1=Reference category

*= > COR (Crude Odds Ratio) at P < 0.25

**=AOR (Adjusted Odds Ratio) Significant at P < 0.05

7. DISCUSSION

This study provides valuable insights into the treatment outcomes and associated factors of acute bacterial meningitis (ABM) among children admitted to pediatric emergency units in selected public hospitals in Addis Ababa, Ethiopia. The findings revealed that 71% of the children had good treatment outcomes, while 29% experienced poor outcomes, including complications, death, or self-discharge. These findings are in line with global and regional data. For instance, a systematic review reported poor outcomes in 17.6% of pediatric cases globally, ranging from 3% to 44%, depending on region and health system capacity (25). A multicenter study by Peltola et al. (2021) showed poor outcomes in 54% of children in Angola, 31% in Latin America, and 5% in Finland, highlighting regional disparities in care (24). Similarly, a study in Nigeria found that 27.2% of children died, and 32.1% of survivors had neurological deficits (26). Within Ethiopia, studies have reported poor outcomes ranging from 15% to 32.65% (14, 15, 22). The persistence of poor outcomes, despite advances such as the introduction of PCV-10 and improved clinical protocols, underscores the urgent need for targeted interventions to improve early diagnosis, effective treatment, and comprehensive supportive care.

The most common clinical presentations observed in this study were fever (83.2%), vomiting (78.5%), and poor feeding (62.7%), consistent with findings from studies conducted in Ethiopia and within the African meningitis belt (4, 14, 21). However, classic meningeal signs such as neck stiffness (10.9%) and Kernig's sign (4%) were less frequently reported, highlighting the diagnostic challenges of ABM in pediatric patients. This trend is not unique to Ethiopia. A diagnostic accuracy study in India found that a meningeal sign like Kernig's and Brudzinski's had poor sensitivity, with detection rates below 5% in children, similar to findings in this study (10). Likewise, a study in the United States emphasized that young children often present with non-specific symptoms such as irritability and lethargy, and that reliance on classical signs frequently leads to under diagnosis (11). These findings collectively underscore the diagnostic limitations in both low- and high-resource settings, especially among infants and toddlers whose presentations differ from adults. In resource-limited contexts like Ethiopia, where advanced diagnostic imaging or immediate lumbar puncture is not always available, over-reliance on clinical symptoms may result in misdiagnosis or treatment delays, thereby increasing the risk of complications and mortality.

This study revealed significant gaps in diagnostic practices for acute bacterial meningitis. Cerebrospinal fluid (CSF) analysis was performed in only 56.4% of patients (171/303), and CSF culture, the gold standard for confirming bacterial etiology, was conducted in just 33.3% (101/303). Of those tested, only 13.5% had a positive Gram stain and 7.9% had a positive CSF culture, underscoring the limited microbiological confirmation. These findings are consistent with earlier Ethiopian studies, where restricted laboratory capacity and empirical treatment based on clinical judgment remain common (21, 30). In contrast, studies from high-resource settings report far higher diagnostic yields. For example, in a U.S.-based cohort, over 90% of suspected meningitis cases underwent CSF analysis with culture positivity rates exceeding 60% due to early lumbar puncture and better lab infrastructure (2). Similarly, in a German prospective study, pathogen identification was achieved in over 80% of cases, significantly enhancing targeted treatment (23). The disparity between diagnostic approaches highlights the urgent need for improved laboratory infrastructure, standardized clinical protocols, and broader access to rapid diagnostic tools in resource-limited settings like Ethiopia to reduce diagnostic delays and misclassification.

The most commonly prescribed antibiotics in this study were Ceftriaxone (51.5%) and vancomycin (46.2%), reflecting adherence to empirical treatment guidelines for acute bacterial meningitis, particularly in children over two months of age. The widespread use of vancomycin may indicate growing concern about resistant *Streptococcus pneumoniae* strains, a trend echoed in global literature (32). For instance, U.S.-based studies have reported routine inclusion of vancomycin to address pneumococcal resistance (2). Similarly, a study conducted in Eastern Ethiopia found high rates of empirical ceftriaxone use, often without culture confirmation, due to diagnostic limitations (22). In another Ethiopian study, ceftriaxone was the predominant antibiotic, yet treatment outcomes varied significantly depending on the timeliness of administration and adjunctive care (21). While empirical treatment is crucial in resource-limited settings, the limited use of culture-guided therapy increases the risk of antimicrobial resistance and may contribute to treatment failure or prolonged hospital stays.

Adjunctive therapies such as fluid resuscitation (84.6%) and antipyretics (72.0%) were widely used, indicating consistent supportive care. However, corticosteroids were administered in only 31.4% of cases. This is lower than usage reported in high-income countries, where rates range

from 40% to 60%, particularly in children with delayed presentation or *Haemophilus influenzae* meningitis (2, 12, 23). Studies in Ethiopia and other African settings have also shown inconsistent corticosteroid use, often due to unclear guidelines or limited evidence in resource-limited contexts (15, 21). Corticosteroids are generally avoided in neonates because of uncertain benefits, which may partly explain the low overall use, as nearly half of the patients in this study were less than three months old. In older children with severe illness, such as altered consciousness or late presentation, not using corticosteroids may have reduced the chance to prevent complications. This highlights the need for clear, age-specific treatment protocols adapted to settings like Ethiopia.

Multivariate analysis identified several factors significantly associated with treatment outcomes. Children from urban areas were over 5.6 times more likely to have good outcomes than those from rural areas (AOR = 5.605; 95% CI: 1.597–19.667), likely due to better access to healthcare and timely intervention. This finding is consistent with findings from Eastern Ethiopia, where rural children had higher rates of delayed care and poor outcomes (23%), and from Nigeria, where rural patients experienced a 27.2% mortality rate due to limited access to timely treatment and supportive care (26, 27).

Children presenting with seizures were 83% less likely to have favorable outcomes (AOR = 0.174), and those with altered consciousness were 98% less likely to recover well (AOR = 0.018). These clinical signs reflect severe disease progression and are supported by findings from Germany, where 43% of children with seizures or altered mental status developed neurological complications (23), and by studies from Angola and Latin America, primarily due to delayed hospital arrival, seizures, low GCS scores, and malnutrition, similar to the risk factors identified in this study (24). Similarly, a systematic review by Teixeira et al. (2020) identified seizures and altered consciousness as critical predictors of adverse outcomes in pediatric bacterial meningitis (25).

Delayed admission (≥ 72 hours after symptom onset) was associated with a 95% lower chance of good outcomes (AOR = 0.054). This is in line with a Danish cohort study that showed treatment delays increased mortality by 60%, as well as local studies in Eastern Ethiopia that linked delayed care to higher rates of complications and death (18, 22). Children with comorbidities such as malnutrition or anemia were 82% less likely to recover well (AOR = 0.185), similar to

findings from Nigeria, where 27.2% of children with comorbidities died and 32.1% developed neurological deficits. Ethiopian studies have also shown comorbidities as strong predictors of poor outcomes (24, 27).

Lastly, children hospitalized for 7–14 days were over 12 times more likely to recover well compared to those discharged earlier (AOR = 12.748; 95% CI: 1.001–162.420). In this study, 143 out of 303 children (47.2%) had a hospital stay of 7–14 days, and this group showed the highest proportion of good outcomes. This underscores the importance of adequate inpatient treatment duration, particularly in managing complications and ensuring full recovery. Supporting this, a study from Eastern Ethiopia reported that children who stayed 7 to 14 days had significantly fewer complications and were more likely to receive complete courses of antibiotics and supportive therapy (22). Similarly, findings from Southwestern Ethiopia indicated that shorter hospital stays (less than 7 days) were linked with early discharge due to resource constraints or caregiver pressure, contributing to increased risk of relapse or treatment failure (27). These comparisons emphasize that optimal inpatient care duration is critical for improving outcomes in pediatric meningitis, especially in resource-limited settings.

8. STRENGTH AND LIMITATION OF THE STUDY

8.1. STRENGTH

- The use of objective data extracted directly from patient charts minimizes recall bias and subjective errors, contributing to the reliability of the results.
- Inclusion of multiple public hospitals for one year increases the generalizability of the study findings to similar settings in Addis Ababa and potentially other regions with comparable healthcare systems.
- Focusing on acute bacterial meningitis treatment outcomes in children fills a critical gap in local data and can guide clinical practice and policy development to improve pediatric care.

8.2. LIMITATION

- As a retrospective study relying on existing medical records, the research is subject to missing or incomplete data, which could affect the comprehensiveness of the analysis.
- The lack of standardized charting across hospitals may lead to variability in data quality and detail, potentially introducing bias.
- The study design does not allow for establishing causal relationships, only associations between factors and treatment outcomes.

9. CONCLUSION AND RECOMMENDATION

9.1. CONCLUSION

This study explored how children diagnosed with acute bacterial meningitis fared in selected public hospitals in Addis Ababa and what factors influenced their outcomes. While it was encouraging that most children recovered well, nearly one in three experienced poor outcomes such as complications, death, or leaving the hospital before completing treatment. The findings revealed that children who lived in rural areas, had delayed hospital presentation, or arrived with severe symptoms like seizures and altered consciousness were at much higher risk of poor outcomes. Having other health conditions like malnutrition or HIV also made recovery more difficult. Interestingly, children who stayed in the hospital for at least 7–14 days had better outcomes, possibly because they received more complete care.

Beyond individual patient factors, the study uncovered system-wide issues affecting treatment outcomes. Many children did not receive recommended tests like CSF analysis or cultures, and only a third were given corticosteroids, even though evidence shows they can help prevent complications in certain cases. These gaps point to the urgent need for better diagnostic tools, more consistent treatment protocols, and earlier access to care—especially for those coming from underserved areas. Strengthening these areas could make a real difference in reducing the long-term impact of this serious illness and align Ethiopia’s progress with the global goal to defeat meningitis by 2030.

9.2. RECOMMENDATION

For Clinical Practice:

- Enhance diagnostic capacity in pediatric emergency and inpatient settings to facilitate early detection of ABM.
- Implement standardized treatment protocols, emphasizing the rational use of antibiotics and adjunct therapies such as corticosteroids to improve outcomes and reduce resistance risks.
- Train healthcare providers on updated guidelines

For Public Health Policy:

- Strengthen vaccination programs targeting preventable causes of bacterial meningitis to reduce disease incidence.
- Address comorbidities and improve access to healthcare services, especially in the rural communities.

For Research:

- Support prospective, intervention studies to establish causal relationships and evaluate the effectiveness of clinical and public health measures.
- Invest in data systems that allow timely monitoring and response to outbreaks and emerging resistance.
- Encourage multi-center collaborations to generate broader evidence applicable to diverse Ethiopian and similar contexts.

By implementing these recommendations, stakeholders can significantly improve the management and outcomes of acute bacterial meningitis in children, ultimately contributing to the global fight against meningitis and enhancing child health in Ethiopia.

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ANNEXES

DATA COLLECTOR’S TRAINING MANUAL

Study Title: Treatment Outcome and Associated Factors of Acute Bacterial Meningitis among Children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia

Introduction

Welcome to the data collection team. This manual is designed to provide you with the necessary guidance to collect accurate, consistent, and high-quality data for the study. Following the procedures outlined here will ensure the reliability and validity of the research findings.

Study Overview

The objective of this study is to assess treatment outcomes and identify factors associated with acute bacterial meningitis in children aged 0–14 years. The data collection will involve reviewing patient medical records from five selected hospitals over one year (January 1, 2024, to December 31, 2024).

Responsibilities of Data Collectors

- Understand the study objectives and procedures.
- Collect data accurately using the provided questionnaire.
- Maintain confidentiality and protect patient information.
- Ensure all collected data is complete and legible.
- Report any issues encountered during data collection to the principal investigator.

Data Collection Tools

You will use a structured questionnaire to extract the following:

- Socio-demographic data
- Clinical characteristics and Diagnostic test results
- Treatment interventions
- Patient outcomes

Data Collection Procedure

Preparation:

- Familiarize yourself with the study protocol and the questionnaire.

- Attend training sessions on how to complete the data abstraction tool.

Chart Review:

- Locate patient charts using the hospital's records for the specified period.
- Check that the patient meets the inclusion criteria (aged 0–14 years, diagnosed with acute bacterial meningitis, admitted to the emergency department).

Data Abstraction:

- Record the data directly onto the questionnaire.
- Ensure all fields are completed; if information is missing, note it as “not available.”

Quality Assurance:

- Double-check completed questionnaires for errors or omissions.
- Submit completed forms to the research supervisor for review.

Ethical Considerations

- Confidentiality: All patient information is confidential and must not be disclosed.
- Professionalism: Respect hospital protocols and maintain professionalism while handling patient records.

Handling Challenges

- Missing Data: If essential data is missing, note it in the designated section of the questionnaire.
- Illegible Records: Consult with the hospital staff or supervisor if records are unclear.
- Systematic Issues: Report technical or procedural issues to the research team leader promptly.

Monitoring and Supervision

The principal investigator and supervisors will monitor data collection to ensure accuracy and consistency. Regular feedback sessions will be held to address challenges and provide ongoing support.

Contact Information

For any questions or concerns, contact:

Principal Investigator: Mekrez Tadesse Delle (0923244198/ kukutad4@gmail.com)

Research Supervisor:

QUESTIONNAIRE

Title: Treatment Outcome and Associated Factors of Acute Bacterial Meningitis among Children Admitted to Pediatric Emergencies of Selected Public Hospitals in Addis Ababa, Ethiopia

Part 1: Socio-demographic Information

1. Hospital:

- ☐ Tikur Anbessa Specialized Hospital
- ☐ Zewditu Memorial Hospital
- ☐ Yekatit 12 Hospital Medical College
- ☐ St. Paul's Hospital Millennium Medical College
- ☐ Ras Desta Damtew Memorial Hospital

2. Age (): _____

- ☐ 0 – 29 days
- ☐ 1 month – 3 month
- ☐ 4 month –5 years
- ☐ 6–9 years
- ☐ 10–12years

3. Gender:

- ☐ Male
- ☐ Female

4. Residence:

- ☐ Urban
- ☐ Rural

5. Vaccination Status:

- ☐ Fully vaccinated
- ☐ Not fully vaccinated

UnknownIf not fully vaccinated, specify the vaccine missing:

6. Was the child exposed to a known source of meningitis infection within the last 30 days?

- ☐ Yes
- ☐ No

If yes, specify the type of exposure (Select all that apply):

- ☐ Close contact with a confirmed case of meningitis
- ☐ Exposure to overcrowded living conditions
- ☐ Family member with symptoms of meningitis
- ☐ Exposure in healthcare settings
- ☐ Other (Specify): _____

Part 2: Clinical Presentation and Diagnosis

1. Signs and symptoms on Admission (Select all that apply):

- ☐ Fever
- ☐ Vomiting
- ☐ Seizures
- ☐ Headache
- ☐ Neck Stiffness
- ☐ Photophobia
- ☐ Altered consciousness
- ☐ Irritability
- ☐ Poor feeding (for infants)
- ☐ Positive Kernig's or Brudzinski's signs
- ☐ Other (Specify): _____

2. Duration of illness before admission

- ☐ Less than 72hrs
- ☐ 72hrs and above

3. Comorbidities present:

- ☐ Yes
- ☐ No

If yes, specify the comorbidity

- ☐ Malnutrition
- ☐ HIV/AIDS
- ☐ Tuberculosis
- ☐ Asthma
- ☐ Anemia
- ☐ Other (Specify): _____

4. Diagnostic Tests:

CSF WBC count _____

CSF differential Neutrophil Count _____

Gram stain done

☐ Yes

☐ No

Gram stain result

☐ Positive

☐ Negative

Protein level

☐ Protein > 100 mg/dl

☐ Protein $\leq$ 100mg/dl

Glucose level

☐ Glucose $\leq$ 40 mg/dL

☐ Glucose > 40 mg/dL

AFB done

☐ Yes

☐ No

AFB result

☐ Positive

☐ Negative

Blood culture

☐ Positive

☐ Negative

5. Imaging conducted

☐ Yes

NoIf yes, Specify:

☐ MRI

☐ CT Scan

☐ Ultrasound

Part 3: Treatment Information

1. Time to First Treatment
 - ☐ < 1 hour
 - ☐ 1–3 hours
 - ☐ 4–6 hours
 - ☐ 6 hours
2. Antibiotics prescribed:
 - ☐ Ampicillin
 - ☐ Gentamicin
 - ☐ Ceftriaxone
 - ☐ Cefotaxime
 - ☐ Vancomycin
 - ☐ Other: _____
3. Use of Adjunctive Therapies:
 - ☐ Corticosteroids
 - ☐ Oxygen therapy
 - ☐ Fluid resuscitation
 - ☐ Seizure management
 - ☐ Mannitol
4. Other (Specify): _____ Duration of Hospital Stay (Days): _____
 - ☐ < 7 days
 - ☐ 7–14 days
 - ☐ >14 days

Part 4: Treatment Outcome Information

1. Treatment Outcome at Discharge:
 - ☐ Good (Improved)
 - ☐ Poor
 - ☐ Death
 - ☐ Complication
 - ☐ self-discharged
2. Complications During Treatment (Select all that apply):

- ☐ Hearing loss
- ☐ Neurological deficits
- ☐ Seizures
- ☐ Hydrocephalus
- ☐ Death
- ☐ None
- ☐ Other (Specify): _____

ASSURANCE OF PRINCIPAL INVESTIGATOR

I, the undersigned accepted all responsibilities for the scientific and ethical conduct of the research project. I have provided a timely progress report to my advisor and have sought the necessary advice and approval from my primary advisors in the course of the research. I have communicated timely to my advisors all stakeholders involved in the study including any source of funding for this research.

Name of the student: _____

Date: _____

Signature: _____

Approval of the primary Advisor

Name of the primary advisor: _____

Date: _____

Signature: _____