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RESEARCH ARTICLE

Etiology, Prevalence, and Risk Factors of Bacterial Meningitis in Children Under Five at Nakuru County Referral Hospital, Kenya

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ABSTRACT

Bacterial meningitis remains a significant public health burden among young children in resource-limited settings. This study aimed to determine the etiology, prevalence, and associated risk factors of bacterial meningitis in children under five admitted to Nakuru County Referral Hospital, Kenya. A retrospective analysis was conducted on medical records of 105 children diagnosed with bacterial meningitis between 2017 and 2021. *Streptococcus pneumoniae* was the most prevalent pathogen, accounting for 42.9% of cases, followed by *Haemophilus influenzae* (30.5%). The mean age of affected children was 2.03 years (SD = 0.833). Age, weight, and gender were significantly associated with the development of bacterial meningitis ($p < 0.001$). Children attending daycare had a significantly higher risk compared to those not attending daycare (OR = 1.996, $p = 0.0113$). Vaccination status also emerged as a significant risk factor (OR = 1.519, $p = 0.0417$). These findings underscore the critical need for early diagnosis, appropriate antimicrobial therapy, and enhanced vaccination coverage to mitigate the burden of bacterial meningitis. Strengthening preventive measures and adherence to treatment guidelines are essential for improving child health outcomes in this region.

Keywords: *Bacterial meningitis, Streptococcus pneumoniae, antimicrobial therapy, vaccination, risk factors*

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INTRODUCTION

Bacterial meningitis, an acute inflammation of the meninges, remains a significant public health challenge globally, disproportionately affecting children under five years of age (Alderson et al., 2021). This age group's immature immune system, rapid growth, and anatomical features render them particularly susceptible to severe infections, including bacterial meningitis (Deckert, 2018). The disease burden is markedly higher in low- and middle-income countries (LMICs) like Kenya, where access to quality healthcare, including preventive measures and timely treatment, is often limited (Hierink et al., 2021).

The etiological spectrum of bacterial meningitis is diverse, with *Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Haemophilus influenzae* type b (Hib) traditionally recognized as the primary causative agents in many regions (Barichello et al., 2023). However, the specific profile of pathogens can vary considerably based on geographical location, socioeconomic conditions, antibiotic use patterns, and the implementation of vaccination programs (Wall, 2019). In recent years, the emergence of antimicrobial resistance has further complicated the management of bacterial meningitis, necessitating continuous surveillance and adaptation of treatment guidelines (Brouwer et al., 2010).

Kenya, like many LMICs, has reported varying prevalence rates of bacterial meningitis among children. Previous studies in different regions of the country have shown disparities in disease incidence, emphasizing the need for region-specific data to inform effective prevention and control strategies (Cassini et al., 2020; Kontis et al., 2015). For instance, a study conducted in Kilifi County reported an incidence of 10.3 cases per 100,000 children under five years Areba (2016), while another in Kisumu revealed a higher incidence of 22.8 cases per 100,000 children (Areba, 2016). These findings underscore the heterogeneous nature of the disease burden within Kenya and the importance of local epidemiological data for guiding public health interventions.

Understanding the risk factors associated with bacterial meningitis is crucial for developing targeted prevention strategies. Several factors have been implicated in the development of the disease, including age, malnutrition, overcrowding, and exposure to environmental pathogens (Akanwake et al., 2022). The impact of these risk factors may vary across different populations and settings, necessitating further investigation to identify specific risk profiles in different regions of Kenya. The clinical presentation of bacterial meningitis in children can be nonspecific, often delaying diagnosis and initiation of appropriate treatment. Early recognition of signs and symptoms, such as fever, headache, stiff neck, vomiting, and altered mental status, is essential for improving patient outcomes (Hasbun, 2022). The introduction of conjugate vaccines against Hib and pneumococcus has significantly reduced the incidence of these pathogens as causes of bacterial meningitis in many countries (Shinjoh et al., 2014). However, the impact of vaccination on disease burden in Kenya has been variable, and the emergence of antibiotic resistance among bacterial pathogens remains a major concern (Shah et al., 2016).

Despite advancements in prevention and treatment, bacterial meningitis continues to be a significant public health problem in Kenya. Comprehensive strategies are required to address the complex interplay of epidemiological, socio-economic, and environmental factors that contribute to the disease burden.

METHODOLOGY

Study Design

A cross-sectional study based on retrospective data according to Machado et al. (2018) was employed. This design allowed for the examination of existing medical records to identify cases of BM, determine causative organisms, and explore potential risk factors.

Study Setting

The study was conducted at Nakuru County Referral Hospital, a tertiary referral facility serving a wide catchment area in Nakuru County, Kenya. The hospital's strategic location and comprehensive healthcare services made it an ideal setting for this study.

Target Population and Sample

The target population comprised all children under five years who were diagnosed with BM at NCRH between 2016 and 2021. A sample of [number] patient records was selected using a purposive sampling technique. Inclusion criteria included children aged under five years with a confirmed diagnosis of BM based on clinical presentation, cerebrospinal fluid (CSF) analysis, and microbiological culture. Exclusion criteria were incomplete medical records or absence of CSF analysis.

Data Collection

Data were extracted from patient medical records using a structured data collection form. Information collected included demographic characteristics (age, sex, residence), clinical presentation, laboratory findings (CSF analysis, blood culture), antimicrobial treatment, and outcome.

Data Analysis

Descriptive statistics were used to summarize demographic and clinical characteristics of the study population. The prevalence of BM was calculated as the number of confirmed cases divided by the total number of children under five admitted during the study period. The distribution of causative organisms was determined, and their antimicrobial susceptibility patterns analyzed. To identify potential risk factors for BM, bivariate and multivariate logistic regression analyses were performed. Variables included in the analysis were age, sex, residence, nutritional status, vaccination history, and underlying medical conditions. Statistical significance was set at $p < 0.05$.

Ethical Considerations

Ethical approval for this study was obtained from the Kabarak University Research Ethics Committee (KUREC) (Ref: KABU01/KUREC/001/01/10/22) and the Nakuru County Referral Hospital Research Department. Informed consent was waived due to the retrospective nature of the study. Patient confidentiality was strictly maintained by de-identifying all data and ensuring that no personal identifiers were recorded on data collection forms. Hard copy records were securely stored in a locked cabinet accessible only to authorized personnel, while electronic data were password-protected and encrypted to prevent unauthorized access. The study adhered to the principles of the Declaration of Helsinki, ensuring respect for patient rights, data integrity, and ethical research conduct.

RESULTS

Socio-demographic factors influencing the prevalence of meningitis among children in Nakuru

Table 1 presents the socio-demographic characteristics of the study population, including age, weight, and gender. The mean age of the children was 2.03 years with a standard deviation of 0.833 years, indicating a relatively young population. The mean weight was 1.48 kg with a standard deviation of 0.502 kg, suggesting that the majority of children were underweight. Statistical analysis using the Chi-square test revealed significant differences in age, weight, and gender distributions among the study participants ($p<0.001$ for all comparisons). This suggests that these variables may be associated with the development of bacterial meningitis.

Table 1:

Socio-Demographic Characteristics of Study Participants

Variable	Category	Mean	Standard Deviation	Pearson Chi-Square	p-value
Age	0–1 years	2.03	0.833	$\chi^2(4, N = 105) = 88.926$	<0.001
	2–3 years				
	>3 years				
Weight	6–8 kg	1.48	0.502	$\chi^2(4, N = 105) = 88.926$	<0.001
	9–12 kg				
	>12 kg				
Gender	Male	–	–	$\chi^2(1, N = 105) = 88.926$	<0.001
	Female				

Prevalence of Common Causative Agents of Bacterial Meningitis among Children Admitted to NCRH

Table 2 presents the distribution of causative organisms identified in the [number] children with bacterial meningitis. *Streptococcus pneumoniae* was the most common pathogen, accounting for 42.9% of cases, followed by *Haemophilus influenzae* at 30.5%. Other organisms identified include *Neisseria meningitidis* (7.6%), *Klebsiella pneumoniae* (13.3%), and *Listeria monocytogenes* (5.7%).

Table 2:

Distribution of Causative Organisms

Causative organism	Count	Percent
Streptococcus pneumoniae	45	42.9
Haemophilus influenza	32	30.5
Naisseria menengitidis	8	7.6
Kleibsiella pneumonia	14	13.3
Listeria monocytogenes	6	5.7
Total	**105**	**100%**

Association between Socio-demographic Factors and Bacterial Meningitis

Table 3 presents the results of the bivariate analysis examining the association between causative organisms (*Streptococcus pneumoniae, Haemophilus influenzae, Neisseria meningitidis, Klebsiella pneumoniae*) and sociodemographic factors (age, gender, and weight). The table includes Pearson's correlation coefficient, Chi-square statistic, odds ratio (OR) with 95% confidence intervals (CI), and p-value for each comparison. The results indicate that there were no significant associations between the causative organisms and age, gender, or weight for any of the pathogens analyzed. This suggests that these sociodemographic factors may not be strong predictors of the specific type of bacteria causing bacterial meningitis in this study population.

Table 3:

Association between Causative Organisms and Sociodemographic Factors

Causative Organism	Subject Demographics	Pearsons Corr. Coeff.	χ2	OR (95% CI)	Sig.
Kleibsiella pneumonia	Age	- 0.131	3.708	0.260 (0.028, 2.410)	0.157
	Gender	-0.124	1.606	0.638 (0.395, 1.029)	0.205
	Weight	0.023	0.056		0.972
Naisseria menengitidis	Age	0.031	0.135	1.128 (0.441, 2.889)	0.935
	Gender	0.025	0.063	0.940 (0. 584, 1.513)	0.495
	Weight	0.059	4.560		0.036
Haemophilus influenza	Age	-0.059	0.369	1.135 (0. 468, 2.755)	0.831
	Gender	0.027	0.079	1.063 (0. 687, 1.645)	0.478
	Weight	-0.137	4.980		0.083
Streptococcus pneumoniae	Age	0.054	1.066	1.272 (0.583, 2.774)	0.587
	Gender	0.059	0.367	1.123 (0. .768, 1.642)	0.042
	Weight	-0.035	0.973		0.615

Risk Factors for Bacterial Meningitis for Children Admitted for Treatment in NCRH

Table 4 presents the results of the bivariate analysis examining the association between bacterial meningitis and potential risk factors, including vaccination status, malnutrition, daycare attendance, delayed milestones, and mode of delivery. The table includes the Chi-square statistic, odds ratio (OR) with 95% confidence intervals (CI), and p-value for each comparison. The results indicate that vaccination status and daycare attendance were significantly associated with an increased risk of bacterial meningitis ($p<0.05$). Children who were not fully vaccinated were 1.519 times more likely to develop bacterial meningitis compared to those who were fully vaccinated (OR=1.519, p=0.0417). Similarly, children attending daycare were 1.996 times more likely to develop bacterial meningitis compared to those not attending daycare (OR=1.996, p=0.0113). There was no significant association between malnutrition, delayed milestones, or mode of delivery and the risk of bacterial meningitis ($p>0.05$).

Table 4:

Association between Bacterial Meningitis and Potential Risk Factors

Factor	$\chi 2$	OR(CI)	p-value
Vaccination status	0.931	1.519 (1.136, 1.265)	0.0417
Malnutrition	1.657	1.673 (0. 687, 1.645)	0.095
Day care	1.139	1.996 (1.835, 2.947)	0.0113
Delayed milestones	0.074	1.318 (0. .685, 1.242)	0.853
Mode of delivery	1.392	2.702 (0.017, 3.1540)	0.721

DISCUSSION

The findings of this study provide valuable insights into the socio-demographic characteristics of children with bacterial meningitis in Nakuru County, Kenya, as well as the prevalent causative agents and associated risk factors. The results underscore the significant public health burden posed by this disease among young children in the region, necessitating targeted prevention and control strategies. The study population was predominantly composed of young children, with a mean age of 2.03 years, aligning with the established age distribution of bacterial meningitis cases. The high prevalence of underweight children, as evidenced by the mean weight of 1.48 kg, is a critical concern. Malnutrition is well-documented to compromise immune function, rendering children more susceptible to infections, including meningitis (Southall and O'Hare, 2014). These findings emphasize the need for integrated nutritional interventions as part of comprehensive care for children at risk of bacterial meningitis.

Streptococcus pneumoniae emerged as the predominant causative agent of bacterial meningitis in this study, followed by *Haemophilus influenzae* (Ceyhan et al., 2014). While these findings are consistent with global trends in the etiology of bacterial meningitis, it is essential to acknowledge that the specific pathogen distribution can vary significantly across different regions. The presence of other pathogens, such as *Neisseria meningitidis*, *Klebsiella pneumoniae*, and *Listeria monocytogenes*, highlights the diverse etiological landscape of the disease and underscores the importance of comprehensive diagnostic and antimicrobial stewardship practices (EL Moussely et al., 2024).

The lack of significant associations between causative organisms and socio-demographic factors (age, gender, and weight) in this study suggests that these variables may not be strong predictors of the specific bacterial pathogen causing meningitis in this population. However, it is crucial to interpret these findings with caution, as the study's retrospective design and relatively small sample size may have limited the statistical power to detect potential associations. Furthermore, the ecological and epidemiological complexities of bacterial meningitis necessitate further investigation to elucidate the interplay between socio-demographic factors and pathogen distribution. The identification of vaccination status and daycare attendance as significant risk factors for bacterial meningitis is consistent with previous research (Goldacre et al., 2014). Incomplete vaccination leaves children vulnerable to vaccine-preventable diseases, including meningitis, emphasizing the importance of robust immunization programs. Daycare settings, characterized by close contact among young children, facilitate the transmission of respiratory pathogens, including those that can cause meningitis. These findings underscore the need for stringent infection prevention and control measures in childcare facilities to mitigate the risk of disease outbreaks.

While malnutrition was not found to be a significant risk factor in this study, it is essential to acknowledge its potential role as an underlying contributor to increased susceptibility to infections. Malnutrition is a complex issue with multiple determinants, and further research is warranted to explore its association with bacterial meningitis in this population. Nutritional interventions, coupled with immunization and infection prevention measures, may be essential for reducing the overall burden of the disease.

This study has several limitations that should be considered when interpreting the findings. The retrospective design, relying on medical records, may have introduced biases due to missing or incomplete data. Additionally, the relatively small sample size may have limited the statistical power to detect significant associations between certain variables. To address these limitations, future studies with larger sample sizes and prospective designs are recommended.

Conclusion

The study findings reveal that bacterial meningitis remains a significant public health concern among children under five in Nakuru County, Kenya. *Streptococcus pneumoniae* emerged as the predominant causative agent, emphasizing the need for continued surveillance of antimicrobial resistance and the importance of pneumococcal vaccination. The identification of daycare attendance and incomplete vaccination as risk factors underscores the necessity for targeted interventions to improve immunization coverage and infection prevention practices in childcare settings. Addressing the nutritional status of young children is also crucial for enhancing their overall health and reducing susceptibility to infections.

Recommendations

Based on the study findings, it is recommended that public health authorities in Nakuru County prioritize the implementation of comprehensive strategies to prevent and control bacterial meningitis among children under five. These strategies should include strengthening immunization programs, promoting exclusive breastfeeding and good nutrition, improving infection prevention and control practices in healthcare facilities and childcare settings, and conducting ongoing surveillance of the epidemiology and antimicrobial resistance patterns of bacterial meningitis. Additionally, further research is needed to explore the underlying factors contributing to the high prevalence of bacterial meningitis in this region and to evaluate the effectiveness of different intervention strategies.

Conflict of Interest

The authors declare no conflict of interest.

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