Open Journal of Pediatrics, 2023, 13, 352-367
https://www.scirp.org/journal/ojped
ISSN Online: 2160-8776
ISSN Print: 2160-8741

In Hospital Death among under Five Years Children Hospitalized with Meningitis in the Eastern of the Democratic Republic of Congo

Jeannière Tumusifu Manegabe[1,2], Furaha Bidhoro[1,2], John Peter Mulindwa[1,2], Muke Kitoga[1,2], Fikiri Bavure[3], Mambo Mwilo[1,2], Kanku Tudiandike[1,2], Archippe Muhandule Birindwa[1,2,3]*

[1]Université Evangélique en Afrique, Bukavu, Democratic Republic of the Congo
[2]Panzi Hospital, Bukavu, Democratic Republic of the Congo
[3]Department of Infectious Diseases, Institute of Biomedicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
Email: jeanniere manegabe6@gmail.com, nisabidorho@gmail.com, mulindwamully@gmail.com kitogamuke@gmail.com, rodfikbav@gmail.com, mambomwingi@ymail.com, kankuleonard815@gmail.com, *birindwaarchippe@gmail.com

How to cite this paper: Manegabe, J.T., Bidhoro, F., Mulindwa, J.P., Kitoga, M., Bavure, F., Mwilo, M., Tudiandike, K. and Birindwa, A.M. (2023) In Hospital Death among under Five Years Children Hospitalized with Meningitis in the Eastern of the Democratic Republic of Congo. *Open Journal of Pediatrics*, **13**, 352-367.
https://doi.org/10.4236/ojped.2023.133041

Received: March 26, 2023
Accepted: May 12, 2023
Published: May 15, 2023

Abstract

Background: Meningitis is a major public health problem needing timely diagnosis, appropriate treatment, prevention and control. Despite the advances in diagnosis and treatment of infectious diseases, meningitis is still considered as an important cause of mortality and morbidity, especially in the paediatric population of lower income countries such as the Democratic Republic of the Congo (DR Congo). In this study, we aimed to analyse the fatality aspect of suspected meningitis among children under five years. **Materials and Methods:** A prospective, descriptive study was carried out in the Paediatrics departments of four hospitals in the South-Kivu province in the Eastern part of the DR Congo from April 2021 to March 2022. Of the 1386 children enrolled, 251 children were suspected of meningitis. This study captures data generated in the framework of routine medical practice, which includes medical history, clinical diagnosis and results of locally conducted laboratory tests. **Results:** Throughout the study period, a total of 251 patients (18.1%) aged 1 month to 59 months with suspected meningitis were recruited out of 1386 children hospitalized in the Paediatrics. The fatality among hospitalized children with suspected meningitis during the study period was 27.9%, however the mortality linked to meningitis decreases with age, ranging from 37.5% among children under 2 years to 19.4% among those over 2 years old. Children hospitalized for meningitis with malnutrition as an underlying conditions, had a 3.5 times greater risk of dying. The case fatality rate was higher in transferred and not vaccinated children respectively (2.3 and 2.5 times). We observe that the death occurs early within the first 3 days. **Conclusion:**

Our study noted a higher fatality rate in children with suspected meningitis that could probably be linked to the gape in vaccination and malnutrition as underline condition.

Keywords

Children, Suspected Meningitis, Cerebrospinal Fluid, Mortality

1. Introduction

Meningitis is a life-threatening disease caused by inflammation of the thin membranes surrounding the brain and spinal cord and most commonly due to bacterial or viral infection [1] [2]. The term meningitis means stricto sensu: inflammation of the meninges. The aetiologies of meningitis are therefore multiple, but above all infectious, bacterial and viral [3]. According to a systematic analysis for the Global Burden of Disease Study 2019, meningitis ranked sixth among the top causes of disease burden in children [4]. Despite the advances in diagnosis and treatment of infectious diseases, meningitis is still considered as an emergency and important cause of mortality and morbidity, especially in the paediatric population, hence it must be diagnosed and treated promptly [5]. But the similar clinical presentation often makes it difficult to differentiate bacterial and non-bacterial aetiologies in children [6] Meningitis in children takes the form of sporadic cases with a rate of 1.5/100,000 and 20/100,000 population in the developed and developing countries, respectively. Annually, minimum of 890,000 cases are estimated to occur, while 160,000 and 135,000 are disabling and fatal cases, respectively [7] [8].

In 2017, representatives from governments, global health organizations, public health agencies, academia, the private sector and civil society called for a global blueprint to defeat meningitis as a threat for public health [1]. According to the WHO, bacterial meningitis is responsible for 17 million deaths worldwide, of which 43% in developing countries. Their spontaneous evolution is fatal and these infections constitute therapeutic emergencies. It is estimated for all ages and all germs combined at 2.2/100,000 inhabitants in France, and at 50/100,000 inhabitants in developing countries [9].

During the last 20 years, around 300,000 cases of meningitis have been reported in the Lapeyssonnie meningitis belt with a lethality of 20% to 60% and 10% to 40% of sequel [5]. Mortality and sequel are very high in developing countries; also remain high in industrialized countries despite early and appropriate antibiotic therapy [9].

Moreover, the results of similar studies carried out in several European countries revealed that the incidence rate of bacterial meningitis was 2.6/100,000 inhabitants in the Netherlands, 3.7/100,000 inhabitants in Italy, 4.3/100,000 population in Kosovo and 3.2/100,000 population in Iceland [10] [11].

The mortality for untreated bacterial meningitis approaches 100% and, even with optimum treatment, mortality and morbidity still happen [12]. Meningitis is most acute in the African meningitis belt, an area stretching from Senegal to Ethiopia with an estimated total population of 500 million in 26 Member States. Since 2010, Member States in the meningitis belt have recorded an annual average of 24,000 suspected cases, resulting in 1800 deaths. The fatality rate fluctuates between 5% and 14%, while 90% of cases are recorded during the epidemic season (which extends from January to June) [13]. Meningitis epidemics have been reported in Africa for more than a century, with the highest rates of mortality observed in children < 5 years old [14] [15].

Meningitis is generally associated with a case fatality rate of between 8% and 15% in treated patients and over 70% when the disease is untreated [13]. In South Kivu, a study carried out in Lwiro shows a meningitis-related mortality of 13% [16].

In this study we aimed to determine the fatality rate and associated factors among under five years children hospitalized on the suspicion of meningitis in four hospital in the South-Kivu province in the Eastern part of the DR Congo.

2. Methods

2.1. Data Collection

This is a prospective, analytical study carried out in the Paediatrics departments of four hospitals in the South-Kivu province in the Eastern part of the DR Congo (the HGR Panzi, Nyantende, as well as Miti Murhesa and the University Clinic of Bukavu) for one year. From April 2021 to March 2022 a total of 1468 children aged from 1 to 59 months were admitted in the Paediatric Department.

Of these, 82 children were excluded, 52 due to missing information and 30 due to patients leaving before end of treatment. Of the remaining 1386 children, 251 children were identified with a diagnosis of acute meningitis and their data extracted from their medical records (non electronic files).

2.2. Study Area

The study was performed on hospitalized patients in the Paediatrics department of the various local hospitals, two general hospitals, Panzi Hospital and clinique Universitaire and two district hospitals, Miti Murhesa and Nyantende. Panzi Hospital, located in Bukavu town, is a teaching hospital that served a population of 453,000 inhabitants including 86,000 (19%) children below 5 years at the time of the study. The Clinique Universitaire Hospital located in the suburban area of Bukavu, served a population of 337,000 inhabitants including 71,000 (21%) children below five years. The other two district hospitals were located in rural areas; the Miti Murhesa district hospital served a population of 231,000 inhabitants including 52,000 (23%) children below 5 years, and the Nyantende Hospital, 132,000 inhabitants including 29,000 (22%) children in 2014 [17] [18].

2.3. Definition of Case

Suspected meningitis: cases were identified using the WHO standard case definition by the rapid development of a fever with axillary and rectal temperatures > 38˚C or >38.5˚C, respectively, combined with at least 1 of the following clinical symptoms: reduced level of consciousness, meningismus (stiff neck), photophobia, bulging fontanel (infants), and convulsions or partial seizures [14] [19] [20].

Probable case: any suspected case with Cerebrospinal fluid (CSF) cloudy, opaque or purulent macroscopic appearance, or CSF with a leukocyte count > 10 leukocytes/mm^3 or revealing the presence of a bacterium identified by Gram staining, or presenting a result positive for CSF antigen detection (e.g. latex agglutination test) [19] [20].

Confirmed case: Any suspected or probable case that is laboratory confirmed by culture or identification of a bacterial pathogen (*Neisseria meningitidis*, *Streptococcus pneumoniae*, *Haemophilus influenzae* type b) in CSF [19] [20].

2.4. Population and Sample

Our study population consists of all children from 1 to 59 months old admitted to the various paediatric departments of the selected hospitals, during our study period, *i.e.* from April 1, 2021 to March 31, 2022. During this period, a through sampling of all included children was taken and analysed.

Our study enrolled, all children meeting the following inclusion criteria:

- Ages from 1 month to 5 years hospitalized in the Paediatrics departments of the four hospitals.
- All probable case and confirmed case.
- From whom a blood and cerebrospinal fluid (CSF) sample was taken.
- From whom parental consent to participate in the study was granted.

2.5. Sample Collection

This study captures data generated in the framework of routine medical practice, which includes medical history, clinical diagnosis and results of locally conducted laboratory tests. The diagnosis of bacterial meningitis is based on the analysis of CSF obtained by lumbar puncture.

All the children admitted with clinical symptoms of meningitis, were clinically examined and a blood and cerebrospinal fluid sample was taken. To collect the data, we developed a survey sheet containing the socio demographic, clinical symptoms, Para clinical results, therapeutic and evolutionary variables. A parental or guardian approval to participle in the study was obtained by signing a consent form.

2.6. Variables

Socio demographic and clinical variables: identity (each child is identified by a code of initials), sex, age in months, place of origin: urban or rural, vaccination status considered complete when the child has already received 3 doses of pentavalent and 3 doses of pneumococcal conjugate vaccine 13 (PCV 13).

Clinical data: convulsion, state of consciousness (defined by the AVPU scale: Awake, Verbal, Pain, Unresponsive), associated signs (digestive, respiratory symptoms), agitation, bulging of anterior fontanel, hyperesthesia, date of admission, date of discharge, history of antibiotic intake, referral or not, associated diseases and the nutritional status.

Outcome: death or cured, the date of death

2.7. Data Analysis

The data collected were entered and analysed on Excel, then by the XLSTAT-2021 software for univariate and bivariate logistic regression to compare the data. We used the Chi square test for the comparison of the proportions and sub categories, the p value less than 0.05 was considered statistically significant. The Emergency Nutrition Assessment (ENA) software (version 2011) was used to assess the nutritional status, while malnutrition was defined as either the weight for the subjects' age or weight vs. height that gave a Z score ≤ −2 standard deviations.

2.8. Ethical Consideration

The study was conducted in accordance with Good Clinical Practice and Good pharmaco epidemiology Practices, all applicable subject privacy requirements adhered to. The study was approved by the National health ethics committee of DR Congo (CNES/DP-SK 001-4125/001-155-2021). Written or witnessed and thumb written informed consent was obtained from the parent/legal representative of each study participant prior to enrolment.

2.9. Funding

This study was supported by the children prize foundation. The funding body had no role in the design of the study, the collection, analysis or interpretation of data, nor in writing of the manuscript.

3. Results

3.1. Socio Demographic and Clinical Characteristics of the Participants

The socio-demographic characteristics and the clinical data of all the children with suspected meningitis are presented in **Table 1**.

Throughout the study period, a total of 251 patients (18.1%) aged 1 month to 59 months with suspected bacterial meningitis were enrolled out of 1386 children hospitalized in the Paediatrics department. More than half (61%) of the children enrolled were male with 1.6 of sex ratio. Of these, 56.6% appeared during the rainy season, 56.6% were from rural areas, 49.8% were not fully vaccinated against *pneumococci* and *Haemophilus influenzae*, 19.9% had malnutrition and 63.7% were not referred. We observe that the prevalence of meningitis increases with age, the greatest number (37.1%) of suspected cases were seen in the eldest children, aged 25 to 60 months and the median age of patients was 22.1 months.

The clinical parameters of our sample show that seizures were observed in 76.1% of patients while coma was present in 59% of patients. Cry incessantly was observed in 10% of patients, hyperesthesia present in 8.4%, digestive signs present in 23.1%, respiratory signs in 19.5%, and a bulging anterior fontanel in 12.7 % with restlessness in 7.2%. Note that fever was observed in all patients. Most of children were treated with ceftriaxone and gentamycin combination (43.8%) followed by chloramphenicol (20.7%) while Meropenem was used for 10.4% (Table 2). The duration of hospital stay was between for days and ten days for 41.8% patients.

Table 1. Socio-demographic data and clinical characteristics of the children treated at the hospitals due to meningitis during our study period.

Variables		Number of children (%) (N = 251)
Season	Rainy season	142 (56.6)
	Dry season	109 (43.4)
Age	≤2 month	72 (28.7)
	3 - 24 month	86 (34.3)
	25 - 60 month	93 (37.1)
Sex	Female	98 (39)
	Male	153 (61)
Address	Rural	142 (56.6)
	Urban	109 (43.4)
Vaccine statute	Not fully vaccinated*	125 (49.8)
ATB used previously	ATB used	129 (51.4)
Nutritional statute	Malnutrition**	50 (19.9)
Transfer	Transfer	91 (36.3)
Symptoms	Fever	251 (100)
	Convulsion	191 (76.1)
	Coma	148 (59)
	Incessant crying	26 (10.4)
	Hyperesthesia	21 (8.4)
	Diarrhea/vomiting	58 (23.1)
	Rapid or difficult breathing	49 (19.5)
	Hustle	18 (7.2)
	Boomed anterior fontanel	32 (12.7)

*: Not fully vaccinated: child who has not yet received the 3 doses of pneumococcal and Haemophilus vaccine; **: Malnutrition: A Z-score cut-off point of <−2 SD to classify low weight-for-age.

Table 2. Therapeutic and evolutionary data of the children treated at the hospitals due to meningitis during our study period.

	Associate Diseases	Number of children (%) (N = 251)
Associate diseases	SEPSIS	79 (31.4)
	Neurological malaria	55 (21.9)
	Congenital heart disease	2 (0.8)
	HIV	2 (0.8)
	None	113 (45)
Antibiotic used	Ceftriaxone and gentamicin	110 (43.8)
	Chloramphenicol	52 (20.7)
	cefotaxime and gentamycin	28 (11.2)
	Meropenem	26 (10.4)
Duration of hospital stay (days)	1 - 3	60 (23.9)
	4 - 10	105 (41.8)
	11 - 20	62 (24.7)
	≥21	24 (9.6)
Outcome	Improved and cured	181 (72.1)
	Death	70 (27.9)
	Death before 72 h	56 (22.3)
	Death after 72 h	14 (5.6)

3.2. Case Fatality Rate of Meningitis

The fatality among hospitalized children with suspected meningitis (**Table 3**) during the study period is 27.9%, however the mortality linked to meningitis decreases with age, ranging from 37.5% among children under 2 months to 19.4% among those over 2 years old (OR 2.36; 95% CI 1.12 - 4.94; p 0.022). Children hospitalized for meningitis and also had malnutrition as underlying conditions had a 3.5 times greater risk of dying (**Table 3**). The case fatality rate was higher in referred and not fully vaccinated children respectively 2.3 and 2.5 times higher (**Table 3**). We observe that the death occurs early in the first 3 days with a statistically significant difference (OR 231; 95% CI 62.5 - 853.5; $p < 0.0001$). The case fatality rate was significantly associated with the appearance of CSF (OR 2.5; 95% CI 1.4; 4.5; p 0.001) (**Table 3**). The case fatality rate was higher in children with the C-reative protein biomarker above 100 mg/dl and those with high number of White cell in the CSF respectively 3.5 and 2.87 times higher (**Table 3**). The highest fatality rate was observed during the three first days of hospitalization (**Table 3**).

Table 3. Identified fatality risk factors among hospitalized children with acute meningitis (n = 251) during the study period.

Risk factors		Death n = 70	OR IC95%	*p*-value
Age (month)	25 - 60	18 (19.4)		1
	≤2	27 (37.5)	2.36 (1.12 - 4.94)	0.022
	3 - 24	25 (29.1)	1.89 (0.89 - 4.02)	0.097
Sex	Boys	41 (26.8)		1
	Girls	29 (29.6)	1.1 [0.6; 2.1]	0.63
Address	Rural	40 (28.2)		1
	Urban	30 (27.5)	1 [0.5; 1.8]	0.91
Vaccination statute	Vaccinated	24 (34.3)		1
	Not vaccinated	46 (65.7)	2.5 [1.4; 4.4]	0.002
ATB received before	No	29 (23.8)		1
	Yes	41 (31.8)	1.4 [0.9; 2.6]	0.158
Malnutrition	No	45 (22.4)		1
	Yes	25 (50)	3.5 [1.8; 6.6]	0.0002
Transfer	No	35 (21.9)		1
	Yes	35 (38.5)	2.3 [1.3; 3.9]	0.005
C reactive protein	≤5	5 (16.7)		1
	6 - 100	48 (27.6)	1.90 (0.68 - 5.26)	0.21
	>100	17 (36.2)	2.83 (0.91 - 8.76)	0.07
Malaria test	Positive	17 (19.1)		1
	Negative	53 (32.7)	2.1[1.1; 3.9]	0.021
Aspect du CSF*	Clear	36 (21.4)		1
	Trouble	34 (41)	2.5 [1.4; 4.5]	0.001
GB CSF **	<10	29 (18.8)		1
	10 - 99	22 (40)	2.87 (1.46 - 5.63)	0.002
	≥100	19 (55.7)	3.5 (1.71 - 7.38)	0.0006
Stay (days)	4 - 10	6 (5.7)		1
	1 - 3	56 (93.3)	231.0 (62.5 - 853.5)	<0.0001
	11 - 20	6 (9.7)	1.76 (0.54 - 5.74)	0.34
	≥21	2 (8.3)	1.5 (0.28 - 7.93)	0.63

*: Cerebrospinal fluid b); **: White blood cell count in cerebrospinal fluid.

4. Discussion

4.1. Socio Demographic and Clinical Characteristics of the Samples

Throughout the study period, we come out with a prevalence of a total of 251 patients (18.1%) aged 1 to 59 months old with suspected bacterial meningitis among the 1386 hospitalized children, which looks lower compare to a study done in Benin in 2016 that found a 24% frequency of meningitis in children under 5 years old [21]. In Ethiopia, Dilla find the overall prevalence of meningitis among under-five children of 13.2% that looks similar to our finding [22]. This can be related to demographic distribution of the disease and the on going prevention program in the different country.

More than half (61%) of the children recruited were male with 1.6 of sex ratio. Results similar to those of a study carried out in Bangui which observes a male predominance with a sex ratio of 1.2 [23]. A study carried out by Samia Al-Ojali in Libya which observed 56% male sex with a sex ratio of 1.3 in favour of the male sex [24], which is similar to result find Ivory Cost by Boni Cisse [14]. But a study done in the sub-Saharan region, observed that the two sexes were equally distributed [25]. This male preponderance may be due to the relative absence of a gene locus for the elaboration of immunoglobulin, which has been documented to be located on the X chromosomes [26] [27]. Moreover some culture norms in Africa valuing boys than girls therefore they brought boys than female to health facilities when both are sick [28].

Of the 251 included children 129 (51.9%) had previous antibiotic treatment, result similar to that of a study done in Brasilia which observed 47.2% of children to have received an antibiotics previously [29]. This can be explain by the absence of regulation in the use of antibiotic in DR Congo were people have easy antibiotic access.

A high number of patients, 142 (56.6) were seen during the rainy season and in Rural. Similar result has been described in Southern Ethiopia by Dilla (58.9%) [22] and Hailemariam Abiy in Northwest Ethiopia (56.6%). When in the sub-Saharan region the prevalence was tight higher compere to our results (68.0%) [25]. This may be due to demographic, socio-cultural, and economic differences between regions and population. Also the fact that meningitis infections may be influenced by some weathers variation even some seasonal and regional variation [30].

In our population, 49.8% of children were not fully vaccinated against pneumococcal as well as *Haemophilus influenzae*, result similar to those found in Ethiopia by Hailemariam Abiy for whom only 45.4% were fully vaccinated [31] contrast to the results of a study carried out in Benin which found that 83.2% were fully vaccinated [21] and 68.6% of patients in Senegal were fully vaccinated according to the national vaccination program [32]. This difference might be due to the successfulness of immunisation program in different countries. In the DR Congo the immunization program against *Pneumococcus Pneumonia* has been introduce recently.

Malnutrition is one of the risk factors that can expose to the development of meningitis [31]. The current study indicate that about 19.9% of the patients were malnourished similar to the finding in Ethiopia by Hailemariam Abiy for whom

21% were recorded as malnourished [31]. A similar study conducted in Felege Hiwot Referral Hospital indicated that 18% of the patients were malnourished [7].

Our study revealed that 36.3% of our included children were referred from other health centers which look similar to result found in Italy on which Forty percent of patients were transferred from other secondary hospitals to the tertiary hospital [33]. The high rate of death among the children transferred could be explained by the fact that it is often a late transfer; a transfer after the child has already been handled at the primary health care structure.

The greatest number (37.1%) of suspected cases were seen in the eldest children, aged 25 to 60 months (median age 22), result almost similar to those obtained by Awulachew Dilla in Ethiopia, 41.5% of children were in the 13 - 59 month group [22], and Boni Cisse in Ivory Coast who found 46.0% of children aged 24 - 59 months (median age 28 months) [14]. Results differ from those obtained by a study carried out in France, where 67.2% of children were under two years old (median 9 months). The Prevalence of meningitis in infants may be partly due to the vulnerability of their choroid plexus to penetration by bacteria during the septicemic process and to low immunological status [26]. Note that children in young age group are more susceptible to infection due to their under- developed immune system [3] [34].

When looking on symptoms of our study group, seizures were observed in 76.1% of patients while coma was present in 59% of patients. Incessant crying was observed in 10% of patients, hyperesthesia present in 8.4%, in 23.1% we noted digestive signs, respiratory signs in 19.5%, and a bulging anterior fontanel in 12.7% with restlessness in 7.2%. Note that fever was observed in all patients. A study done in 2018 in the department of Paediatrics for Koirala Institute of Health Sciences, Nepal found that the common clinical presentations in children were fever (96%), convulsions (58%), and vomiting (40%) [6]. This is explained by the meningitis clinic, which varies according to the age of the child [3] [34].

4.2. Case Fatality Rate of Meningitis

The overall fatality of meningitis in children remains higher in the current study, 27.9% compare to a study done in Mali (Paediatrics department of the CHU Gabriel Touré) that found 18% [35]. In Afghanistan, the in-hospital case fatality was 21.5% [28]. This difference can be explained by the fact that our study was carried out during the period of the COVID 19 pandemic during which consultations were delayed for fear of being contaminated and the high number of not fully vaccinated children in our study group. The differences in fatality rates observed in different studies are also due to several reasons, including type of study design, age spectrum of the children, definition of acute meningitis, culture, and socio-economic, nutritional status and HIV status [28].

The risk factors associated with fatality of suspected meningitis in our study are: age, malnutrition, vaccination, referred, late consultation and young age.

The mortality linked to meningitis decreases with age, ranging from 37.5% among children under 2 months to 19.4% among those over 2 years old. In opposite to the results found in Afghanistan, bivariate analysis identified coma on admission, no adjunctive dexamethasone therapy, no PCV or Hib vaccination, male gender and a purpuric/petechial rash as factors for death [28].

In this study, immunization status of children determines the clinical outcome of meningitis. Children who completed their vaccination had better outcome than those who did not complete their vaccination. Mortality is higher among unvaccinated children (65.7%) compared to vaccinate, this could be due the protective effect of vaccines to prevent against major causes of childhood meningitis [34] [36].

Children hospitalized for meningitis and also had malnutrition as underlying conditions, had a 3.5 times greater risk of dying. The case fatality rate was higher in transferred and not vaccinated children respectively 2.3 and 2.5 times higher in children. This would be explained by the immune deficiency created by this state of malnutrition. Also the delay in consultation explains this high mortality from the admission of the patient because this study was carried out during the period of the COVID 19.

We observe that the death occurs early in the first 3 days with a statistically significant difference ($p < 0.0001$). Result different from a study made in Tunisia, which observes that 50% of patients died in the first 24 hours [37]. This would be explained by the fact that the management of meningitis is an emergency and that the stabilization of the patient must be done in the first hours of his admission. Also the delay in consultation explains this high mortality from the admission of the patient because this study was carried out during the period of the COVID 19 pandemic, a period during which many patients preferred to stay at home than to go to the hospital. Early diagnosis and rapid initiation of appropriate therapy are the keys in patients with suspected community-acquired bacterial meningitis [38].

5. Conclusion

Our study noted a higher fatality rate in children with suspected meningitis that could probably be linked to several aspects of the management but also to the gape in vaccination. The prevention process will need to be deeply explored for better understanding of this higher fatality rate.

Authors' Contributions

AMB designed and supervised the study. JM, FB, JM and KM collected data from all medical records of admitted patients. JTM analyzed the data in close communication with AMB under the orientation of statisticians at the Evangelical University in Africa. JTM was mainly responsible for writing the manuscript, which was critically revised by AMB and KL. All authors read and approved the final manuscript.

Acknowledgements

Acknowledgments to the Children's prize foundation for funding research and their fight to reduce infant mortality. Our sincere thanks also go to all the staff of the Evangelical University in Africa. We thank the staff of Panzi Hospital, clinique Universitaire hospital, Miti Murhesa hospital and Nyantende hospital involved in this study for their collaboration.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] World Health Organisation (2021) Defeating Meningitis by 2030: A Global Road Map. Organisation Mondiale de la Santé, Genève. https://apps.who.int/iris/handle/10665/342010

[2] Organisation mondiale de la Sante (2015) Contrôle des épidémies de méningite en Afrique.

[3] Bourillon, A., Benoist, G., Chabrol, B., Cheron, G. and Grimprel, E. (2020) Pédiatrie Pour le Praticien. 7e edition.

[4] Abbafati, C., *et al.* (2020) Global Burden of 369 Diseases and Injuries in 204 Countries and Territories, 1990-2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *The Lancet*, **396**, 1204-1222.

[5] Águeda, S., Campos, T. and Maia, A. (2013) Prediction of Bacterial Meningitis Based on Cerebrospinal Fluid Pleocytosis in Children. *The Brazilian Journal of Infectious Diseases*, **17**, 401-404. https://doi.org/10.1016/j.bjid.2012.12.002

[6] Chaudhary, S., Bhatta, N.K., Lamsal, M., Chaudhari, R.K. and Khanal, B. (2018) Serum Procalcitonin in Bacterial & Non-Bacterial Meningitis in Children. *BMC Pediatrics*, **18**, Article No. 342. https://doi.org/10.1186/s12887-018-1314-5

[7] Tilahun, T., *et al.* (2018) Clinical Outcomes and Risk Factors of Meningitis among Children in Referral Hospital, Ethiopia, 2016: A Retrospective Chart Review. *Ethiopian Journal of Health Sciences*, **28**, 563-570.

[8] Peltola, H. and Roine, I. (2009) Improving the Outcomes in Children with Bacterial Meningitis. *Current Opinion in Infectious Diseases*, **22**, 250-255. https://doi.org/10.1097/QCO.0b013e328329c47a

[9] Bourrillon, A., *et al.* (2011) Pediatrie Pour les Praticiens. 6e Edition, Elsevier Masson SAS, Paris.

[10] Berangi, Z., Karami, M., Mohammadi, Y., Nazarzadeh, M. and Zahraei, S.M. (2019) Epidemiological Profile of Meningitis in Iran before Pentavalent Vaccine Introduction. *BMC Pediatrics*, **19**, Article No. 370. https://doi.org/10.1186/s12887-019-1741-y

[11] Rossi, P.G., Stanghellini, E., Curtale, F. and Borgia, P. (2009) Incidence of Bacterial Meningitis (2001-2005) in Lazio, Italy: The Results of a Integrated Surveillance System. *BMC Infectious Diseases*, **9**, Article No. 13. https://doi.org/10.1186/1471-2334-9-13

[12] Kim, K.S. (2010) Acute Bacterial Meningitis in Infants and Children. *The Lancet Infectious Diseases*, **10**, 32-42. https://doi.org/10.1016/S1473-3099(09)70306-8

[13] Organisation mondiale de la Sante (2021) Cadre pour la mise en oeuvre de la strategie pour vaincre la meningite d'ici2030 dans la region africaine de l'OMS.

[14] Boni-cisse, C., *et al.* (2019) Etiology of Bacterial Meningitis among Children < 5 Years Old in Côte d'Ivoire: Findings of Hospital-Based Surveillance before and after Pneumococcal Conjugate Vaccine Introduction. *Clinical Infectious Diseases*, **69**, S114-S120. https://doi.org/10.1093/cid/ciz475

[15] Mazamay, S., *et al.* (2021) An Overview of Bacterial Meningitis Epidemics in Africa from 1928 to 2018 with a Focus on Epidemics "Outside-the-Belt". *BMC Infectious Diseases*, **21**, Article No. 1027. https://doi.org/10.1186/s12879-021-06724-1

[16] Mushagalusa, B., Babunga, M., Badibanga, M., Karazo, N. and Riziki, M. (2015) Bacterial Meningitis in Children in Lwiro (South Kivu DRC). *International Journal of Innovation and Applied Studies*, **11**, 204-206.

[17] Birindwa, M., Jeanniere, M. andersson, R., Mindja, A. and Nordén, R. (2020) Decreased Number of Hospitalized Children with Severe Acute Lower Respiratory Infection after Introduction of the Pneumococcal Conjugate Vaccine in the Eastern Democratic Republic of the Congo. *The Pan African Medical Journal*, **37**, Article No. 211. https://doi.org/10.11604/pamj.2020.37.211.22589

[18] de la Sante, M. (2014) Deuxième enquête démographique et de santé (eds-rdc ii 2013-2014). MPSMRM, MSP et ICF International, Rockville.

[19] Organisation Mondiale de la Santé (2019) Procédures opérationnelles Standard pour la surveillance, la préparation et la riposte aux épidémies de méningite en Afrique. Brazzaville. https://creativecommons.org/licenses/by-nc-sa/3.0/igo

[20] W.H. Organization (2009) Standard Operating Procedures for Enhanced Meningitis Surveillance in Africa.

[21] Agossou, J., *et al.* (2016) Serotypes of Bacteria Encountered in Childhood Purulent Meningitis in Children in Parakou (Benin) in 2011. *Open Journal of Pediatrics*, **6**, 109-119. http://www.scirp.org/journal/ojped https://doi.org/10.4236/ojped.2016.61017

[22] Awulachew, E., Diriba, K. and Awoke, N. (2020) Bacterial Isolates from CSF Sample and Their Antimicrobial Resistance Patters in among Under-Five Children Suspected for Meningitis in Dilla University Referral Hospital. https://doi.org/10.1101/2020.06.01.127456

[23] Tekpa, G., Gbangba Ngai, E., Yangatimbi, E., Kitakossi, F., Mossoro-kpinde, C. and Mbelesso, P. (2020) Aspects cliniques et bactériologiques des méningites purulentes en zone rurale centrafricaine. *Revue Malienne d'Infectiologie et de Microbiologie*, **15**, 44-53. https://doi.org/10.53597/remim.v15i1.1565

[24] Al-ojali, S.M., Al-fituri, S.M., Ramadan, M.A.G., Walid, M., Ramadan, A. and Busba, A.O. (2022) Bacterial Meningitis among Children and Antibiotic Sensitivity Patterns in the East of Libya. *International Journal of Multidisciplinary Research and Publications*, **4**, 101-105.

[25] Valerie, H. (2021) Baseline Incidence of Meningitis, Malaria, Mortality and Other Health Outcomes in Infants and Young Sub-Saharan African Children Prior to the Introduction of the RTS, S/AS01$_E$ Malaria Vaccine. *Malaria Journal*, **20**, Article No. 197.

[26] Iregbu, K.C. and Abdullahi, N. (2015) Profiles of Acute Bacterial Meningitis Isolates in Children in National Hospital, Abuja. *Nigerian Medical Journal*, **56**, 297-300. https://doi.org/10.4103/0300-1652.169749

[27] Ingersoll, M.A. (2017) Sex Differences Shape the Response to Infectious Diseases. *PLOS Pathogens*, **13**, e1006688.

http://journals.plos.org/plospathogens/article/file?id=10.1371/journal.ppat.1006688&type=printable

[28] Rahimi, B.A., Ishaq, N., Mudaser, G.M. and Taylor, W.R. (2022) Outcome of Acute Bacterial Meningitis among Children in Kandahar, Afghanistan: A Prospective Observational Cohort Study. *PLOS ONE*, **17**, e0265487. https://doi.org/10.1371/journal.pone.0265487

[29] Mantese, O., Hirano, J., Santos, I. and Silva, V.M. (2002) Etiological Profile of Bacterial Meningitis in Children. *Jornal de Pediatria*, **78**, 467-474. https://doi.org/10.2223/JPED.901

[30] Diarra, F. (2012) Facteur pronostic et dévenir des enfants atteints de méningites dans le département de Pédiatrie du CHU Gabriel Toure de 2009 à 2010.

[31] Shiferaw, Z., *et al.* (2019) Clinical Outcome of Meningitis and Its Risk Factors among Children Admitted in Debre Markos Referral Hospital Pediatric Ward, Northwest Ethiopia, 2019.

[32] Basse, I., *et al.* (2020) Purulent Meningitis in Children: A Retrospective Study of 70 Cases in Senegal. *International Journal of Infectious Diseases and Therapy*, **5**, 127-130. https://doi.org/10.11648/j.ijidt.20200504.14

[33] Ciofi, M., Esposito, S., Parola, L., Ravà, L., Gargantini, G. and Longhi, R. (2014) In-Hospital Management of Children with Bacterial Meningitis in Italy. *Italian Journal of Pediatrics*, **40**, 87.

[34] Thomas, Y., Adehossi, É., Abboud, P., Blaizot, R. and Bleibtreu, A. (2022) Maladies Infectieuses Tropicales. 3rd Edition, Alinéa Plus, Paris. https://www.infectiologie.com

[35] Maiga, B. and Sacko, K. (2019) Méningites Bactériennes chez l'Enfant au Service de Pédiatrie du CHU Gabriel Toure. *Health Sciences and Disease*, **20**, 63-64.

[36] Thigpen, M., *et al.* (2011) Bacterial Meningitis in the United States, 1998-2007. *The New England Journal of Medicine*, **364**, 2016-2041. https://doi.org/10.1056/NEJMoa1005384

[37] Thabet, F., *et al.* (2007) Pneumococcal Meningitis Mortality in Children. Prognostic Factors in a Series of 73 Cases. *Archives de Pédiatrie*, **14**, 334-337.

[38] Figueiredo, A., *et al.* (2018) Acute Community-Acquired Bacterial Meningitis. *Neurologic Clinics*, **36**, 809-820. https://doi.org/10.1016/j.ncl.2018.06.007

Survey Sheet

1) DEMOGRAPHIC DATA
- ID:
- Names (Initials):
- Age in months:
- Gender:
  - F
  - M
- Address:
  - Urban
  - Rural

2) BACKGROUND
- VACCINATION
  - BCG-OPV 0
  - Penta-Pneumo 1 2 3
  - Rotavirus
  - Yellow fever vaccine and Measles vaccine
- Taking antibiotics:
  - Yes
  - No

3) SYMPTOMS
- Fever:
  - Yes
  - No
- Seizure:
  - Yes
  - No
- Conscience /Coma:
  - Yes
  - No
  - AVDI
- Respiratory symptoms:
  - Yes
  - No
  - Which one?
- Digestive symptoms:
  - Yes
  - No
  - Which one?
- Other neurological symptoms:
  - Yes
  - No

4) LARATORY TEST

- GB:
- White Count:
- QUANTITATIVE C-Reactive Protein:
- Lumber Puncture/CSF: Appearance: Cytology (White blood cells):
- Gram colouring:
- Blood culture:

5) TREATEMENT

- Ceftriaxone + Gentamycin
- Chloramphenicol
- Ampicillin + Gentamycin + Cefotaxime
- Meropenem
- Other: specify:

6) EVOLUTION

- Cure
- Death
- Sequel ………………………………. Which?..

7) DURATION OF HOSPITALIZATION: