The Scientific Journal of University of Benghazi

http://journals.uob.edu.ly/sjuob

Study of Meningitis Inflammatory Disease among children admitted to Benghazi Pediatrics Hospital during 2017-2020

Asma. B. Elshebani [*1], Amal. M. Elfaitouri [1], Mariam. A. S. Busaadia [2], Abd Alraouf E. alobadi [2], Butgains A. Alhassi [2], Mayar. H. Alsaiti [2], Mohamed. S. Alatti [2], Sondos. I. Boujanah [2]

1 Department of Infectious Disease, Faculty of Public Health, University of Benghazi, Benghazi, Libya.

2 Department of Environmental Health, Faculty of Public Health, University of Benghazi, Benghazi, Libya.

Received: 26 / 04 / 2022; Accepted: 05 / 06 / 2022

الملخص:

التهاب السحايا هو التهاب يصيب الأغشية الحساسة -التي تسمى السحايا، والتي تغطي الدماغ والنخاع الشوكي. يحدث التهاب السحايا عندما يصاب السائل المحيط بالسحايا بالعدوى، الأسباب الأكثر شيوعًا لالتهاب السحايا هي الفيروسات والبكتيريا والأوليات والفطريات وعوامل أخرى.ولمعرفة الصورة الوبائية لالتهاب السحايا لدى مرضى مستشفى بنغازي للأطفال أجْريتْ دراسة وصفية مقطعية في مستشفى الأطفال ببنغازي من2017 إلى 2020. كانت غالبية حالات التهاب السحايا عند الذكور (59٪) والإناث (41٪)، بينما كانت غالبية حالات التهاب السحايا في الفئة العمرية أقل من سنة (73.7٪). بالإضافة إلى أن غالبية المرضى وفقًا لوحدة القبول كانت أعلى وحدة أمراض القلب (ب) (25.9٪) والأدنى كانت من وحدة الجراحة (0.2٪). بشكل عام، زادت غالبية مرضى التهاب السحايا حسب العام من 2017 (17.2٪) إلى 2020 (24.6٪)، بينما أظهر مرضى التهاب السحايا حسب الشهور والسنوات أعلى نسبة له في يوليو (13.8٪) وأغسطس (12.8٪)، وبحسب الموسم والسنوات في الصيف (35.2٪) والشتاء (14.2٪). وكان توزيع المريض حسب مدة المرض من 6 إلى 10 أيام (20.2٪)، توزيع المريض حسب حالة الخروج لكل السنوات بصحة جيدة (89.9٪). نستنتج من هذه الدراسة أن التهاب السحايا يصيب الذكور أكثر من الإناث، وهو شائع عند الأطفال الذين تقل أعمارهم عن عام واحد، يكون التهاب السحايا أكثر شيوعًا خلال شهري يوليو وأغسطس، ويظهر بشكل أكثر شيوعًا في الصيف منه في الشتاء.

الكلمات المفتاحية: التهاب السحايا، علم الأوبئة، التوزيع، الموسم، مستشفى الأطفال، بنغازي.

Abstract

Background: Meningitis is an inflammation that affects the delicate membranes called meninges, which cover the brain and spinal cord. Meningitis occurs when fluid surrounding the meninges becomes infected. The most common causes of meningitis are viruses, bacteria, protozoa, fungi, and other agents.

Aim: To investigate the epidemiological picture of meningitis in patients at Benghazi Pediatric Hospital.

Methods: a descriptive cross-sectional study was conducted from 2017 – 2020.

Results: The majority of meningitis cases were in males (59%) with females at 41%, while the majority of meningitis cases were in the age group of below 1 year (73.7%). The majority of patients according to the unit of admission, were from unit B (the cardiovascular unit) (25.9%) and the lowest was from the surgery unit (0.2%). In general, the majority of meningitis patients according to the year had an increase from 2017 (17.2%) to 2020 (24.6%). While meningitis occurring in patients according to months showed the highest incidence in July (13.8%) and August (12.8%), and according to the season in the summer (35.2%) and winter (14.2%). The distribution of patients according to the duration of disease was from 6 to 10 days (20.2%); the distribution of patients according to outcome in all years, the majority were discharged in good health (89.9 %).

Conclusion: This study concluded that meningitis affected males more than females, and is common in children whose age is under one year. Meningitis is more common during July and August, showing more incidence in summer than winter.

Keywords: Distribution, Epidemiology, Meningitis, Pediatric Hospital, Season.

1. INTRODUCTION

The central nervous system (CNS) is framed by the brain and spinal string, both secured by layers called meninges, ordered into three layers: pia mate, archanoid mater, and dura mater; if there is an infection in the two-layer pia, arachnoids, this infection is called meningitis [1]. Meningitis is an inflammation of the layers of the brain or spine, which is caused by various infectious agents, such as bacteria, viruses, fungi, and protozoans, that more commonly result in a mild or asymptomatic infection. Young children are most at risk for meningitis[2].

*Correspondence:

Asma. B. Elshebani.
asma.elshebani@uob.edu.ly

The main bacterial species responsible for causing meningitis are *Streptococcus pneumonia*, *Haemophilus influenza* type b, and *Neisseria meningitidis*. Thereafter, new vaccines such as *the H. influenza* b conjugate vaccine and the heptavalent pneumococcal conjugate vaccine resulted in pronounced declines in the invasive diseases caused by these pathogens. However, bacterial meningitis remains a serious cause of morbidity and mortality in childhood in regions where immunization coverage is below optimal levels [3,4]. Many viruses can cause viral meningitis. However, enteroviruses have been found to be the cause of most viral meningitis cases worldwide. The pathogenesis of viral meningitis is not clearly defined, and diagnosed [5,6]. Viral meningitis usually affects young children and is most commonly seen in summer and autumn[7].

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018

Meningitis is a life-threatening disease with a high case fatality rate and leads to serious long-term complications [8]. Meningitis has many symptoms, the most common ones include a severe headache, high temperature, neurological signs such as lethargy, coma, nausea and vomiting, sensitivity to light, and a stiff neck [8]. Also, meningitis and meningitis-related sepsis can result in severe after-effects, such as loss of hearing, visual and physical weakness, cognitive disability, and limb loss, which have emotional, social and financial impacts on those who have been infected. Although there has been significant progress in reducing the incidence of meningitis over the past 20 years, there were still an estimated 5 million new cases globally and 290 000 deaths from meningitis in 2017 [9]. Therefore, it remains a major global public health threat despite the availability of safe and cost-effective vaccines [10,11]. The global mortality rate for meningitis continues to be high, ranging between 2% to 30% globally [12].

Epidemics of meningitis are seen all over the world, particularly in sub-Saharan Africa [13,14]. Updated information is important to add recommendations for the treatment or prevention of meningitis which could have great significance for local and global health. We aimed to determine the epidemiological picture of meningitis patients at Benghazi Pediatric Hospital, with the following objectives: to find the age and sex distribution of cases; to find the rate of meningitis in each year, and to find the seasonal variations of the disease.

2. MATERIAL AND METHODS

2.1. Study design

A descriptive cross-sectional study was conducted at Benghazi Pediatrics Hospital, from March 2020 to January 2021. All cases admitted to the hospital from January 2017 to December 2020 were included in this study.

2.2. Statistical analysis

The files Performa were designed from the case history file and in accordance with the requirements of the aim and objectives of the study. Necessary permission for this study was sought from the authorities including the treating doctors. All information present in the patients' records was collected and analyzed. Results were expressed as mean ± standard deviation (SD), number and percentage (%). Categorical data were compared using the Chi-square test.

Statistical analysis was performed with the aid of the statistical package for the social sciences (SPSS) computer program (Version 23 Windows). P value < 0.05 was considered significant. Data were presented in tables and figures; figures were done by Microsoft Excel Program.

3. RESULTS

In table 1, the distribution of patients according to age shows that the highest frequency was among patients aged less than one year (73,7%) followed by the aged 1-5 years (20.5%).

Table 1: Distribution of patients according to age.

Age /year	No.	%
<1	764	73.7
1-5	213	20.5
6 - 10	45	4.3
11 -15	14	1.4
>15	1	0.1
Total	**1037**	**100**

Mean age = 1.2years, Std. Deviation =2.3 years, Median= 4 months, Minimum age= One day, Maximum = 19 years.

In figure 1, the distribution of patients according to sex shows that more than half of the meningitis patients were male (59%) and 41% were female.

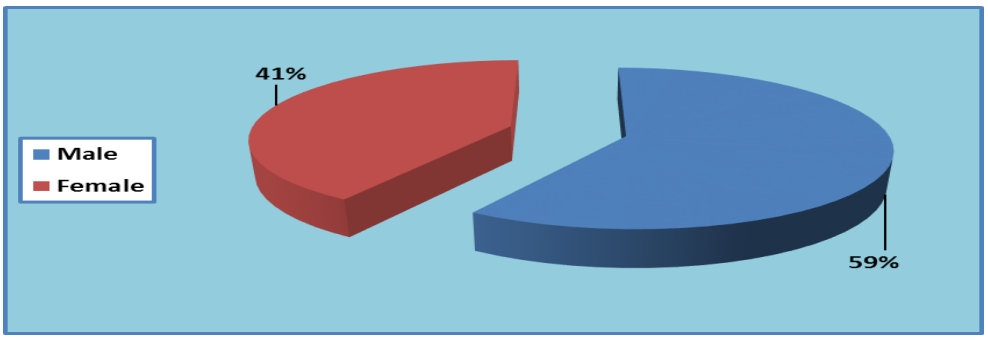
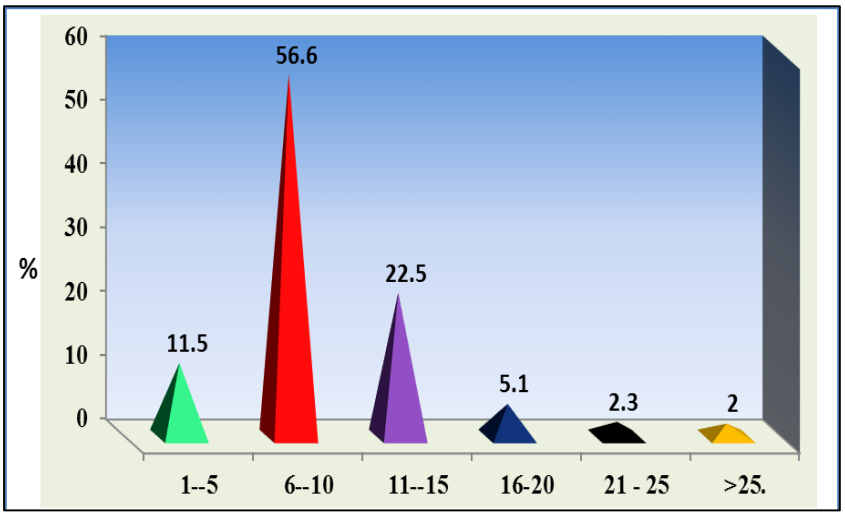


Figure 1. Distribution of patients according to sex.

In figure 2, the distribution of patients according to the duration of the disease shows the highest duration was from 6-10 days (56.6%) and the least was >25 days (2%).

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018



Mean =10.1days ,Std .Deviation = 5.8days, Median= 9 days, Minimum =One day, Maximum =76 days.

Figure 2. Distribution of patients according to the duration of the disease.

In table 2, the distribution of patients according to the unit of admission shows the highest frequency was from patients admitted to Unit B(cardiovascular unit) (26%), and the lowest was from the surgery unit(0.2%).

Table 2: Distribution of patients according to the unit of admission.

Unit of admission	No.	%
Unite A (Respiratory)	251	24.2
Unite B (Cardiovascular)	269	25.9
Unite C (Neurology)	205	19.8
Neonate	163	15.7
Gastro	78	7.5
ICU (Intensive care unit)	53	5.1
Nephro	8	0.8
Isolation	8	0.8
Surgery	2	0.2
Total	**1037**	**100**

In figure 3, the distribution of patients according to the year of incidence shows the highest increase in 2018 (31%) then in 2019 (27.2%) after which comes 2020 (24.6%), and 2017, the lowest (17.2%).

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018

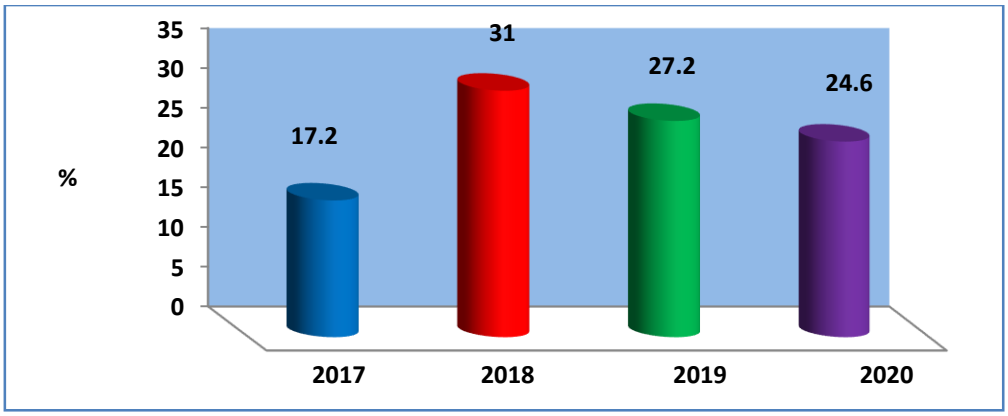


Figure3. Distribution of patients according to the years.

In table 3, the rate of meningitis in each year shows an increase in the rate of meningitis cases 2017-2018; a slight decrease in 2018-2019; then again an increase in 2020.

Table 3: Rate of meningitis in each year.

Years	Total admission		Meningitis cases		Rate of meningitis
	No.	%	No.	%	
2017	15205	24.5	179	17.2	11.8/1000
2018	18011	29	321	31	17.8/1000
2019	16210	26	282	27.2	17.4/1000
2020	12762	20.5	255	24.6	20/1000
Total	**62188**	**100**	**1037**	**100**	**16.7/1000**

Table 4 and Figure 4 show the distribution of patients according to the months and total years, showing the highest frequency in July (13.8%) and August (12.8%).

Table 4: Distribution of patients according to the months and years.

Months	2017		2018		2019		2020		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
January	10	5.6	10	3.1	35	12.4	30	11.9	85	8.2
February	6	3.4	12	3.7	20	7.1	22	8.6	60	5.8
March	14	7.8	19	5.9	26	9.2	34	13.3	93	9
April	12	6.7	16	5	21	7.4	8	3.1	57	5.5
May	21	11.7	22	6.9	11	3.9	11	4.3	65	6.3
June	13	7.3	24	7.5	24	8.5	22	8.6	83	8
July	14	7.8	69	21.5	37	13.1	23	9	143	13.8
August	31	17.3	53	16.5	20	7.1	29	11.4	133	12.8
September	11	6.1	30	9.3	25	8.9	23	9	89	8.6
October	20	11.2	27	8.4	29	10.3	18	7.1	94	9
November	18	10.1	15	4.7	16	5.7	24	9.4	73	7
December	9	5	24	7.5	18	6.4	11	4.3	62	6
Total	**179**	**100**	**321**	**100**	**282**	**100**	**255**	**100**	**1037**	**100**

X^2= 108.795. df=33 ; p= 0.0001(Significant).

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018

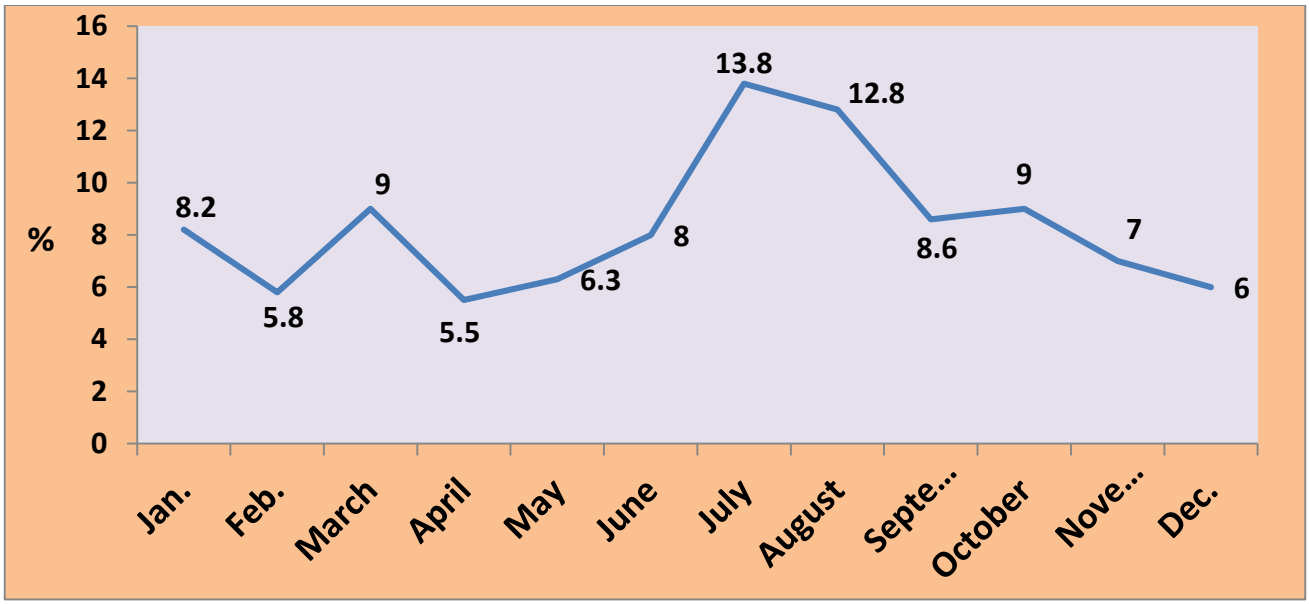


Figure 4. Distribution of patients according to the months and years.

Table 5 shows the distribution of patients according to the season and year, Where the highest frequency in all years was during the summer (35.2%).

Table 5:Distribution of patients according to the season and year.

Season	2017		2018		2019		2020		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Spring	47	26.2	57	17.8	58	20.6	51	20	213	20.5
Summer	58	32.4	146	45.5	81	28.7	75	29.4	365	35.2
Autumn	49	27.4	72	22.4	70	24.8	64	25.1	250	24.1
Winter	25	14	46	14.3	73	25.9	65	25.5	209	20.2
Total	**179**	**100**	**321**	**100**	**282**	**100**	**255**	**100**	**1037**	**100**

X^2= 37.908. df=9 ; p=0.0001 (Significant).

In table 6, the distribution of patients according to outcome in all years shows the highest frequency in discharged in good health (89.9%).

Table 6: Distribution of patients according to outcome and years.

Outcome	2017		2018		2019		2020		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Discharged in good health	160	89.4	298	92.8	253	89.7	221	86.7	932	89.9
Died	6	3.4	10	3.1	14	5	16	6.3	46	4.4
Discharged against medical advise	5	2.8	8	2.5	13	4.6	10	3.9	36	3.5
Transferred to other hospitals	8	4.4	5	1.6	2	0.7	8	3.1	23	2.2
Total	**179**	**100**	**321**	**100**	**282**	**100**	**255**	**100**	**1037**	**100**

X2=15.381 .df=9 ; p= 0.081(Not significant).

4. DISCUSSION

In this study, we found that the majority of meningitis cases were in the age group of below one year (73.7 %) (table 1). The youngest child was <1 year old, and the oldest child was 19 years old. This comes in agreement with a study that shows that meningitis in infancy has serious consequences. The 2% of children who survived the acute attack died before the age of 5 years, neonatal meningitis was associated with a higher frequency of disability, especially neuromotor disability and seizure disorders, than meningitis after one month of age[15]. In another study on children's meningitis in medical colleges and hospitals, Kolkata showed that 44.17% of meningitis cases were below three years of age[16]. A previous study at Aghia Sofia children's hospital in Athens showed that the risk of meningitis was higher in infants and young children aged < 5 years [17]. Also, a study from Iraq at Al-Ramadi Maternity and Children's Hospital showed that the first age group (< 1 year) occupied the highest number (60.8%) with a statistically significant (P < 0.05). Similar results were also reported in Jordan. The incidence of bacterial meningitis is higher in developing countries than in developed countries and particularly high in children under one year of age [18]. Increased exposure to infections and underlying immune system problems present at birth increase an infant's risk of meningitis.

Males were found to be slightly more affected than females where males were (59%) and females were (41%) as shown in (figure 2); similar results were reported in Cuba [19], North America [20], and Saudi Arabia [21]. While in a different study from Kenya, findings reported that female children (56%) were more at risk of being affected with clinical symptoms of meningitis compared to their male counterparts (44%). About 38% of the children diagnosed with bacterial meningitis were female [22].

Treatment of bacterial meningitis, the duration of antibiotic therapy depends on the organism isolated. For *S pneumoniae* (pneumococcus) and *H influenzae* type b (Hib),10–14 days of treatment is generally recommended, while for *N meningitides* a seven-day course is sufficient. In *Listeria monocytogenes* and group B *Streptococcal meningitis*, antibiotics should be given for 14–21 days. For Gram-negative bacilli, a minimum of three weeks is needed [23]. That can be the potential reason which could account for our results revealing 59% of patients stay 6-10 days for treatment and 2% stay more than 25 days, assuming that most infections are bacterial infections since there was no data available of analytic results of the patient confirming organism of meningitis infection. According to the unit of admission, the distribution of patients in this study shows that the highest percentage was from unit B, the cardiovascular unit (26%), and the lowest percentage was (0.2%) from the surgery unit, while there was no significant difference between units of admission. The results of the present study of meningitis among children admitted to Benghazi Pediatrics Hospital during the years 2017 to 2020 showed an increased rate of admitted children with meningitis in the year 2017 (11.7/ 1000) whereas in the year 2018 it was (17.8/1000), with no significant difference between the two years; a slight decrease from the year 2018 to 2019 then again an increase in 2020 (20/1000). While a previous study in 2012 at the same hospital showed a rate of (6.06/1000) [24], which can indicate a rate increase in meningitis cases from 2012 to 2020. A large Norwegian study reviewed the incidence among children in the age group of 2 to 16 years and they observed a decline in the occurrence from 19.1 per 100,000 in 1988 - 1991, to 6.9 per 100,000 in 2003 - 2006. The incidence of bacterial meningitis among children in Norway has decreased significantly over the last 20 years, and meningitis is now a rare disease. Bacterial meningitis is most common among children below the age of two and is still associated with substantial mortality and risk of long-term neurological sequelae [25]. Furthermore, a study in the Emirates showed that there has been a decline in the incidence of meningitis cases in Al-Ain over the past five years. This decrease can potentially be attributed to multiple factors including improvements in living conditions, the regional introduction of vaccines against *H. influenzae* type b and

N. meningitides, better availability of healthcare facilities, earlier detection of meningitis, and improved prevention and management methods by the Ministry of Health against all types of meningitis infections. The decline in incidence rates is unlikely to have been affected by changes in surveillance because no modifications were made to the national diagnostic criteria used for meningitis, and only passive surveillance was conducted throughout the entire study period [26]. An early Korean study agrees with our results showing a rapid increase in the rate of meningitis (45%) in the year 1989, reaching 89% in 1995 [27]. In addition, our study reveals a significant increase in meningitis according to the months and years showing X^2= 27.673. df=11; P = 0.004. The highest frequency was in July and August which corresponds with other studies which showed that the incidence of meningitis in tropical areas occurs in the dry season and decreases in periods of rains, while temperate regions usually experience epidemics in the winter and spring periods [28,29].

A relationship between climate and dust and meningitis has often been advocated in the last decade. First quantitative studies were recently conducted [30-32], leading to new hypotheses on the relationships between them. In our study, most cases were reported during the summer season. Results from another study highlighted the special case of dust in comparison to wind, humidity, or temperature: a strong similarity between sections is noticed in the elaboration of the time-lags between the seasonal element of dust and meningitis. This result, together with the supposition of dust damaging the pharyngeal mucosa and easing bacterial irruption reinforces our confidence in dust forcing on meningitis seasonality districts is noticed in the elaboration of the time-lags between the seasonal element of dust and meningitis . Dust data should now be integrated into epidemiological and forecasting models to make them more realistic and usable from a public health perspective [33]. Moreover, our results according to the distribution of patients according to outcome and years show the highest frequency in all years was in patients who were discharged in good health, and the lowest frequency in all years was in patients who were discharged against medical advice with no significant difference.

5. CONCLUSION

From this study, we found that meningitis affected males more than females, and is common in children whose age is below one year. Additionally, meningitis is more common during July and August, showing more incidence in summer than winter. The epidemiology of meningitis in our study follows similar patterns of age, sex, and seasonality distribution as found in other countries and populations. We recommend that a prospective study be done.

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018

6. REFERENCES

1. World Health Organization. (Meningococcal meningitis, 2018). https://www.who.int/emergencies/diseases/meningitis/en/
2. Sáez-Llorens X. and McCracken G. Bacterial meningitis in children. The Lancet. 2003;361(9375):2139-48.
3. World Health Organization. Managing epidemics: key facts about major deadly diseases.2018. https://apps.who.int/iris/handle/10665/272442
4. Crum-Cianflone N, Sullivan E. Meningococcal Vaccinations. Infectious Diseases and Therapy.2016;5(2):89-112.
5. Mohamed N, Elfaitouri A, Fohlman J, Friman G, Blomberg J. A sensitive and quantitative single-tube real-time reverse transcriptase-PCR for detection of enteroviral RNA. Journal of Clinical Virology.2004;30(2):150-156.
6. Elfaitouri A, Mohamed N, Fohlman J, Aspholm R, Frisk G, Friman G et al. Quantitative PCR-Enhanced Immunoassay for Measurement of Enteroviral Immunoglobulin M Antibody and Diagnosis of Aseptic Meningitis. Clinical and Vaccine Immunology.2005;12(2):235-241.
7. Logan S, MacMahon E. Viral meningitis. BMJ.2008;336(7634):36-40.
8. Parsons A, Aslam F, Grill M, Aksamit A, Goodman B. Rheumatoid Meningitis: Clinical Characteristics, Diagnostic Evaluation, and Treatment. The Neurohospitalist.2020;10(2):88-94.
9. Knudsen A. Disease burden in the Nordic region. Results from the Global Burden of Disease Study 2017 (GBD 2017). European Journal of Public Health. 2019;29
10. Christensen H, Hickman M, Edmunds W, Trotter C. Introducing vaccination against serogroup B meningococcal disease: An economic and mathematical modelling study of potential impact. Vaccine. 2013;31(23):2638-2646.
11. Bassey B, Vaz R, Gasasira A, Braka F, Weldegriebriel G, Komakech W et al. Pattern of the meningococcal meningitis outbreak in Northern Nigeria, 2009. International Journal of Infectious Diseases.2016;43:62-67.
12. Owusu M, Nguah S, Boaitey Y, Badu-Boateng E, Abubakr A, Lartey R et al. Aetiological agents of cerebrospinal meningitis: a retrospective study from a teaching hospital in Ghana. Annals of Clinical Microbiology and Antimicrobials. 2012;11(1):28.
13. Greenwood B. Meningococcal meningitis in Africa. Transactions of the Royal Society of Tropical Medicine and Hygiene.1999;93(4):341-353.
14. Novak R, Kambou J, Diomandé F, Tarbangdo T, Ouédraogo-Traoré R, Sangaré L et al. Serogroup A meningococcal conjugate vaccination in Burkina Faso: analysis of national surveillance data. The Lancet Infectious Diseases. 2012;12(10):757-764.
15. Bedford H, de Louvois J, Halket S, Peckham C, Hurley R, Harvey D. Meningitis in infancy in England and Wales: follow up at age 5 years. BMJ. 2001;323(7312):533-533
16. Swarnali J, Gautam KJ, Pankaj KM, Siddhartha M. Meningitis in children: a study in medical college & hospital, Kolkata. Bangladesh J Child Health. 2012; 36 (1): 20-25
17. Theodoridou M, Vasilopoulou V, Atsali E, Pangalis A, Mostrou G, Syriopoulou V et al. Meningitis registry of hospitalized cases in children: epidemiological patterns of acute bacterial meningitis throughout a 32-year period. BMC Infectious Diseases. 2007;7(1).
18. Mohammed M. Risk Factors of Meningitis in Children Under Five Years in Al-Ramadi Maternity and Children Hospital. Al-Anbar Medical Journal. 2009;7(1)76-84.
19. Grimwood K. Legacy of bacterial meningitis in infancy. BMJ. 2001;323(7312):523-524.
20. Levine O, Farley M, Harrison L, Lefkowitz L, McGeer A, Schwartz B. Risk Factors for Invasive Pneumococcal Disease in Children: A Population-based Case-Control Study in North America. Pediatrics. 1999;103(3):e28-e28.
21. Abomelha A, Uduman S, Saleh M, Al-Rajeh S, Sibai M, Al-Agib A. Childhood Bacterial Meningitis. Annals of Saudi Medicine. 1988;8(4):274-278.
22. Serem J, Chege M, Maina D. Predictors of Bacterial Meningitis among Paediatric Patients Aged 0 - 5 Years at Kenyatta Hospital, Kenya. Open Journal of Pediatrics. 2018;08(03):207-220.
23. Quagliarello V, Scheld W. Treatment of Bacterial Meningitis. New England Journal of Medicine. 1997;336(10):708-716.
24. Elshebani A, Muftah E, Najat LG, Gazali AA, Mohamed MA, Ibrahim MM,et al. Meningitis among Children admitted to Benghazi Pediatrics Hospital during. Sch. J. App. Med. Sci. 2012; 6(1F): 421-426.
25. Skoe Ø, Døllner H.,[Childhood bacterial meningitis in the Norwegian county Sør-Trøndelag 1988 - 2007]. Tidsskr Nor Laegeforen. 2009;129(9):851-854.
26. Dash N, Ameen A, Sheek-Hussein M, Smego R. Epidemiology of meningitis in Al-Ain, United Arab Emirates, 2000–2005. International Journal of Infectious Diseases. 2007;11(4):309-312.
27. Choi EH, Lee HJ. Clinical outcome of invasive infections by penicillin-resistant Streptococcus pneumoniae in Korean children. Clin Infect Dis. 1998;26(6):1346-1354.
28. Molesworth A, Thomson M, Connor S, Cresswell M, Morse A, Shears P et al. Where is the meningitis belt? Defining an area at risk of epidemic meningitis in Africa. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2002;96(3):242-249.

29. Moore P. Meningococcal Meningitis in Sub-Saharan Africa: A Model for the Epidemic Process. Clinical Infectious Diseases. 1992;14(2):515-525.

30. Sultan B, Labadi K, Guégan J, Janicot S. Climate Drives the Meningitis Epidemics Onset in West Africa. PLoS Medicine. 2005;2(1):e6.

31. L Agier, A Deroubaix, N Martiny, P Yaka, A Djibo and H. Broutin et al. Seasonality of meningitis in Africa and climate forcing: aerosols stand out. J R Soc Interface.2012; (10) 0814.

32. Yaka P, Sultan B, Broutin H, Janicot S, Philippon S, Fourquet N. Relationships between climate and year-to-year variability in meningitis outbreaks: A case study in Burkina Faso and Niger. International Journal of Health Geographics. 2008;7(1).

33. Ku L, Boggess K, Cohen-Wolkowiez M. Bacterial Meningitis in Infants. Clinics in Perinatology. 2015;42(1):29-45.

 ISSN:Online **2790-1637**, Print **2790-1629**; National Library of Libya, Legal number : **154/2018**