Original Papers

Bacteriological Profile and Antibiotic Susceptibility Pattern of Neonatal Sepsis at a Teaching Hospital in Bayelsa State, Nigeria

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Abstract: Background: Sepsis is one of the most common causes of neonatal hospital admissions and is estimated to cause 26% of all neonatal deaths worldwide. While waiting for results of blood culture, it is necessary to initiate an empirical choice of antibiotics based on the epidemiology of causative agents and antibiotic sensitivity pattern in a locality.
Objective: To determine the major causative organisms of neonatal sepsis at the Niger Delta University Teaching Hospital (NDUTH), as well as their antibiotic sensitivity patterns, with the aim of formulating treatment protocols for neonates.
Methods: Within a 27-month period (1st of October 2011 to the 31st of December 2013), results of blood culture for all neonates screened for sepsis at the Special Care Baby Unit of the hospital were retrospectively studied.
Results: Two hundred and thirty-three (49.6%) of the 450 neonates admitted were screened for sepsis. Ninety-seven (43.5%) of them were blood culture positive, with 52 (53.6%) of the isolated organisms being Gram positive and 45 (46.4%) Gram negative. The most frequently isolated organism was *Staphylococcus aureus* (51.5%) followed by *Escherichia coli* (16.5%) and *Klebsiella pneumoniae* (14.4%). All isolated organisms demonstrated the highest sensitivity to the quinolones.
Conclusion: Neonatal sepsis is a significant cause of morbidity among neonates admitted at the NDUTH. There is a need for regular periodic surveillance of the causative organisms of neonatal sepsis as well as their antibiotic susceptibility pattern to inform the empirical choice of antibiotic prescription while awaiting blood culture results.
Key words: neonatal sepsis, bacterial isolates, antibiotic sensitivity

INTRODUCTION

Neonatal sepsis is a systemic inflammatory response to infection and/or isolation of bacteria from the blood stream in the first 28 days of life [1].

Systemic inflammatory response also describes a clinical syndrome in which there are two or more of the following symptoms: fever, hypothermia, tachycardia, tachypnoea and abnormal white blood cells in immature forms [1].

Sepsis is one of the most common causes of neonatal hospital admissions [2–4] and is estimated to cause 26% of all neonatal deaths worldwide [5]. It contributes to 30 to 50% of neonatal deaths in developing countries [6]. Neonatal sepsis is classified as early onset when it occurs within the first 72 hours of life and late onset when it occurs after 72 hours [7–9]. Early onset sepsis is caused by

organisms prevalent in the maternal genital tract, labour room or operating theatre [10, 11] while late onset sepsis usually results from nosocomial or community-acquired infection [3, 11].

Newborns are particularly susceptible to sepsis as a result of their immature immune system, the decreased phagocytic activity of their white blood cells and their incompletely developed skin barriers [12–14]. Common risk factors for neonatal sepsis in Sub-Saharan Africa have been identified as prematurity and low birth weight, prolonged rupture of foetal membranes, maternal peri-partum pyrexia, obstructed labour and birth asphyxia [15–19].

Neonatal sepsis is a medical emergency which presents with subtle, diverse and nonspecific symptoms and signs [20]. Delay in diagnosis and commencement of appropriate treatment may result in high morbidity and mortality rates [20]. Blood culture, which is the gold stand-

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ard for the diagnosis of sepsis, takes at least 48 hours to obtain preliminary results [21]. It is therefore necessary to initiate an empirical choice of antibiotics based on the epidemiology of causative agents and antibiotic sensitivity patterns in a locality [22]. Periodic bacterial surveillance is a necessity in every unit because the organisms responsible for neonatal sepsis have been shown to vary across geographical boundaries and with time of onset of illness [7].

Since the inception of the Special Care Baby Unit (SCBU) in the Niger Delta University Teaching Hospital (NDUTH) in 2008, no study has been conducted on neonatal sepsis. The present study was therefore carried out to determine the major causative organisms of neonatal sepsis in the NDUTH, as well as their antibiotic sensitivity patterns, with the aim of formulating treatment protocols for neonatal sepsis in the unit. Information derived from the present study will also serve as a baseline for similar studies in the future aiming to determine changes if any, in causative organisms of neonatal sepsis.

METHODS

Study centre

This was a retrospective descriptive study, carried out at the Special Care Baby Unit (SCBU) of the Niger Delta University Teaching Hospital (NDUTH) Bayelsa State, Nigeria between the 1st of October 2011 and the 31st of December 2013 (27 months). The patients admitted to the SCBU are infants aged 0 to 28 days with medical problems.

Ethical consideration

Ethical clearance was obtained from the Research and Ethics Committee of the Niger Delta University Teaching Hospital.

Subjects

All neonates who had a blood culture test within the study period were recruited for the study. Those with clinical suspicion or risk factors for sepsis had blood culture tests. There was clinical suspicion of sepsis in the presence of fever, respiratory distress, seizures, lethargy, apnoea, poor feeding, jaundice, hypothermia, convulsion, vomiting, irritability, lethargy, abdominal distension and bleeding diathesis. Risk factors for sepsis included out-born delivery, poor umbilical cord care, peri-natal asphyxia, pre-term birth, maternal diabetes in pregnancy, invasive procedures, instrumental delivery, prolonged rupture of foetal membranes, maternal chorio-amnionitis and peri-partum pyrexia.

None of the study subjects had undergone urethral catheterisation, and none had been diagnosed with other underlying conditions.

Specimen collection

Blood samples were aseptically collected at the Special Care Baby Unit by Paediatric Registrars following established hospital guidelines regarding specimen collection. Samples were collected before the commencement of antibiotics. Two to three milliliters of venous blood was aseptically collected into sterile blood culture bottles and immediately transported to the microbiology laboratory.

Specimen processing

Samples were incubated aerobically at room temperature for at least 24 hours, and bottles with signs of growth were immediately sub-cultured on MacConkey Agar, Chocolate Agar and Blood agar. Gram staining was done and bacterial isolates were identified and classified by morphology and appropriate biochemical tests.

Antibiotic susceptibility testing

The Kirby-Bauer disk diffusion method was used to assess the antibiotic susceptibility of the isolates, with the results interpreted according to the standards of the National Committee for Clinical Laboratory Standards (Clinical Laboratory Standard Institute) [23]. Antibiotic resistance was quantified based on the zone of inhibition around the antibiotic disc as either susceptible, intermediately susceptible or resistant. Intermediate results were considered resistant. Resistance to more than three classes of antibiotics was considered broad-spectrum or multidrug resistance.

The concentration of the antibiotic discs used were as follows: Gatifloxacin 5 μg, Streptomycin 10 μg, Vancomycin 30 μg, Pefloxacin 5 μg, Cefixime 5 μg, Ofloxacin 5 μg, Gentamicin 10 μg, Chloramphenicol 30 μg, Amoxicillin-Clavulanate 30 μg, Ceftriaxone 30 μg, Erythromycin 15 μg, Cefuroxime 30 μg, Tetracycline 30 μg, Cloxacillin 5 μg, Ceftazidime 30 μg, Co-trimoxazole 25 μg, Nitrofurantoin 50 μg, Ciprofloxacin 5 μg.

The sensitivity of particular isolates to each tested antibiotic was calculated by the number of isolates susceptible divided by the total number of isolates and expressed as a percentage.

Collation of results

Results of blood culture for all neonates within the study period were retrieved from the microbiology laboratory at the NDUTH. Using the names of these neonates, other relevant information was subsequently retrieved from the ward register of the Special Care Baby Unit

(SCBU) of the NDUTH. Information retrieved from the registers of the microbiology laboratory and SCBU included age at onset of symptoms, sex, gestational age at birth, birth weight, organisms isolated in blood culture if any, antibiotic sensitivity pattern of isolated organisms and clinical outcome.

Early onset sepsis was classified as that occurring within the first 72 hours of life while late onset sepsis was classified as that occurring after 72 hours [7–8].

All neonates born before 37 completed weeks of gestation were classified as preterm, those born between 37 to 42 weeks of gestation were classified as term, and those born after 42 completed weeks of gestation were classified as post term [24].

Treatment protocol

After collection of blood culture samples, the neonates were empirically commenced on intravenous ceftazidime and gentamicin according to the clinical protocol. Clinical response was monitored daily and antibiotics were changed to ciprofloxacin if the neonate showed poor response after 48 to 72 hours of antibiotics. Antibiotics were subsequently changed according to the sensitivity pattern of isolated organisms after retrieval of blood culture results. All neonates with blood culture-proven sepsis were treated with intravenous antibiotics for at least 10 to 14 days before discharge if clinically stable.

Data analysis

Data was collected onto an excel 2010 spread sheet and presented as means and percentages in tabular form. The significance among percentages was calculated with the Chi-square test using Epi-Calc statistical package with a p value of < 0.05 considered statistically significant.

RESULTS

General characteristics

During the 27 months study period, 223 (49.6%) of the 450 babies admitted into the SCBU had blood culture tests. There were 136 males and 87 females with a male to female ratio of 1.56:1. The age at the time of blood culture sample collection ranged from 30 minutes to 28 days with a mean age of 4.52 ± 6.72 days. The birth weight ranged from 700 to 4400 g with a mean birth weight of 2751 ± 0.93 g.

Ninety-seven (43.5%) of the 223 neonates were blood culture-positive, comprised of 62 (63.9%) males and 35 (36.1%) females with a male to female ratio of 1.77:1. Sixty-four (66.0%) had early onset while 33 (34.0%) had late onset sepsis. Sixty-nine (71.1%) of the blood culture-positive neonates were born at term, 27 (27.8%) were preterm and one (1.0%) was post term.

Distribution of organisms

Fifty-two (53.6%) of the isolated organisms were gram positive while 45 (46.4%) were gram negative. The most frequently isolated organism in the neonates was *Staphylococcus aureus* followed by *Escherichia coli* and *Klebsiella pneumoniae* (Table 1). None of the subjects was infected with more than one organism.

Table 1.   Distribution of organisms

Organism	Number	Percentage
Staphylococcus aureus	50	51.5
Escherichia coli	16	16.5
Klebsiella pneumoniae	14	14.4
Proteus mirabilis	8	8.2
Pseudomonas aeruginosa	7	7.2
Streptococcus pyogenes	2	2.1
Total	97	100

Table 2.   Distribution of organisms by age of onset

Organism	Early onset		Late onset	
	Number	Percentage	Number	Percentage
Staphylococcus aureus	28	43.8	22	66.7
Escherichia coli	14	21.9	2	6.1
Klebsiella pneuminiae	9	14.1	5	15.2
Proteus mirabilis	6	9.4	2	6.1
Pseudomonas aeruginosa	6	9.4	1	3.0
Streptococcus pyogenes	1	1.6	1	3.0
Total	64	100	33	100

Distribution of organisms by age of onset

As shown in Table 2, *Staphylococcus aureus* was the organism most frequently isolated from the 64 neonates with early onset sepsis, followed by *Escherichia coli* and *Klebsiella pneumoniae*. Gram negative organisms accounted for 54.7% of the isolates.

Staphylococcus aureus was also the most frequently isolated organism in the 33 neonates with late onset sepsis, followed by *Klebsiella pneumonia*, *Escherichia coli* and *Proteus mirabilis*. In this group, Gram positive organisms accounted for over two-thirds of the isolates.

Though *Staphylococcus aureus* was the most frequently isolated organism in both early onset and late onset sepsis, significantly more neonates in the late onset group had *Staphylococcus aureus* sepsis (Chi-square = 4.58, *p* value = 0.032).

Distribution of organisms by gestational age at birth

The most frequently isolated organism in the preterm neonates was *Staphylococcus aureus*, followed by *Klebsiella pneumoniae* and *Escherichia coli* (Table 3).

The most prevalent organism in the term neonates was *Staphylococcus aureus*, followed by *Escherichia coli* and *Klebsiella pneumonia*.

Staphylococcus aureus was isolated from the single post term neonate with culture-proven sepsis.

Gram positive organisms were responsible for the majority of sepsis cases irrespective of gestational age.

Clinical outcome of the 97 blood culture-positive neonates

Seventy-eight (80.4%) of the 97 blood culture-positive neonates got better and were discharged, ten (10.3%) were discharged by their parents against medical advice, eight (8.2%) died and one (0.01%) was referred to another tertiary hospital for spina bifida surgery. Seven (25.9%) of the 27 pre-terms with culture-proven sepsis died, while one (1.5%) of the 69 term babies with culture-proven sepsis died. This difference was statistically significant (Chi-square = 12.18, p value = 0.000)

The case fatality rate was highest in the neonates with *Klebsiella pneumoniae* septicaemia followed by *Pseudomonas aeruginosa* septicaemia and *Escherichia coli* septicaemia (Table 4). The difference was not statistically significant (Chi-square = 0.46, p value = 0.794).

Five of the 64 neonates with early onset sepsis died, while three of the 33 with late onset sepsis died. The difference was not statistically significant (Chi-square = 0.03, p value = 0.863).

Antibiotic sensitivity pattern of the bacterial isolates

All the isolates tested against the quinolones (Gatifloxacin, Pefloxacin, Ofloxacin and Ciprofloxacin) showed sensitivity greater than 50% (62.5% to 100%) as shown in Table 5. With the exception of *Staphylococcus aureus* to cefexime and ceftriaxone and *Escherichia coli* to ceftazidime, most isolates showed a sensitivity of less than 50% to the cephalosporins. *Staphylococcus aureus* showed a broad sensitivity of 50% or more to 11 of the 16 antibiot-

Table 3. Distribution of organisms by gestational age at birth

Organism	Preterm		Term		Post term	
	Number	Percentage	Number	Percentage	Number	Percentage
Staphylococcus aureus	15	55.6	35	50.7	1	100
Escherichia coli	4	14.8	12	17.4	0	0.0
Klebsiella spp	5	18.5	9	13.0	0	0.0
Proteus mirabilis	1	3.7	6	8.7	0	0.0
Pseudomonas aeruginosa	2	7.4	5	7.2	0	0.0
Streptococcus pyogenes	0	0.0	2	2.9	0	0.0
Total	27	100	69	100	1	100

Table 4. Distribution of organisms in the eight neonates that died

Organism	Total number	Number who died	Case fatality (%)
Klebsiella pneumoniae	14	3	21.4
Staphylococcus aureus	50	2	4.0
Escherichia coli	16	2	12.5
Pseudomonas aeruginosa	7	1	14.2

Table 5. Antibiotic sensitivity pattern of the bacterial isolates

Antibiotic	Sensitivity pattern %				
	Staphylococcus aureus	*Escherichia coli*	*Klebsiella pneumoniae*	*Proteus mirabilis*	*Pseudomonas aeruginosa*
Gatifloxacin	92.9	85.7	66.7	—	—
Streptomycin	91.3	—	—	—	—
Vancomycin	87.5	—	—	—	—
Pefloxacin	84.6	66.7	66.7	—	—
Cefixime	80.0	22.2	0.0	20.0	16.7
Ofloxacin	72.0	85.7	78.6	85.7	85.7
Gentamicin	66.7	56.3	35.7	—	42.9
Chloramphenicol	63.6	—	—	—	—
Amoxicillin/Clavulanate	63.0	31.3	21.4	50.0	57.1
Ceftriaxone	60.9	—	—	—	—
Erythromycin	54.8	—	—	—	—
Cefuroxime	47.4	40.0	25.0	33.3	28.6
Tetracycline	40.0	40.0	—	—	—
Cloxacillin	40.0	—	—	—	
Ceftazidime	39.1	54.5	23.1	42.9	28.6
Cotrimoxazole	12.0	20.0	—	—	—
Nitrofurantoin	—	—	50.0	50.0	—
Ciprofloxacin	—	62.5	75.0	100.0	100.0

ics tested. It was most sensitive to gatifloxacin followed by streptomycin and vancomycin.

Escherichia coli demonstrated the highest sensitivity to both gatifloxacin and ofloxacin followed by pefloxacin and ciprofloxacin.

Klebsiella pnuemoniae demonstrated the highest sensitivity to ofloxacin followed by ciprofloxacin and both gatifloxacin and pefloxacin. It was highly resistant to cefixime.

Proteus mirabilis demonstrated the highest sensitivity to ciprofloxacin followed by ofloxacin.

Pseudomonas aeruginosa also demonstrated the highest sensitivity to ciprofloxacin (100.0%) followed by ofloxacin.

Klebsiella pneumoniae and *Pseudomonas aeruginosa* showed poor sensitivity to gentamicin.

DISCUSSION

Neonatal sepsis remains an important public health problem despite considerable progress in hygiene, the introduction of new antimicrobial agents, and advanced measures for early diagnosis and treatment [25, 26].

The prevalence of culture-proven sepsis in the present study was 43.5%, a finding similar to the 41.6% prevalence reported by West and Tabansi [27] in Port Harcourt,

Nigeria. Ugwu [28] and Mokuolu et al. [29]. However, reported a lower prevalence of 35.1% and 30.8% among neonates in Delta State and Ilorin respectively, all in Nigeria. Bukhari and Alrabiaah [8] reported a much lower prevalence of 5.0% in Saudi Arabia. The reason for the comparably higher prevalence in the present study is not clear, but it may be due to differences in predisposing factors and infection control practices in the different centres.

In the present study, males were found to have a higher prevalence of sepsis compared to their female counterparts. Other researchers in Nigeria [29, 30], Ethiopia [31], Iraq [32] and Indonesia [33] reported similar findings. The higher prevalence of sepsis in males may be explained by the increased biological vulnerability of males to infection [34]. Omoregie et al. [35], however found no significant sex difference in the prevalence of bacterial sepsis among young children in Benin City.

Early onset sepsis was more prevalent than late onset sepsis in the present study, a finding similar to that reported by West and Tabansi [27] in Port Harcourt but different from Muhammed et al. [36] in Pakistan and Jumah and Hassan [32] in Iraq, who reported a higher prevalence of late onset sepsis. The disparity may be due to differences in risk factors in the different geographical locations. These risk factors include prematurity, prolonged rupture of foetal membranes, maternal pyrexia, obstructed labour,

birth asphyxia and maternal peri-partum pyrexia [15–19]. This emphasizes the urgent need to prevent early onset sepsis by promoting clean delivery practices and the use of antibiotic prophylaxis for high-risk mothers during the peri-partum period [37]. Hand washing has been shown to be effective in preventing neonatal sepsis, but the implementation of hand-washing protocols has been difficult even in optimal conditions [38]. Health personnel require education, constant reminding and feedback if compliance is to be maintained [39]. Other measures aimed at preventing neonatal sepsis include minimizing invasive procedures, skin preparation before procedures, strict antibiotic policy and restriction of admissions to the neonatal unit [40].

There were more neonates with Gram positive sepsis in the present study, and *Staphylococcus aureus* predominated in both early and late onset sepsis. Mokuolu et al. [29] and Yusuf et al. [41] also found *Staphylococcus aureus* as the predominant organism. West and Tabansi [27], however, reported a Gram negative predominance. The most prevalent organisms in late onset sepsis in the present study are similar to data on the aetiology of neonatal sepsis from 27 low and middle-income countries where *Staphylococcus aureus*, *Eschericia coli* and *Klebsiella pneumoniae* were the most prevalent organisms in community-acquired sepsis [42]. Factors that have been implicated in the increased incidence of late onset sepsis include poor hygiene, poor cord care and bottle feeding [3]. Therefore, there is an urgent need to enlighten the general public on the proper care of newborn infants.

The case fatality rate of 8.2% in the present study is lower than that reported in other Nigerian studies [27, 28, 30, 43] and from Iraq [32] and Indonesia [33]. Differences in mortality rates for neonatal sepsis may be attributable to differences in socio-economic, geographical and racial factors, the use of ventilators, incubators, differences in causative organisms and antibiotic use [44]. The present study also showed that significantly more preterms with sepsis died compared to their term counterparts. Ogunlesi and Ogunfowara [43], Kardana IM [33], and Jumah and Hassan [32] also reported prematurity to be significantly associated with mortality in neonatal sepsis. The association of prematurity with mortality in neonatal sepsis may be due to deficiencies in humoral and cellular immunity. Premature infants have extremely low immunoglobulin levels (except for IgG) to specific maternal antigens, since those immunoglobulins are passively transferred across the placenta in the last trimester of pregnancy [14, 45, 46].

The bacterial isolates in the present study demonstrated the highest sensitivity to the quinolones, a finding similar to reports by West and Peterside [47] in Port Harcourt

and Iroha et al. [30] in Lagos. This study highlighted the need for a review of the first-line antibiotics currently in use at the neonatal unit of the NDUTH since all isolated organisms showed a low sensitivity to both gentamicin and ceftazidime. Antibiotic drug resistance of micro-organisms is a rapidly emerging and potentially dangerous problem which is worse in developing countries, since the transmission of resistant strains results from poor infection prevention and control practices in hospitals [48, 49]. Though methicillin-resistant *Staphylococcus aureus* (MRSA) remains a problem in many healthcare settings, the NDUTH does not routinely test for MRSA as it is yet to be detected. Not surprisingly, the majority of the *Staphylococcus aureus* isolates were very sensitive to the commonly prescribed antibiotics tested.

CONCLUSION

Neonatal sepsis is a significant cause of morbidity among neonates admitted at the NDUTH. *Staphylococcus aureus* is the most prevalent Gram positive organism, while *Escherichia coli* and *Klebsiella pneumoniae* are the most prevalent Gram negative organisms. Isolated organisms demonstrated the highest sensitivity to the quinolones. There is an urgent need for the training and retraining of healthcare personnel and members of the public on the prevention and management of neonatal sepsis. There is also need for regular periodic surveillance of the causative organisms of neonatal sepsis as well as their antibiotic susceptibility patterns to inform the choice of empirical antibiotic prescription while awaiting blood culture results.

AUTHORS' CONTRIBUTIONS

OP conceived the idea for the study, OP and KP collected the data, OP analyzed the data and wrote the manuscript, KP and FOA revised the manuscript for significant intellectual contribution. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

REFERENCES

1. Chiesa C, Panero A, Osborn JF, et al. Neonatal sepsis: a clinical and laboratory challenge. Clin Chem 2004; 50(2): 279–287.
2. Darmstadt GL, Batra M, Zaida AKM. Parenteral antibiot-

ics for the treatment of serious neonatal bacterial infections in developing country settings. Pediatr Infect Dis J 2009; 28(1): S37–S42.

3. Sankar MJ, Agarwal R, Deorari AK, et al. Sepsis in the newborn. Indian J Pediatr 2008; 75(3): 261–272.

4. Sundaram V, Kumar P, Dutta S, et al. Blood culture confirmed bacterial sepsis in neonates in North Indian tertiary care centre: changes over the last decade. Jpn J Infect Dis 2009; 62(1): 46–50.

5. Lawn JE, Cousens S, Zupan J, et al. 4 million neonatal deaths: When? Where? Why? Lancet 2005; 365(9462): 891–900.

6. Antia-Obong CE, Utsalo SJ, Udo JJ, et al. Neonatal Septicaemia in Calabar, Nigeria. Central Afr J Med 1992; 36: 161–165.

7. Al-Zwani EJK. Neonatal septicaemia in the neonatal care unit, Al-Anbar Governorate, Iraq. East Medit Health J 2002; 8: 4–5.

8. Bukhari EE, Alrabiaah AA. A review of clinically suspected sepsis and meningitis in infants under 90 days old in a tertiary care centre in Saudi Arabia. J Microbiol Infect Dis 2011; 1(2): 47–52.

9. Chacko B, Sohi I. Early onset sepsis. Indian J Pediatr 2005; 72(1): 23–26.

10. Bellig LL, Ohning BL. Neonatal Sepsis. [Retrieved 6th June 2013]; Available: http://www.emedicine.com/ped/topic2630.html.

11. Zaidi AK, Thaver D, Ali SA, et al. Pathogens associated with sepsis in newborns and young infants in developing countries. Pediatr Infect Dis J 2008; 28(1 Suppl): S10–S18.

12. Levy O. Innate immunity of the newborn: basic mechanisms and clinical correlates. Nat Rev Immunol 2007; 7(5): 379–390.

13. Shah GS, Budhathoki S, Das BK, et al. Risk factors in early neonatal sepsis. Kathmandu Univ Med J 2006; 4(2): 187–191.

14. Trotman H, Bell Y, Thame M, et al. Predictor of poor outcome in neonates with bacterial sepsis admitted to the University Hospital of the West Indies. West Indian Med J 2006; 55(2): 80–83.

15. Ben Hamida Nouaili E, Harouni M, Chaouachi S, et al. Early onset neonatal bacterial infections: a retrospective series of 144 cases. Tunis Med 2008; 86(2): 136–139.

16. Bomela HN, Ballot DE, Cooper PA. Is prophylaxis of early onset group B Streptococcal disease appropriate for South Africa? South Afr Med J 2001; 91(10): 858–860.

17. Laving AM, Musoke RN, Wasunna AO, et al. Neonatal bacterial meningitis at the newborn unit of Kenyatta National Hospital. East Afr Med J 2003; 80(9): 456–462.

18. Madhi SA, Radebe K, Crewe-Brown H, et al. High burden of invasive *Streptococcus agalactiae* in South African Infants. Ann Trop Paediatr 2003; 23(1): 15–23.

19. Nathoo KJ, Mason PR, Chimbira TH. Neonatal septicaemia in Harare hospital, aetiology and risk factors—the puerperal sepsis study group. Cent Afr J Med 1990; 36(6): 150–156.

20. Ahmed Z, Ghafoor T, Waqar T, et al. Diagnostic value of C-reactive protein and hematological parameters in neonatal sepsis. J Coll Phys Surg Pak 2005; 15(3): 152–156.

21. Buttery JP. Blood cultures in newborns and children: optimizing an everyday test. Arch Dis Child Fetal Neonatal Ed 2002; 87(1): 25–28.

22. Asuquo UA. Antibiotic therapy in neonatal septicaemia (Editorial). Niger J Paediatr 1996; 23: 1–3.

23. National Committee for Clinical Laboratory Standards. Performance standards for antimicrobial susceptibility testing. Performance standards for antimicrobial susceptibility testing: Eleventh Informational Supplement, M100-S11. 2001, Wayne, Pa.

24. Battaglia FC, Lubchenco LO. A Practical classification of newborn infants by weight and gestational age. J Pediatr 1967; 71(2): 159–163.

25. Gottoff SP. Neonatal sepsis and meningitis. Nelson textbook of Pediatrics 15th Edition. In: Behrman RE, Kliegmen RM, Arvin AM, eds. Philadelphia: WB Saunders Co.; 1996. pp 273–289.

26. Haque K.H. Infection and immunity in the newborn. Forfar and Arneil's textbook of Pediatrics 5th Edition. In: Campbell AGM, Macintosh N, eds. London: Churchill Livingstone; 1998.

27. West BA, Tabansi PN. Clinico-Bacteriological profile of early and late onset sepsis in a tertiary hospital in Nigeria. J Med Med Sci 2012; 3(2): 107–111.

28. Ugwu GIMG. Pattern of morbidity and mortality in the newborn special care unit in a tertiary institution in the Niger Delta region of Nigeria: A two year prospective study. Global Advanced Res J Med Med Sci 2012; 1(6): 133–138.

29. Mokuolu AO, Jiya N, Adesiyun OO. Neonatal septicaemia in Ilorin: bacterial pathogens and antibiotic sensitivity pattern. Afr J Med Med Sci 2002; 31(2): 127–130.

30. Iroha EO, Egri-Okwaji MTC, Kesah CN, et al. Changing patterns of causative organisms of neonatal septicaemia at the Lagos University Teaching Hospital. Niger J Paediatr 1998; 25(1): 1–5.

31. Gebrehiwot A, Lakew W, Moges F, et al. Bacterial profile and drug susceptibility pattern of neonatal sepsis in Gondar University Hospital, Gondar North West Ethiopia. Der Pharmacia Lettre 2012; 4(6): 1811–1816.

32. Jumah DS, Hassan MK. Predictors of mortality outcome in neonatal sepsis. Med J Basrah University 2007; 25(1): 11–18.

33. Kardana IM. Incidence and factors associated with mortality of neonatal sepsis. Paediatr Indones 2011; 51(3): 144–148.

34. Petit PL, Van Ginneken JK. Analysis of Hospital records in four African countries, 1978–1990, with emphasis on infectious diseases. J Trop Med Hyg 1995; 98(4): 217–227.

35. Omoregie R, Egbe CA, Ogefere HO, et al. Effects of gender and seasonal variation on the prevalence of bacterial

septicaemia among young children in Benin City, Nigeria. Libyan J Med 2009; 4(3): 107–109.

36. Muhammed Z, Ahmed A, Hayat U, et al. Neonatal sepsis: Causative bacteria and their resistance to antibiotics. J Ayub Med Coll Abottabad 2010; 22(4): 33–36.

37. Seale AC, Mwaniki M, Newton CRJC, et al. Maternal and early onset neonatal bacterial sepsis: burden and strategies for prevention in Sub-Saharan Africa. Lancet Infect Dis 2010; 9(7): 428–438.

38. Boyce JM, Pittet D. Guideline for hand hygiene in health care settings. MMWR Recomm Rep 2002; 51(RR-16): 1–45.

39. Chandra PN, Millind K. Lapses in measures recommended for preventing hospital-acquired infections. J Hosp Infect 2001; 47(3): 218–222.

40. Vergnano S, Sharland M, Kazembe P, et al. Neonatal sepsis: an international perspective. Arch Dis Child Fetal Neonatal Ed 2005; 90(3): F220–F224.

41. Yusuf MA, Haziyamin T, Hamid ATA. Isolation and identification of bacteria associated with neonatal septicaemia at the Specialist Hospital Bauchi. IOSR J Pharm Biological Sci 2012; 2(6): 47–50.

42. Waters D, Jawad I, Ahmad A, et al. Aetiology of community-acquired neonatal sepsis in low- and middle-income countries. J Global Health 2011; 1(2): 154–170.

43. Ogunlesi TA, Ogunfowara OB. Predictors of mortality in neonatal septicaemia in an under-resourced setting. J Nat Med Assoc 2010; 102(10): 915–921.

44. Koutouby A, Habibullah J. Neonatal sepsis in Dubai, United Arab Emirates. J Trop Pediatr 1995; 41(3): 177–180.

45. Edmond K, Zaidi A. New approaches to preventing diagnosing and treating neonatal sepsis. PLoS Medicine 2010; 7(3): e1000213.

46. Hafidh Y, Hidayah D, Sunyataningkamto. Factors affecting mortality of neonatal sepsis in Moewardi Hospital Surakarta. Paediatr Indones 2007; 47(2): 74–77.

47. West BA, Peterside O. Sensitivity pattern among bacterial isolates in neonatal septicaemia in Port Harcourt. Ann Clin Microbiol Antimicrob 2012; 11(7).

48. Faryal FF, Rahbar HM, Ali T. Antibiotic drug resistance in neonatal sepsis. In Proceedings of the 10th National Annual Pediatric Conference 2001.

49. Kumar SG, Adithan C, Harish BN, et al. Antimicrobial resistance in India: A review. J Nat Sci Biol Med 2013; 4(2): 286–291.