The role of the season at admission in neonatal sepsis: a retrospective chart review of a 1-year data at University of Gondar comprehensive specialized hospital

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Abstract

Objective: Neonatal sepsis is a global public health concern in general and causes a massive burden in developing countries particularly in sub-Saharan Africa. Though it is mostly preventable, neonatal sepsis remained the leading cause of mortality in developing countries. This study was conducted to determine the current proportion and identify factors associated with neonatal sepsis to suggest directions.

Results: In this study 504 randomly selected neonatal charts were reviewed. The proportion of overall neonatal sepsis was 63.69% (95% CI 59.38, 67.79), where early-onset sepsis was 59.33% (95% CI 54.96, 63.55) and late-onset sepsis was 4.17% (95% CI 2.73, 6.31). Maternal intra-partum fever, season of birth and admission, vaginal mode of delivery and preterm gestational age at birth increased the likelihood of overall and early-onset neonatal sepsis. In conclusion of this study, neonatal sepsis remaining the leading cause of morbidity among younger infants. Intra-partum conditions were major contributors to neonatal sepsis. Thus, providing emphasis on associated factors in particular and universal safe obstetric care in general is recommended.

Keywords: Neonatal sepsis, University of Gondar, Early-onset neonatal sepsis

Introduction

Globally, an estimated 2.8 million neonatal deaths occurred in 2013 and the mortality showed a rising trend from 2000 to 2013 [1]. Among the death of under-5 years old children, neonatal death increased from about 37% in 2000 to nearly 42% in 2013 [1, 2].

Neonatal mortality in sub-Saharan Africa is estimated to be 29 per 1000 live births [3]. Similarly, Ethiopia is struggling with 29 per 1000 live births. The distribution of neonatal mortality throughout the country varies from region to region; 18 in Addis Ababa, 34–38 in other regions, and 47 in Amhara region that put Amhara region the highest neonatal death section in the country [4].

According to the 2016 report, 2.6 million children death occurred in the first month of life and the first week of life holds the highest proportion [5]. Prematurity, intra-partum related events such as birth asphyxia and birth trauma, and neonatal sepsis together contributed to almost three-quarters of all neonatal deaths [6].

A systematic infection, neonatal sepsis, is an important cause of morbidity and mortality of neonates. It resulted in 7% of loss and is the third leading cause of death in the globe [1, 7]. Previous reports indicated that yearly cases of neonatal sepsis in sub-Saharan Africa ranged from 380,000 to 2,000,000 with annual related neonatal deaths of 270,000 [8, 9].

In developing countries due to the scarcity of microbiological investigations; a clinical criteria in identifying neonates with possible sepsis are commonly used approach. Sepsis in neonates is commonly described as a clinical syndrome and distinguished by signs and symptoms. Fever, temperature instability, vomiting, diarrhea,
irritability, lethargy, breathing problem, low blood sugar, jaundice, reduced sucking, and seizures are the most common symptoms of neonatal sepsis [10].

In Ethiopia, some studies showed that clinically diagnosed neonatal sepsis was the common neonatal morbidity with a proportion in excess of 75% [11, 12]. Also the bacterial pathogen isolation rate in neonatal sepsis was high and almost 70% of isolates were multiple drug-resistant strains [13].

It is reported that neonatal, infant and under-five mortality in general is inversely related to the gross domestic product per capita purchasing power, particularly of developing countries [14]. Specifically, neonatal sepsis poses an enormous public health burden for the sub-Saharan Africa with a significant associated economic cost. So that strategic investment in illustration of the disease etiology, diagnosis, treatment, and prevention is recommended [15].

This study, therefore, intended to determine the current proportion of clinically diagnosed neonatal sepsis at the University of Gondar Comprehensive Specialized Hospital. The study also aimed to identify factors associated with neonatal sepsis so that practitioners and policymakers working at the neonatal health settings will consume the findings.

**Main text**

**Methods**

A retrospective study was conducted among neonates admitted in an intensive care unit (NICU) from January 1st to December 31st, 2017 at the University of Gondar Comprehensive Specialized Hospital. The Hospital is located at about 740 km northwest of Addis Ababa and as part of the country the area has four seasons. Summer is a rainy season extends from June to August characterized by heavy rain falls. September to November is a spring season which is characterized by a dry and moist weather. Winter, a dry and sunny season runs from December to February and autumn runs from March to May [16].

The data were extracted from April 16 to May 15, 2018, at the University of Gondar Specialized Hospital record room. The Hospital is found in Gondar town and serves for more than seven million people residing in the northwest part of the country. The neonatal intensive care unit (NICU) is a unit under the pediatrics and child health department and the unit provides an inpatient medical service for neonates. It has a caring capacity of about 30 beds at a time. Averages of nearly 2500 neonates were admitted in the unit between January 1st and December 31st, 2017.

Neonates admitted in the intensive care unit of the University of Gondar Comprehensive Specialized Hospital from January 1st to December 31st, 2017 were included in this study. Whereas, those neonatal charts which had an incomplete observation of major variables such as admission date, diagnosis and outcome were excluded.

The sample size was determined using Epi-info version 7.2 statistical software; Statcalc for cohort or cross-sectional study sample size calculator. We considered the assumptions: 95% confidence level, 80% power, unexposed to the exposed ratio of 1, 86.77% outcome in the unexposed groups, the odds ratio of 2.859 [12] and 15% contingency. Then, a sample size of 504 was calculated. Finally, the sample size was distributed proportional to each month based on an estimated caseload and then a simple random sampling technique was used to select neonatal charts.

A clinically diagnosed neonatal sepsis was used as an outcome variable in this study. Explanatory variables such as maternal socio-demographic, obstetric and neonatal variables were also extracted from the chart.

A semi-structured data extraction tool was used for data extraction. It was prepared in English and data extraction was done by trained data extractors. The data extraction process was evaluated daily and necessary adjustment was made. During the data extraction period, about 120 randomly selected charts were incomplete, missed major variables and replaced by new random samples.

The collected data were checked manually for completeness and entered into Epi-info software version 7.2. The data were transported to STATA version 14 for analysis. The descriptive analysis was done and results were presented in tables and text form.

Bivariate logistic regression analysis was done for each explanatory variable with the outcome variable, clinically diagnosed neonatal sepsis. Independent variables that were statistically associated with the outcome variable at a P value of 0.2 in the bivariate analysis were further run in the multivariable logistic regression model. The model fitness was assessed by post estimation Pearson or Hosmer–Lemeshow goodness-of-fit test at a P-value of > 0.05. Then the final associated factors were determined using the adjusted odds ratio with its 95% confidence level and statistical significance was declared at P-value of ≤ 0.05.

**Results**

**Maternal characteristics of neonates admitted in the NICU**

A total of 504 charts of neonates admitted in the NICU were reviewed. The median age of the mothers was 26 (IQR: 9) years and more than three quarters (78.17%) of them were between the age of 20 and 35 years. More than half, (56.55%), of the mothers resided out of Gondar town. The majority, (96.22%), of mothers attended ANC and (88.57%) of them were received TT2+ during their index pregnancy. About 157 (31.16%) of the mothers had
at least one complication during index pregnancy and premature rupture of membrane (PROM) occurred in 13% of cases.

Approximately, about 80% of the mothers had a singleton pregnancy and in about 82% of the mothers the labor was of spontaneous onset. More than two-thirds (65.08%), of mothers gave spontaneous vaginal delivery and about 73% births occurred at Hospitals (Table 1).

**Characteristics of neonates who were admitted in NICU**

Two hundred ninety-nine, (59.44%), neonates were males, and about 41% were preterm births. Before admission to NICU, quarters (25.6%) of neonates were resuscitated with bag and mask and nearly 46% were hypothermic at admission. Early onset neonatal sepsis was diagnosed among 59.33%, sepsis in general was diagnosed among 63.69% neonates and one neonate was diagnosed for both early and late onset sepsis during his/her stay in the unit (Table 2).

**Factors associated with neonatal sepsis**

The multivariable logistic regression analysis revealed that intra-partum maternal fever found to be statistically significant predictor for both early-onset [AOR: 10.86, 95% CI (1.35–87.7)] and overall neonatal sepsis [AOR: 8.64, 95% CI (1.06–70.4)]. Neonates who were admitted during the dry and moist season from September to November were more likely to have both early-onset [AOR: 1.89, 95% CI (1.02–3.51)] and overall neonatal sepsis [AOR: 2.18, 95% CI (1.67–4.05)] as compared to June to August rainy season admissions. Moreover, neonates delivered vaginally were about 2 times [AOR: 2.22, 95% CI (1.24–4.32)] likely to have an early-onset and overall [AOR: 2.14, 95% CI (1.21–3.77)] sepsis. Likewise, neonates born before 37 complete weeks were likely to have early-onset [AOR: 5.03, 95% CI (3.04–8.33)] and overall [AOR: 4.03, 95% CI (2.43–6.71)] sepsis as compared to their counterparts (Table 3).

**Discussion**

This research determined the proportion of neonatal sepsis and identified factors associated with sepsis among neonates admitted in the NICU of the University of Gondar Comprehensive Specialized Hospital.

Accordingly, the proportion of EONS was 59.33%, LONS was 4.17%, and overall sepsis was 63.69%. Maternal intra-partum fever, the season of birth and admission, vaginal delivery and preterm gestational age at births increased the likelihood of overall sepsis and EONS.

The proportion of neonatal sepsis in general and early-onset sepsis, in particular, was 63.69% and 59.33% in this study in that order. This finding is slightly lower than previous studies done in Gondar 77.8% [17], and Shashemene 77.9% [12]. This small variation could be attributed to the large sample size in the current study. However, both findings could reflect that neonatal sepsis is the most prevalent morbidity among neonates in developing countries.

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**Table 1** Socio-demographic and obstetric characteristics of mothers of neonates admitted in NICU of the UoGCSH from January to December 2017, northwest Ethiopia (n = 504)

| Characteristics                              | Frequency | Percent |
|----------------------------------------------|-----------|---------|
| Current maternal age in years                |           |         |
| < 20                                         | 51        | 10.12   |
| 20–34                                        | 394       | 78.17   |
| ≥ 35                                         | 59        | 11.71   |
| Residence                                    |           |         |
| Gondar town                                  | 219       | 43.45   |
| Out of Gondar town                           | 285       | 56.55   |
| Had ANC in the index pregnancy               |           |         |
| Yes                                          | 483       | 96.22   |
| No                                           | 19        | 3.78    |
| TT vaccination in index pregnancy            |           |         |
| Not vaccinated                               | 20        | 4.08    |
| TT one                                      | 36        | 7.35    |
| TT two and above                             | 434       | 88.57   |
| Parity (number of births)                   |           |         |
| I                                            | 259       | 51.39   |
| II–IV                                       | 182       | 36.11   |
| ≥ V                                          | 63        | 12.50   |
| Complication during index pregnancy          |           |         |
| Antepartum hemorrhage (APH)                  | 33        | 6.55    |
| Premature rapture of membrane (PROM)         | 66        | 13.10   |
| Pregnancy-induced hypertension (PH)          | 58        | 11.51   |
| Previous bad obstetrics history              |           |         |
| Yes                                          | 26        | 5.16    |
| No                                           | 478       | 94.84   |
| Type of pregnancy                            |           |         |
| Singleton                                    | 404       | 80.16   |
| Twin                                        | 100       | 19.84   |
| Onset of labor                               |           |         |
| Elective cesarean section                    | 47        | 9.33    |
| Spontaneous onset                            | 414       | 82.14   |
| Induced                                     | 43        | 8.53    |
| Place of birth                               |           |         |
| Home                                        | 19        | 3.77    |
| Health center                                | 116       | 23.02   |
| Hospital                                    | 369       | 73.21   |
| Mode of delivery                             |           |         |
| Spontaneous vaginal delivery                 | 328       | 65.08   |
| Cesarean section                             | 144       | 28.57   |
| Instrument-assisted delivery                 | 32        | 6.35    |

* Tetanus Toxoid, † Stillbirth or early neonatal death or intra-uterine fetal death
The presence of maternal fever in the intra-partum period increased the likelihood of neonatal sepsis by 9 and early-onset sepsis by 11 times as revealed in this study. This finding is in line with previously conducted studies. Likewise, the odds of having neonatal sepsis was 6 times higher among intra-partum fever cases in Mekelle city, Ethiopia [18] and 37 times in Karachi, Pakistan [19]. In addition, a study in Bangladesh demonstrated that intra-partum fever was a significant predictor of neonatal sepsis [20]. Studies reported that intra-partum fever is suggestive of maternal infections. So that, maternal infection frequently transmitted to the baby as ascending, via circulation or during passage through the birth canal and it usually causes early-onset sepsis [20, 21].

In this study, the season of birth and admission has shown a statistically significant association with the probability of being diagnosed for neonatal sepsis in this study. Neonates born and admitted to NICU in September to November had nearly 2 times increased odds of developing neonatal sepsis than June to August births. A study conducted in Canada also identified a significant seasonal variation in neonatal sepsis in which an increased infection during the summer months was observed [22]. Another study from Benin City, Nigeria showed a significantly higher proportion of sepsis among female neonates during the dry season [23]. The reason related to seasonal variation in neonatal sepsis is unclear. However, an assumption that is related to high temperature with moderate humidity of such season might create a favorable environment for microbial growth could be attributed to the association [24].

In our study, the mode of delivery illustrated a statistically significant association with neonatal sepsis. Neonates born vaginally had twice more odds of developing neonatal sepsis than cesarean births. Some studies showed a higher odds of neonatal sepsis among cesarean births [13, 25]. On the other hand, the vaginal canal is colonized by different microbial and believed to result in neonatal colonization. As revealed in a study done in Pakistan [26], significantly increased neonatal sepsis in repeatedly done vaginal examination case could a be a logical explanation for this finding.

Neonates who were born before 37 complete weeks had more than 4 times higher odds of infection compared with term births. Previous studies also identified a positive association of sepsis among preterm neonates. A similar association was noted by the studies conducted in Makassar [27], Jakarta, Indonesia [28], and Mexico [29] in which preterm neonates were more likely to have an infection. Manuck et al. study further identified that neonatal morbidity was most frequently occurred among preterm groups [30]. This susceptibility is mainly ascribed to the limited capacity of preterm neonates to defend against microorganisms [31].

In this study, neonatal sepsis remaining the leading cause of morbidity among younger infants. Maternal intra-partum fever, a season of birth and admission, vaginal delivery and preterm gestational age at births increased the likelihood of overall sepsis and EONS. Mainly intra-partum conditions contributed to neonatal sepsis. Thus, providing emphasis on associated factors in particular and universal safe obstetric care, in general, is recommended.

**Limitations of the study**
Despite retrospective nature, this study was generated from a single hospital and its representativeness is limited. Thus, it is informative to conduct large scale prospective study which shall address the quality of obstetric and neonatal services.
Table 3 Factors associated with neonatal sepsis among neonates admitted in NICU of UoGCSH from January to December 2017, northwest Ethiopia (n = 504)

| Variables                         | Neonatal sepsis (overall sepsis) | AOR (95% CI) | Neonatal sepsis (EONS) | AOR (95% CI) |
|-----------------------------------|----------------------------------|--------------|------------------------|--------------|
|                                   | Yes     | No    | Yes     | No    | Yes     | No    |
| Had ANC                           |         |       | Yes     | No    |         |       |
| Yes                               | 306     | 179   | 1       |       | 287     | 198   | 1       |
| No                                | 15      | 4     | 1.44 (0.42, 4.93) | 13 | 6 | 0.94 (0.30, 2.94) |
| History of APH                    |         |       | Yes     | No    |         |       |
| Yes                               | 27      | 6     | 1.79 (0.64, 5.01) | 26 | 7 | 1.49 (0.56, 3.96) |
| No                                | 294     | 177   | 1       |       | 274     | 197   | 1       |
| Maternal fever during labor       |         |       | Yes     | No    |         |       |
| Yes                               | 19      | 1     | 8.64 (1.06, 70.4) | 19 | 1 | 10.86 (1.35, 87.7) |
| No                                | 302     | 182   | 1       |       | 281     | 203   | 1       |
| Duration of labor                 |         |       | Yes     | No    |         |       |
| Zero h                            | 25      | 22    | 1       |       | 25      | 22    | 1       |
| 1–12 h                            | 188     | 116   | 1.08 (0.47, 2.49) | 172 | 132 | 0.96 (0.41, 2.26) |
| > 12 h                            | 108     | 45    | 2.19 (0.87, 5.51) | 103 | 50 | 1.94 (0.76, 4.94) |
| Place of birth                    |         |       | Yes     | No    |         |       |
| Home                              | 16      | 3     | 3.90 (0.96, 15.79) | 11 | 8 | 1.36 (0.43, 4.33) |
| Health center                     | 87      | 29    | 1.78 (0.94, 3.38) | 289 | 196 | 1.69 (0.89, 3.22) |
| Hospital                          | 218     | 151   | 1       |       |         |       |
| Season of birth                   |         |       | Yes     | No    |         |       |
| Sep–Nov                           | 85      | 34    | 2.18 (1.67, 4.05) | 77 | 42 | 1.89 (1.02, 3.51) |
| Dec–Feb                           | 74      | 47    | 0.92 (0.50, 1.68) | 71 | 50 | 0.93 (0.51, 1.72) |
| Mar–May                           | 93      | 57    | 1.31 (0.74, 2.32) | 86 | 64 | 1.26 (0.71, 2.25) |
| Jun–Aug                           | 69      | 45    | 1       |       | 66      | 48    | 1       |
| Mode of delivery                  |         |       | Yes     | No    |         |       |
| Spontaneous vaginal delivery      | 231     | 93    | 2.14 (1.21, 3.77) | 213 | 111 | 2.22 (1.24, 4.32) |
| Cesarean delivery                 | 69      | 75    | 1       |       | 66      | 78    | 1       |
| Instrument-assisted delivery      | 21      | 15    | 1.27 (0.53, 3.06) | 21 | 15 | 1.52 (0.62, 3.71) |
| Gestational age at birth          |         |       | Yes     | No    |         |       |
| Preterm (< 37 weeks)              | 168     | 41    | 4.03 (2.43, 6.71) | 165 | 44 | 5.03 (3.04, 8.32) |
| Term (37–41 weeks)                | 133     | 129   | 1       |       | 115     | 146   | 1       |
| Post-term (≥ 42 weeks)            | 21      | 13    | 1.59 (0.69, 3.61) | 20 | 14 | 1.65 (0.72, 3.80) |
| Did the baby cry at birth         |         |       | Yes     | No    |         |       |
| Yes                               | 231     | 159   | 1       |       | 210     | 180   | 1       |
| No                                | 90      | 24    | 1.33 (0.49, 3.55) | 90 | 24 | 1.84 (0.69, 4.88) |
| 5th minute APGAR score            |         |       | Yes     | No    |         |       |
| Unknown                           | 102     | 60    | 0.77 (0.43, 1.36) | 83 | 79 | 0.50 (0.28, 0.90) |
| < 7                               | 54      | 15    | 1.68 (0.75, 3.77) | 54 | 15 | 1.47 (0.65, 3.30) |
| ≥ 7                               | 165     | 108   | 1       |       | 163     | 110   | 1       |
| Bag and mask ventilated at birth  |         |       | Yes     | No    |         |       |
| Yes                               | 103     | 26    | 1.91 (0.76, 4.78) | 103 | 26 | 1.79 (0.73, 4.44) |
| No                                | 218     | 157   | 1       |       | 197     | 178   | 1       |

Abbreviations
ANC: antenatal care; EONS: early-onset neonatal sepsis; LONS: late-onset neonatal sepsis; NICU: neonatal intensive care unit; UoGCSH: University of Gondar comprehensive specialize Hospital.

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Authors’ contributions
TWG conceived and design the idea, participated in data management, analysis, interpretation, and paper write up. EGZ and AML participated in data analysis and interpretation. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
Ethical clearance was obtained from the Ethical Committee of the Institute of public health in the University of Gondar. Officials from University of Gondar Comprehensive Specialized Hospital were communicated through a formal letter which was taken from the institute of public health and permission for data collection was granted from the hospital. Confidentiality of information was maintained through not extracting personal identifiers and keeping data in password protected computer.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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References
1. Liu L, Oza S, Hogan D, Perin J, Rudan J, Lawn JE, et al. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet. 2015;385(9966):430–40.
2. Kassebaum NJ, Bertozzi-Villa A,Coggeshall MS, Shackelford KA, Steiner C, Heuton KR, et al. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9947):980–1004.
3. Unicef. Levels and Trends in Child Mortality: Report 2010: Estimates Developed by the UN Inter-Agency Group for Child Mortality Estimation: United Nations Children’s Fund, 2010.
4. Central Statistical Agency (CSA) [Ethiopia] and ICF. Ethiopia Demographic and Health Survey 2016. Addis Ababa: CSA and ICF; 2016. p. 2016.
5. United Nations Children’s Fund, World Health Organization; World Bank, United Nations. Levels & Trends in Child Mortality: Report 2017: Estimates developed by the UN Inter-agency Group for Child Mortality Estimation: New York: United Nations Children’s Fund, 2017.
6. MCEE W. MCEE-WHO methods and data sources for child causes of death 2000–2015. World Health Organization, 2016.
7. Gershon AA. Infectious diseases of children: Mosby. 2004.
8. Qazi SA, Stoll BJ. Neonatal sepsis: a major global public health challenge. Pediatr Infect Dis J. 2009;28(1):151–2.
9. Seale AC, Blencowe H, Zadik A, Ganatra H, Syed S, Engmann C, et al. Neonatal severe bacterial infection impairment estimates in South Asia, sub-Saharan Africa, and Latin America for 2010. Pediatr Res. 2013;74(S1):73.
10. Shahe CK, Dey SK, Shabuj KH, Chisti J, Mannan M, Jashimuddin M, et al. Neonatal sepsis a review. Bangladesh J Child Health. 2012;36(2):82–9.
11. Teavebe T, Mohammed S, Tilahun Y, Melaku B, Fenta M, Dagnaw T, et al. Clinical outcome and risk factors of neonatal sepsis among neonates in Felege Hiwot referral Hospital, Bahir Dar, Amhara Regional State, North West Ethiopia 2016: a retrospective chart review. BMC Res Notes. 2017;10(1):265.
12. Getabelew A, Aman M, Fantaye E, Yehyesi T. Prevalence of neonatal sepsis and associated factors among neonates in neonatal intensive care unit at selected governmental hospitals in Shashemene Town, Oromia Regional State, Ethiopia, 2017. Int J Pediatr. 2018;2018:8701272.
13. Muges F, Eshetie S, Yeshitela B, Abate E. Bacterial etiologic agents causing neonatal sepsis and associated risk factors in Gondar, Northwestern Ethiopia. BMC Pediatr. 2017;17(1):137.
14. O’Hare B, Makuta I, Chiwaula L, Bar-Zeev N. Income and child mortality in developing countries: a systematic review and meta-analysis. J R Soc Med. 2013;106(10):408–14.
15. Ranjeva SL, Warf BC, Schijff SJ. Economic burden of neonatal sepsis in sub-Saharan Africa. BMJ Global Health. 2018;3(1):e000347.
16. Climate. http://www.ethiopianantreasures.co.uk/pages/climate.htm. Accessed 10 Aug 2019.
17. Kokeb M, Desta T. Institution Based prospective cross-sectional study on patterns of neonatal morbidity at Gonder University Hospital Neonatal Unit, North-West Ethiopia. Ethop J Health Sci. 2016;26(1):73–9.
18. Gebremedhin D, Berhe H, Gebrekristos K. Risk factors for neonatal sepsis in public hospitals of Mekelle City, North Ethiopia, 2015: unmatched case control study. PLoS ONE. 2016;11(5):e0154798.
19. Alam MM, Saleem AF, Shalik AS, Munir O, Qadir M. Neonatal sepsis following prolonged rupture of membranes in a tertiary care hospital in Karachi, Pakistan. J Infect Develop Cries. 2014;8(01):067–73.
20. Hasan M, Mahmood C. Predictive values of risk factors in neonatal sepsis. J Bangladesh Coll Phys Surg. 2011;2(9):187–95.
21. Soman M, Green B, Daling J. Risk factors for early neonatal sepsis. Am J Epidemiol. 1985;121(5):712–9.
22. Shah PS, Yoon W, Kalapesi Z, Bassil K, Dunn M, Lee SK. Seasonal variations in healthcare-associated infection in neonates in Canada. Arch Dis Childhood-Fetal Neonatal Ed. 2013;98(1):F65–9.
23. Oh ORC, Igbarumah I, Omijire R. Effects of gender and seasonal variation on the prevalence of bacterial septicaemia among young children in Benin City, Nigeria. 2009.
24. Ricard JD, Boyer A, Dreyfuss D. The effect of humidification on the incidence of ventilator-associated pneumonia. Respir Care Clin N A. 2006;12(2):263–73.
25. Adatara P, Afaya A, Salia SM, Afaya RA, Konlan KD, Agyabeng-Fadoh D, et al. Risk factors associated with neonatal sepsis: a case study at a specialist hospital in Ghana. Sci World J. 2019;2019:9369051.
26. Bhutta ZA, Yusuf K. Early-onset neonatal sepsis in Pakistan: a case control study of risk factors in a birth cohort. Am J Perinatol. 1997;14(09):577–81.
27. Hayun M, Alasiry E, Daud D, Fabriani DB, Madjid D. The risk factors of early onset neonatal sepsis. Am J Clin Exp Med. 2015;3(3):78–82.
28. Ocviyanti D, Wahono WT. Risk factors for neonatal sepsis in pregnant women with premature rupture of the membrane. J Pregen. 2018;2018:6.
29. Leal YA, Álvarez-Nemegyei J, Velázquez JR, Rosado-Quiba U, Diego-Rodríguez N, Pazo-Baeza E, et al. Risk factors and prognosis for neonatal sepsis in southeastern Mexico: analysis of a four-year historic cohort follow-up. BMC Pregin Childbirth. 2012;12(1):48.
30. Manuck TA, Rice MM, Baillit JL, Grobman WA, Reddy UM, Wapner RJ, et al. Preterm neonatal morbidity and mortality by gestational age: a contemporay cohort. Am J Obstet Gynecol. 2016;215(1):103.
31. Petrova A, Mehta R. Dysfunction of innate immunity and associated pathology in neonates. Indian J Pediatr. 2007;74(2):185–91.

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