https://www.banglajol.info/index.php/BJMM/index

Bangladesh Journal of Medical Microbiology

January 2024, Volume 18, Number 1, Page 22-29

ISSN (Print) 2070-1810

ISSN (Online) 2072-3105

Original Article ***Open Access***

Prevalence and Antibiotic Resistance Patterns of Neonatal Bloodstream Pathogens in Tertiary Care Hospitals: A Retrospective Analysis

Ritu Saha[1], Shamoli Saha[2], Hasiba Mahmuda[3], Afzalunnessa Binte Lutfor[4]

[1]Associate Professor and Head, Department of Microbiology, Bashundhara Ad-din Medical College, South Keraniganj, Dhaka, Bangladesh; [2]Assistant Professor (C.C.), Department of Microbiology, Bashundhara Ad-din Medical College, South Keraniganj, Dhaka, Bangladesh; [3]Assistant Professor(C.C.), Department of Microbiology, Bashundhara Ad-din Medical College, South Keraniganj, Dhaka, Bangladesh; [4]Professor and Head, Department of Microbiology, Ad-din Women's Medical College, Maghbazar, Dhaka, Bangladesh, Former Research Associate, Department of Respiratory Oncology and Molecular Medicine, Tohuku University, Sendai, Japan

Abstract

Background: Neonatal bloodstream infections (BSIs) are a leading cause of mortality in developing countries, necessitating effective treatment strategies. **Objective:** This retrospective study investigated the prevalence and antibiotic susceptibility patterns of bacterial pathogens causing neonatal BSIs in two tertiary hospitals in Dhaka, Bangladesh. **Methodology:** This is a retrospective study took place in Ad-din Women's Medical College & Hospital, Dhaka & Rushmono specialized Hospital, Dhaka, Bangladesh in between the time period of July 2019 to December 2020. A total of 1825 blood samples were obtained from patients who were admitted at the Neonatal Intensive care unit of Ad-din Women's Medical College & Hospital, Dhaka & Rushmono specialized Hospital, Dhaka, Bangladesh from July 2019 to December 2020. All the blood samples were processed for culture using a BACT/Alert blood culture machine. Further identification & antimicrobial susceptibility tests were performed using standard microbiological procedure. **Results:** The analysis of 1825 blood samples obtained from neonatal intensive care facilities unveiled a bloodstream infection (BSI) rate of 17.2%. The predominant isolates identified were coagulase-negative *Staphylococci* (CoNS) (10%) and Acinetobacter spp. (60%); these organisms are classified as Gram-positive and Gram negative bacteria, respectively. The preponderance of infections was caused by Gram-positive organisms, specifically CoNS, which evolved highly sensitive to imepenem, vancomycin, and linezolid but resistance to ampicillin, cephradine and erythromycin. Methicillin resistance is present in 31.5% of *Staphylococcus aureus* and nearly half (47%) of the CoNS. Vancomycin resistance is present in one-tenth of the isolated *Staphylococcus species*. Acinetobacter spp. exhibited greater susceptibility to colistin (100%), meropenem (90.67%), piperacillin-tazobactum (92%), and amikacin (82.67%), but resistance to ampicillin (90%), cephradin (80%), cefuroxime (90%), and cefixime (61%). Proteus, Enterobacterieceae, including E. coli, Klebsiella, and Enterobacter, exhibited greater resistance to ampicillin, cephradin, and chloramphenicol while demonstrating greater sensitivity to meropenem (100%), piperacillin-tazobactum (95-98%), amikacin (80-82%), and gentamycin (76%-80%). **Conclusion:** Major causative agents of neonatal blood stream infection were coagulase-negative *Staphylococci* (CoNS) and *Acinetobacter spp*. Multidrug resistance among these bacteria was observed in the study; which necessitate the implementation of antibiotic stewardship program to improve neonatal outcome.

Keywords: BSI: blood stream infection; antimicrobial-resistant organisms; neonatal intensive care unit; Coagulase-negative *staphylococci*, MRSA; *Acinetobacter species*

Bangladesh Journal of Medical Microbiology, January 2024;18 (1):22-29

Correspondence: Dr. Ritu Saha, MBBS, MD, Associate Professor and Head, Department of Microbiology, Bashundhara Ad-din Medical College, South Keraniganj, Dhaka, Bangladesh; Email: ritu86.smc@gmail.com; Cell No.: +8801735725363; ORCID: https://orcid.org/0000-0003-3567-2942

DOI: https://doi.org/10.3329/bjmm.v18i1.76965

Introduction

Bloodstream infection is one of the major causes of neonatal mortality in developing countries. In some communities, almost half of patients in neonatal intensive care units acquire blood stream infections[1,2]. The World Health Organization has estimated that 10

million neonates die during the first five days after birth. Some developing countries reported that septicemia affects one in five neonates[3]. Neonatal infection can be acquired vertically from birth canal bacteria or environmentally due to lack proper health facilities. Neonatal septicemia is a clinical syndrome bacteremia with symptoms and clinical signs in the first months of life and delay in its diagnosis and treatment which causes mortality[4].

Neonates are very much susceptible to infection because of their compromised immune systems. Neonatal sepsis has significant morbidity and mortality and is difficult to diagnose on presentation. For this reason, those with suspected sepsis are commenced on empiric antibiotic therapy until sepsis can be ruled out. Overuse of antibiotics results in the development of antimicrobial-resistant organisms (ARO). Infection with ARO results in delay in starting effective antibiotic therapy, fewer possible treatment options and increased morbidity and mortality, with prolonged hospital stay and greater costs of hospitalization[5].

Pathogens vary CoNSiderably between different neonatal units. In many hospitals, gram-positive organisms cause up to 70.0% of nosocomial infections in neonates with coagulase negative *staphylococci* (CoNS) accounting for more than half of these[6-7]. On the other hand, in some developing countries, gram-negative organisms may be far more prevalent as neonatal pathogens, with a higher incidence of antimicrobial resistance[3]. Pathogens also vary over time, for example, the first outbreak of multiple-drug-resistant was described in 2004 by A. baumannii in extremely low birth weight infants in the USA[8]. But now a days, Acinetobacter is one of the most important microorganism responsible for neonatal blood stream infection in our country[9].

There are epidemiological differences in the incidence, risk factors, pattern, antimicrobial sensitivities of pathogens, and mortality of neonatal sepsis among different regions and countries in the world[10]. Empiric antibiotic therapies rely on monitoring antimicrobial sensitivity patterns in culture isolates. To accelerate the progress of preventing neonatal morbidity and mortality, specific strategies tailored to specific coun tries are required for the prevention and treatment of neonatal sepsis. Antibiotic stewardship, including appropriate choice and administration of antibiotics, de-escalation of therapy, and a multidisciplinary team approach to managing neonatal sepsis, is recommended to limit inappropriate antibiotic use and prevent the development of resistant microorganisms. Moreover, Identification of risk factors and early diagnosis and the institution of therapy according to local epidemiology and antimicrobial resistance patterns can improve neonatal survival.

In this study, we aimed to identify the most prevalent bacterial pathogens involved in neonatal BSI in two tertiary health care hospitals in Dhaka city with NICU facilities. We also determined antibiotic susceptibility patterns of the pathogens to see the changing trend of antimicrobial susceptibility in this region.

Methodology

Study Settings: This is a retrospective study which was taken place in Ad-din Women's Medical College & Hospital, Dhaka & Rushmono specialized Hospital, Dhaka, Bangladesh in between the time period of July 2019 to December 2020.

Study Population: A total of 1825 blood samples were obtained from patients who were admitted at the Neonatal Intensive Care Unit (NICU) with the symptom of neonatal sepsis in the age group of 0 to 28 days. Outdoor patient's samples were excluded.

Study Procedure: All the blood samples were processed for culture using a BACT/Alert blood culture machine to identify the presence of bacterial pathogens. Manual method has been utilized as well. Antimicrobial susceptibility tests were performed on the isolated pathogens using Kirby-Bauer disk diffusion method.

Isolation and Identification of Bacterial Isolates: Collected blood samples were directly inoculated into pediatric FAN blood culture bottle. Bottles were incubated in the BACT/Alert machine for up to 5 days. One drop of blood from growth positive culture bottles were directly inoculated onto MacConkey (MC) agar and blood agar (5% sheep blood) plates. Blood agar plates and MacConkey plates were then incubated at 37°C in aerobic condition. The bacterial isolates were identified and confirmed by using standard microbiological and biochemical tests like Gram staining, growth on selective media, colony morphology on culture media, lactose fermentation, indole, and citrate utilization, H_2S production, catalase, coagulase, oxidase, and urease test according to guidelines of World Health Organization[11].

Antimicrobial Susceptibility Testing: According to Clinical and Laboratory Standards Institute (CLSI) guidelines of 2019 antimicrobial susceptibility testing was performed by using disc diffusion (Kirby-Bauer's) technique on Mueller Hinton agar (Merck, Germany)[12].

The antibiotic discs of ampicillin (Amp), cephradine (Ceph), cotrimoxazole (Cot), ciprofloxacin (Cip), levofloxacin (Lev), nalidixic acid (NA), ceftriaxone (CTR), chloramphenicol (Clo), amoxyclav (AMC), cefixime (CXM), cefotaxime (CTX), gentamicin (Gen), amikacin (AK), azithromycin (Az), ceftazidime (CAZ), meropenem (Mero), piperacillin-tazobactam (PIT), colistin (Col) were used for Gram negative bacteria and ampicillin (Amp), cephradine (Ceph), cotrimoxazole (Cot), ciprofloxacin (Cip), levofloxacin (Lev), cefotaxime (CTX), ceftriaxone (CTR), amoxyclav (AMC), gentamicin (Gen), amikacin (AK), imepenem (Ime), cefixime (CXM), oxacillin (Ox), cloxacillin (Clox), erythromycin (Ery), doxycycline (Do), vancomycin (Van), linezolid (Lz) were used for Gram positive bacteria. All antibiotic discs are obtained from Oxoid Ltd, Bashingstore, Hampire, UK.

Statistical analysis: Microsoft Excel program were used for statistical analysis and figure generation.

Ethical Clearance: The research protocol was approved by Institutional Review Board (IRB) of Addin Women's Medical College & Hospital, code no AWMC IRB/21 July 2023/027.

Results

A total of 1825 blood culture samples were taken from patients admitted in neonatal intensive care unit, of them majority were female (1009 Female, 816 Male) with male female ratio M: F=1: 1.24 [Figure: 1]

Figure I: Distribution of the received sample according to sex group

Frequency of neonatal blood stream infection from the received samples was illustrated in Table-1. Blood stream Infection rate was 17.2% (313/1825). Among the growth positive cases, 39.61% (124/313) were infected by Gram negative bacilli while while 60.38% (189/313) cases were infected by Gram positive cocci (Table 1).

Table 1: Frequency of neonatal blood stream infection from samples of suspected cases

Sample received	Frequency	Percent
Growth Positive	313	17.2
Growth Negative	1512	82.8
Total	**1825**	**100.0**

Coagulase negative *Staphylococci* (CoNS) 165 (52.7%) was the predominant isolates followed by, Acinetobacter 75 (23.9%), *Staphylococcus aureus* 31 (6.1%) & *Klebsiella spp.* (5.4%). Few *Enterobacter*, *Proteus*, *Pseudomonas*, *Enterococci species* were also isolated. No Salmonella Typhi and Salmonella paratyphi were detected. These findings suggest that Coagulase negative *Staphylococci Spp.* and *Acinetobacter Spp.* are mostly responsible for neonatal blood stream infection whereas, Salmonella Typhi is not responsible for blood stream infection in neonates like childhood and adult patients (Table 2).

Table 2: Distribution of Bacterial Pathogens Causing Neonatal Bloodstream Infection

Pathogen	Frequency	Percent
CoNS	165	52.7
Acinetobacter	75	23.9
Staphylococcus aureus	19	6.1
Klebsiella	17	5.4
Enterobacter	18	5.8
E. coli	5	1.6
Proteus	5	1.6
Pseudomonas	4	1.3
S. pneumonie	3	1.0
Enterococci	2	0.6
Salmonella Typhi	0	0.0
Salmonella paratyphi	0	0.0
Total	**313**	**100.0**

Distribution of Gram-positive and Gram-negative bacteria responsible for neonatal BSI are illustrated in Figure II and Figure III. CoNS and *Staphylococcus aureus* are predominant Gram-positive Isolates Whereas, *Acinetobacter, Enterobacter* and *Klebsiella* are frequently isolated among Gram negative bacteria.

The rates of susceptibility to selected antimicrobial agents against Gram positive cocci and Gram-negative bacilli are demonstrated in Table 3 and Table 4, respectively.

Staphylococci were responsible for majority of Neonatal blood stream infection cases; among these, CoNS were most frequently isolated. They showed

high resistance to ampicillin (92.73%), cephradin (83.03%), erythromycin (52.12%), and high sensitivity to imipenem (86.06%), vancomycin (90.30%) and linezolid (100%) (Table 3). *Staphylococcus aureus* is the second commonest Gram-positive organism responsible for BSI. Almost half (47%) of the CoNS and one third (31.5%) *Staphylococcus aureus* are methicillin resistant. Almost 10% of the isolated *Staphylococcus species* are resistant to vancomycin.

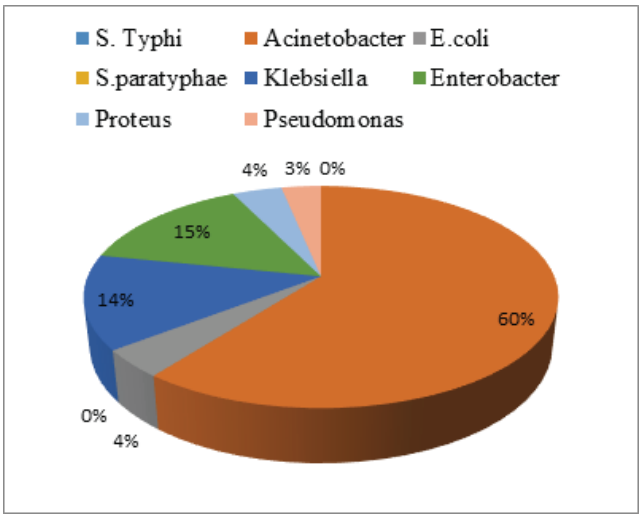

Figure II: Distribution of Gram-positive bacteria causing neonatal BSI

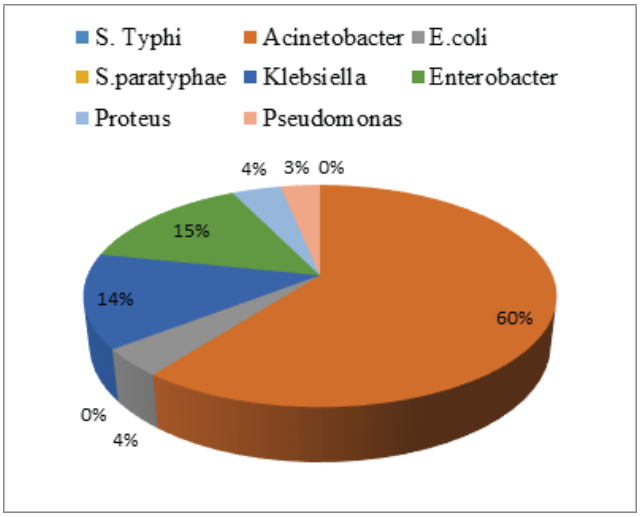

Figure III: Distribution of Gram-Negative bacteria causing neonatal BSI

Acinetobacter species is the commonest Gram-negative pathogen in neonatal blood stream infection. They showed higher sensitivity to colistin (100%), meropenem (90%), piperacillin-tazobactum (92%), & amikacin (82%) (Table 4).

Higher resistance is observed to Ampicillin (90%), cephradin (80%), cefuroxime (90%) and cefixime (80%). Among the isolated Acinetobacter species 48% are multi drug resistant (cephalosporin,

Table 3: Susceptibility pattern of Gram-positive organisms causing neonatal blood stream infection

Antibiotics	**CoNS (165)**	***S. aureus*(19)**	***Enterococci* (3)**	***S. pneumoniae (2)***
Ampicillin	12 (7.27%)	2 (10.53%)	1 (33.33%)	0 (0.00%)
Amoxyclav	106 (64.24%)	13 (68.42%)	2 (66.67%)	1 (50.00%)
Amikacin	129 (78.18%)	13 (68.42%)	2 (66.67%)	2 (100.00%)
Cephradine	28 (16.97%)	4 (21.05%)	1 (33.33%)	0 (0.00%)
Cotrimoxazole	94 (56.97%)	14 (73.68%)	2 (66.67%)	1 (50.00%)
Ciprofloxacin	79 (47.88%)	12 (63.16%)	2 (66.67%)	1 (50.00%)
Cefepime	97 (58.79%)	14 (73.68%)	2 (66.67%)	1 (50.00%)
Ceftriaxone	98 (59.39%)	12 (63.16%)	2 (66.67%)	1 (50.00%)
Cefotaxime	76 (46.06%)	10 (52.63%)	2 (66.67%)	1 (50.00%)
Cloxacillin	44 (26.67%)	7 (36.84%)	2 (66.67%)	1 (50.00%)
Cefixime	56 (33.94%)	8 (42.11%)	3 (100%)	1 (50.00%)
Doxycycline	101 (61.21%)	11 (57.89%)	3 (100%)	1 (50.00%)
Erythromycin	79 (47.88%)	7 (36.84%)	1 (33.33%)	1 (50.00%)
Gentamicin	109 (66.06%)	15 (78.95%)	3 (100%)	2 (100.00%)
Imepenem	142 (86.06%)	15 (78.95%)	2 (66.67%)	2 (100.00%)
Levofloxacin	85 (51.52%)	10 (52.63%)	2 (66.67%)	1 (50.00%)
Linezolid	165 (100%)	19 (100%)	3 (100%)	2 (100.00%)
Oxacillin	45 (27.27%)	8 (42.11%)	1 (33.33%)	1 (50.00%)
Vancomycin	149 (90.30%)	16 (84.21%)	3 (100%)	2 (100.00%)

*Methicillin resistance means resistance to penicillin, oxacillin, cloxacillin

Table 4: Susceptibility Pattern of Gram-negative organisms isolated from Blood stream infection

Antibiotics	*Acinetobacter* (N=75)	*Enterobacter* (N=18)	*Proteus* (N=5)	*Pseudomonas* (N=4)	*E. coli* (N=5)
Ampicillin	8 (10.67%)	2 (11.11%)	1 (20.00%)	NU	1(20.00%)
Azithromycin	NU	NU	NU	2 (50.00%)	NU
Amoxiclav	13 (17.33%)	12 (66.67%)	3 (60.00%)	3 (75.00%)	3 (60.00%)
Amikacin	62 (82.67%)	16 (88.89%)	4 (80.00%)	4 (100%)	4 (80.00%)
Cephradine	15 (20.00%)	3 (16.67%)	1 (20.00%)	0 (0.00%)	1 (20.00%)
Cotrimoxazole	42 (56.00%)	11 (61.11%)	3 (60.00%)	3 (75.00%)	3 (60.00%)
Ciprofloxacin	37 (49.33%)	10 (55.56%)	3 (60.00%)	2 (50.00%)	3 (60.00%)
Ceftriaxone	37 (49.33%)	12 (66.67%)	3 (60.00%)	2 (50.00%)	3 (60.00%)
Cefotaxime	38 (50.67%)	11 (61.11%)	3 (60.00%)	2 (50.00%)	2 (40.00%)
Cefuroxime	8 (10.67%)	11 (61.11%)	3 (60.00%)	NU	2 (40.00%)
Ceftazidime	37(49.33%)	10 (55.56%)	2 (40.00%)	2 (50.00%)	3 (60.00%)
Cefixime	29 (38.67%)	11 (61.11%)	3 (60.00%)	3 (75.00%)	3 (60.00%)
Chloramphenicol	31(41.33%)	5 (27.78%)	3 (60.00%)	NU	3 (60.00%)
Colistin	73 (97.3%)	18 (100%)	5 (100%)	4 (100%)	5 (100%)
Doxycycline	35 (46.67%)	8 (44.44%)	3(60.00%)	NU	3 (60.00%)
Gentamicin	50(66.67%)	13 (72.22%)	3 (60.00%)	3 (75.00%)	4 (80.00%)
Levofloxacin	38 (50.67%)	11 (61.11%)	3 (60.00%)	2 (50.00%)	3 (60.00%)
Meropenem	6 (90.67%)	18 (100%)	5 (100%)	4 (100%)	5 (100%)
Nalidixic acid	34 (45.33%)	10 (55.56%)	2 (40.00%)	2 (50.00%)	2 (40.00%)
Piperacillin Tazobactam	69 (92.00%)	17 (94.44%)	5 (100%)	4 (100%)	5 (100%)

NU=Not Used

fluoroquinolone and aminoglycoside), 14% are resistant to meropenem and 2.7% isolates are resistant to colistin (Polymixin E).

Enterobacterieceae like *E. coli, Klebsiella, Enterobacter, Proteus* showed higher sensitivity to meropenem (100%), piperacillin- tazobactum (95-98%), amikacin (80-82%), gentamycin (76-80%) and high resistance to ampicillin, cephradin, chloramphenicol (Table 4).

Discussion

The complications related to neonatal blood stream infections and the rising resistances against commonly used antimicrobial agents are the compelling matters of the world now. The overall blood stream infection rate in this study was found to be 17.2% and anaerobic culture was not done. Patients admitted to ICUs have a higher risk of nosocomial BSIs than those admitted to other units. Neonates are more vulnerable to infection as they can acquire infection vertically from dealing.

The most frequently isolated pathogens among neonates were Coagulase negative *Staphylococci species* (52.7%, 165/313) and *Acinetobacter species* (24.0%, 75/313) in this study. Several authors demonstrated that Gram-positive pathogens are more common causes of hospital acquired blood stream infections among neonates than gram-negative pathogens and yeast[13-15]. Within the first week of life, neonates become rapidly colonized by environmental pathogen[16-17]. The risk of BSI is substantially increasing with CoNS & *Acinetobacter* infection with the use of central venous catheters (CVC), mechanical ventilation, and parenteral nutrition, and with exposure to other invasive skin or mucosa-breaching procedures[18-19]. Consequently, infants admitted to a hospital obtain most of their microorganisms from the hospital environment, their parents, and staff[20]. Transmission via the hands of hospital staff can lead to endemic strains circulating for extended periods[21]. Antibiotic resistance in skin-residing strains has been found to be low at birth but it increases rapidly during the first week of hospitalization. The spectrum and antibiotic resistance pattern of microorganisms isolated from neonates depends on the selective pressure as a result of perinatal antibiotic exposure[22]. CoNS & A*cinetobacter spp*. blood infection can occur in the babies without being under intensive care or antibiotics, mechanical ventilation or having indwelling catheters[23]. However, we have observed an increase of susceptibility against Cotrimoxazole (50%) than the studies of previous decades[24]. Hopefully, if this trend continues, cheaper first line antibiotics to treat neonatal blood stream infections might be

possible in near future.

Staphylococci spp., the major pathogen of neonatal BSI in this study, was ascertained with high resistance to ampicillin, cephradine, erythromycin. CoNS showed sensitivity to amikacin (78.0%), imepenem (86.0%), vancomycin (90.0%) and linezolid (100.0%). Almost half (47.0%) of the CoNS and one third (31.5%) *Staphylococcus aureus* are methicillin resistant. Almost 10.0% of the isolated *Staphylococcus species* are resistant to vancomycin. Similar findings were observed in some studies done in other developing countries[15,25].

We have found increase resistance of CoNS species towards Cephalosporin ranging from 46-67%. Previous studies have shown that the antimicrobial resistance patterns reflect the antibiotic use in that hospital unit and it is probable that the predominant use of Beta-lactams and aminoglycosides in our NICU have exerted a selective pressure on the commensal CoNS population[26]. Both vancomycin and linezolid are good treatment of choice against CoNS and *S. aureus* which are usually resistant to commonly used antibiotics. But emergence of vancomycine resistant *staphylococcus* (10.0%) is very much alarming news for clinicians.

Acinetobacter spp. is the second commonest pathogens in neonatal blood stream infection. We have observed higher sensitivity to colistin (98.0%), meropenem (97.0%), piperacillin- tazobactum (80.0%), and amikacin (77.8%).

In previous decades *Acinetobacter* remained as the most common isolate of Neonatal BSI in Bangladesh, but *Coagulase-negative staphylococci* (CoNS) are found to be the most commonly isolated pathogens in the neonatal intensive care unit (NICU) in some other countries[27]. They are the major pathogen involved in Late Onset Neonatal Sepsis (LONS), particularly in infants born at a lower gestational age.

Enterobacterieceae showed higher sensitivity to meropenem (80-100%), piperacillin- tazobactum (100.0%), amikacin (80.0% to 100.0%), and gentamycin (76.0%). So, carbapenems may be CoNSidered as a good choice of treatment for BSI caused by them (*E. coli, Enterobacter, Klebsiella, Proteus*) as it is showed the highest level of resistance against β-lactams, especially penicillins and third generation cephalosporins.

Instead of being a Salmonella endemic country, no *Salmonella Typhi* and *Salmonella paratyphi* was detected in the present study. This finding may suggest that *Salmonella Typhi* is not responsible for blood stream infection in neonates like childhood and adult patients. Further studies may require to establish the statement. Newborn babies are less likely to suffer from Salmonella because of least chance of horizontal and vertical transmission of the bacteria to neonate[28].

Limitation of the Study: Due to resource CoNStraints, we could not distinguish indoor and outdoor patient samples. So, we couldn't distinguish nosocomial from community-acquired BSI. We were also unable to obtain patient data on clinical symptoms or other risk factors for newborn BSI other than age and sex. Also, we were not able to perform any molecular tests on received samples due to lack of required resources and adequate fund.

Conclusion

Major bacterial pathogens involved with neonatal bloodstream infections (BSI) occurring in Dhaka city among different age groups of patients and their antibiotic susceptibility patterns are demonstrated in our study. In a nutshell our study reveals that CoNS are predominant pathogen for neonates. High resistance to ampicillin, cephradine, erythromycin, and high sensitivity to imipenem, vancomycin and linezolid have found among CoNS strains. Methicillin resistant and Vancomycin resistant strains of *Staphylococcus* and multidrug resistant Acinetobacter species are increasing than the previous decade. Clinicians and policy maker should pay special attention regarding this. We hope that, our findings will help healthcare professionals to provide better care for their patients & also help the researchers and policy makers to make appropriate antibiotic policy to face future challenges of infectious diseases.

Acknowledgements
None

Conflict of Interest
The authors declared no conflict of interest.

Financial Disclosure
This study was not funded.

Authors' contributions
Ritu Saha conceived and designed the study, analyzed the data, interpreted the results, and wrote up the draft manuscript.
Shamoli Saha, Hasiba Mahmuda contributed to the analysis of the data, interpretation of the results and critically reviewing the manuscript.
Afzalunnessa Binte Lutfor involved in the manuscript review and editing.
All authors read and approved the final manuscript.

Data Availability
Any inquiries regarding supporting data availability of this study should be directed to the corresponding author and are available from the corresponding author on reasonable request.

Ethics Approval and CoNSent to Participate
Ethical approval for the study was obtained from the Institutional Review Board. As this was a prospective study the written informed CoNSent was obtained from all study participants. All methods were performed in accordance with the relevant guidelines and regulations.

How to cite this article: Saha R, Saha S, Mahmuda H, Lutfor AB, Prevalence and Antibiotic Resistance Patterns of Neonatal Bloodstream Pathogens in Tertiary Care Hospitals: A Retrospective Analysis. Bangladesh J Med Microbiol, 2024;18(1):22-29

ORCID
Ritu Saha: https://orcid.org/0000-0003-3567-2942
Shamoli Saha: https://orcid.org/0009-0003-6188-6925
Hasiba Mahmuda: https://orcid.org/0009-0005-5209-0663
Afzalunnessa Binte Lutfor: https://orcid.org/0000-0002-0176-8746

Article Info
Received: 7 October 2023
Accepted: 2 December 2023
Published: 1 January 2024

References

1. Modi N, Doré CJ, Saraswatula A, Richards M, Bamford KB, Coello R, et al. A case definition for national and international neonatal bloodstream infection surveillance. Arch Dis Child Fetal Neonatal Ed. 2009;94(1):F8-12.
2. Johnson J, Robinson ML, Rajput UC, Valvi C, Kinikar A, Parikh TB, et al. High Burden of Bloodstream Infections Associated With Antimicrobial Resistance and Mortality in the Neonatal Intensive Care Unit in Pune, India. Clin Infect Dis. 2021;73(2):271–80.
3. Elster T, Beata Czeszyńska M, Sochaczewska D, Konefał H, Baryła-Pankiewicz E. [Analysis of risk factors for nosocomial infections in the Neonatal Intensive Care Unit of the Pomeranian Medical University in Szczecin in the years 2005-2008]. Ginekol Pol. 2009;80(8):609–14.
4. El-Jadba A, El-Yazji M. Neonatal Septicemia In Gaza City Hospitals. Pak J Med Sci. 2009;25(2):226–31.
5. Patel SJ, Saiman L. Antibiotic Resistance in Neonatal Intensive Care Unit Pathogens: Mechanisms, Clinical Impact, and Prevention Including Antibiotic Stewardship. Clinics in Perinatology. 2010;37(3):547–63.
6. van der Zwet WC, Kaiser AM, van Elburg RM, Berkhof J, Fetter WPF, Parlevliet GA, et al. Nosocomial infections in a Dutch neonatal intensive care unit: surveillance study with definitions for infection specifically adapted for neonates. Journal of Hospital Infection. 2005;61(4):300–11.
7. Couto RC, Carvalho EAA, Pedrosa TMG, Pedroso ÊR, Neto MC, Biscione FM. A 10-year prospective surveillance of nosocomial infections in neonatal intensive care units. American Journal of Infection Control. 2007;35(3):183–9.
8. Simmonds A, Munoz J, Aguero-Rosenfeld M, Carbonaro C, Montecalvo M, Clones B, et al. Outbreak of Acinetobacter infection in extremely low birth weight neonates. Pediatr Infect Dis J. 2009;28(3):210–4
9. Akter M, Jahan N, Islam M, Chowdhury F, Hoque S, Khanom S, et al. Multidrug Resistant Acinetobacter Spp. Blood Stream Infection in A Neonatal Intensive Care Unit of An Urban Specialized Hospital in Dhaka. J Dhaka Med Coll. 2015;24(1):47–52.
10. Jin L, Zhao C, Li H, Wang R, Wang Q, Wang H. Clinical Profile, Prognostic Factors, and Outcome Prediction in Hospitalized Patients With Bloodstream Infection: Results From a 10-Year Prospective Multicenter Study. Front Med (Lausanne). 2021;8:629671.
11. WHO. Basic laboratory procedures in clinical bacteriology, 2nd ed. World Health Organization. 2003;167.
12. Patel JB, Clinical and Laboratory Standards Institute, editors. Performance standards for antimicrobial disk susceptibility test ; approved standards. 12. ed. Wayne, PA: Committee for Clinical Laboratory Standards; 2015. 29–50 p. (Documents / Clinical and Laboratory Standards Institute).
13. Benjamin DK, Stoll BJ. Infection in late preterm infants. Clin Perinatol. 2006;33(4):871–82
14. Stoll BJ, Hansen N, Fanaroff AA, Wright LL, Carlo WA, Ehrenkranz RA, et al. Late-onset sepsis in very low birth weight neonates: the experience of the NICHD Neonatal Research Network. Pediatrics. 2002;110(2 Pt 1):285–91
15. Ballot DE, Nana T, Sriruttan C, Cooper PA. Bacterial bloodstream infections in neonates in a developing country. ISRN Pediatr. 2012;2012:508512.
16. Brady MT. Health care-associated infections in the neonatal intensive care unit. Am J Infect Control. 2005;33(5):268–75.
17. Goldmann DA. Bacterial colonization and infection in the neonate. The American Journal of Medicine. 1981;70(2):417–22.
18. Graham PL, Begg MD, Larson E, Della-Latta P, Allen A, Saiman L. Risk factors for late onset gram-negative sepsis in low birth weight infants hospitalized in the neonatal intensive care unit. Pediatr Infect Dis J. 2006;25(2):113–7.
19. Adams-Chapman I, Stoll BJ. Prevention of nosocomial infections in the neonatal intensive care unit. Curr Opin Pediatr. 2002;14(2):157–64.
20. Huebner J, Goldmann DA. Coagulase-negative staphylococci: role as pathogens. Annu Rev Med. 1999;50:223–36.
21. Patrick CH, John JF, Levkoff AH, Atkins LM. Relatedness of strains of methicillin-resistant coagulase-negative Staphylococcus colonizing hospital personnel and producing bacteremias in a neonatal intensive care unit. Pediatr Infect Dis J. 1992;11(11):935–40.
22. Hira V, Kornelisse RF, Sluijter M, Kamerbeek A, Goessens WHF, de Groot R, et al. Colonization dynamics of antibiotic-resistant coagulase-negative Staphylococci in neonates. J Clin Microbiol. 2013;51(2):595–7.
23. Kollef MH, Zilberberg MD, Shorr AF, Vo L, Schein J, Micek ST, et al. Epidemiology, microbiology and outcomes of healthcare-associated and community-acquired bacteremia: a multicenter cohort study. J Infect. 2011;62(2):130–5.
24. Ahmed D, Nahid MA, Sami AB, Halim F, Akter N, Sadique T, et al. Bacterial etiology of bloodstream infections and antimicrobial resistance in Dhaka, Bangladesh, 2005-2014. Antimicrob Resist Infect Control. 2017;6:2.
25. Burnie JP, Naderi-Nasab M, Loudon KW, Matthews RC. An epidemiological study of blood culture isolates of coagulase-negative staphylococci demonstrating hospital-acquired infection. J Clin Microbiol. 1997;35(7):1746–50.
26. Klingenberg C, Aarag E, Rønnestad A, Sollid JE, Abrahamsen TG, Kjeldsen G, et al. Coagulase-negative staphylococcal sepsis in neonates. Association between antibiotic resistance, biofilm formation and the host inflammatory response. Pediatr Infect Dis J.

2005;24(9):817–22.
27. Jean-Baptiste N, Benjamin DK, Cohen-Wolkowiez M, Fowler VG, Laughon M, Clark RH, et al. Coagulase-negative staphylococcal infections in the neonatal intensive care unit. Infect Control Hosp Epidemiol. 2011;32(7):679–86.
28. Reed RP, Klugman KP. Neonatal typhoid fever. Pediatr Infect Dis J. 1994;13(9):774–7.