

Original Research Article

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Prevalence of Gram negative bacteria causing neonatal septicemia in a tertiary care hospital of Dehradun, Uttarakhand, India

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A B S T R A C T

Neonatal sepsis is a clinical syndrome of bacteremia characterized by signs and symptoms of systemic involvement during first month of life. It is a common cause of morbidity and mortality in full term and preterm neonates. The microorganisms and their sensitivity pattern vary from region to region and time to time. The current study was conducted to know the pattern of Gram Negative bacterial organisms at a tertiary level hospital and their response to commonly used antibiotics. This descriptive study was conducted at Department of Microbiology, Sri Guru Ram Rai Institute of Medical and Health Sciences (SGRRIM&HS), Dehradun (Uttarakhand) from January 2014 to January 2015. Blood Samples were collected from neonates admitted in the Neonatal Intensive care unit (NICU) of Sri Mahant Indresh Hospital (SMI), Patel Nagar Dehradun. Blood was taken from 550 neonates admitted to Special Care Baby Unit fulfilling criteria for neonatal sepsis. The clinical and laboratory data was recorded. A total of 550 blood cultures were taken and culture positivity was seen in 102 cases (18.54%). *Klebsiella pneumoniae* was the most common organism found in 27(50%) cases, followed by *Escherichia coli* in 14 (25.93%). Maximum (100%) resistance was seen in *Klebsiella pneumoniae* for Amoxi-Clav (AMC), Cefotaxime (CTX), Ceftazidime (CAZ), Amikacin (AN). 100% resistance for Amoxi-Clav (AMC) was also seen in *E.coli* however for Ceftazidime the resistance was 92.85% Neonatal sepsis is a leading cause of neonatal admissions, morbidity and mortality in developing countries. Drug resistance is one of the emerging issues especially for routinely used antibiotics as found in our study.

Key words

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Bacterial isolates,
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Introduction

Despite advances in vaccines and pharmacologic agents, infection triggering sepsis that can progress to septic shock and ultimately death continues to be a major paediatric problem.

Neonatal septicemia is one of the commonest causes of Neonatal mortality and morbidity(1). Neonatal septicemia is a clinical syndrome of bacteraemia characterized by systemic signs and

symptoms of infection in first month of life. It encompasses systemic infections of newborn including meningitis, pneumonia, arthritis osteomyelitis and urinary tract infections of the newborn (2). The pathogens most often implicated in neonatal sepsis in developing countries differ from those seen in developed countries. Overall, Gram negative organisms are more common and are mainly represented by *Klebsiella*, *Escherichia coli*, *Pseudomonas*, and *Salmonella* (3,4,5).

In developed countries GBS (Group B *Streptococcus*) and *Escherichia coli* are generally identified as the dominant EOS (Early onset sepsis) pathogens and CONS the dominant LOS (Late onset sepsis) pathogen followed by GBS and *Staphylococcus aureus* (6,7). In developing countries *Escherichia coli*, GBS, *Enterobacter*, *Enterococcus*, and *Listeria* are mostly associated with EOS disease. In some cases, LOS disease has a higher case fatality rate, particularly when Gram negative bacteria are involved. *Pseudomonas spp*, *Salmonella*, and *Serratia* are more often associated with LOS disease (8). Gram-negative bacteria are the cause of approximately 19% of cases of nosocomial sepsis and of over 30% of pneumonias (9,10). These infections are severe and present high case fatality rates (40 to 90%) (11).

Nonmaternal strains of *Escherichia Coli* (other patients or environment) can cause invasive diseases(11). *Klebsiella* and *Enterobacter* present in the gastrointestinal tracts of the patient, from invasive procedures and catheters have also been involved in these infections (12,13). Several other gram-negative bacilli have also been associated with outbreaks of hospital infections at neonatal units, especially those associated with environmental

contamination, such as: *Pseudomonas aeruginosa*, *Serratia marcescens*, *Acinetobacter spp* and *Stenotrophomonas maltophilia* among others (14,15,16).

Early identification of the organism and prompt antibiotic treatment are essential to reduce the escalating rates of morbidity and mortality. Many underlying diseases and conditions should however be considered along with possible sources of infection, invasive procedures including central intravenous catheters, empiric therapy and defence systems of the host while calculating morbidity and mortality. Personal hygiene of the staff in Neonatal Intensive Care Units (NICU) and newborn babies, skin and umbilical stump care are very important in preventing neonatal infections which could go a long way in reducing neonatal septicemias (17).

The objective of this study was to analyse the prevalence of gram negative bacteremia and assess the antibiotic resistance patterns of the isolates in NICU.

Materials and Methods

The present cross sectional study was conducted in the Department of Microbiology, Sri Guru Ram Rai Institute of Medical and Health Sciences (SGRRIM&HS), Dehradun (Uttarakhand) from January 2014 to January 2015. Samples were collected from 550 neonates with clinically suspected septicemia admitted in the Neonatal Intensive care unit (NICU) of Sri Mahant Indresh Hospital (SMI), Patel Nagar Dehradun. Both term and preterm neonates admitted with clinical diagnosis and with clinical suspicion of neonatal septicemia were taken for the study. Inclusion criteria included all newborns with clinical suspicion of sepsis irrespective of inborn or out born, age, sex,

weight and gestational age and neonates presenting with signs and symptoms such as: fever, hypothermia, temperature instability, any respiratory distress/ apnoea, cyanosis/ pallor, jaundice, feed acceptance/ rejection, failure to gain weight, lethargy, vomiting, diarrhoea, hepatosplenomegaly, hypotension. For a sample showing the growth of organisms of low pathogenicity, a repeat sample was taken out and on isolation of the organism on repeat culture; it was included in this study.

The data collected by daily surveillance of patients' charts included age, sex, underlying conditions, predisposing factors, source of infection, therapy, complications, outcome, serum proteins and leucocytic count.

Amidst aseptic precautions 1 ml sample of venous blood was drawn in a blood culture bottle containing 5-10 ml of culture media. The blood, collected aseptically, was inoculated into ready to use BacT/ALERT PF Plus Culture Bottles (yellow colour coded) for paediatric use with all due precautions and shaken well. The bottles were labelled with patient information. The BacT Alert bottle with medium and blood was transported to the lab immediately.

The culture bottles were loaded into the instrument after scanning the bar code of the bottle and incubated. Positive or negative culture bottles were determined by BacT/ALERT Microbial Detection System. No action was taken until the BacT/ALERT instrument signalled a culture bottle either positive or negative. Blood cultures were considered negative only after 5 days of incubation.

In the present study used two automated systems for the early detection of organisms and their antibiotic sensitivity pattern: 1.

BacT/ Alert System 2. Vitek 2 Compact. The Vitek ID and AST cards were chosen according to the results of the Gram staining of the positive blood cultures. For Gram-negative bacteria, 145 µL of 0.5-McFarland bacterial suspensions, were pipetted into 0.45% sodium chloride. For identification of Gram-negative bacteria, the GN 341 cards (bioMérieux), were used and AST-280, AST-281 for AST according to the manufacturer's instructions. The Vitek-2 ID and AST cards were logged and loaded into the Vitek-2 Compact system. The MICs obtained were resolved into the 3 clinical categories (susceptible, intermediate, and resistant), according to the interpretative criteria provided by the automated systems' recommendations (CLSI, 2010). For Gram-negative rods, the following antibiotics were tested: ampicillin, amoxicillin/clavulanic acid, piperacillin, piperacillin/tazobactam, cefotaxime, ceftazidime, cefepime, imipenem, meropenem, levofloxacin, amikacin, gentamicin, colistin, and trimethoprim/ sulfamethoxazole (CLSI, 2010).

Results and Discussion

Out of a total of 550 neonates studied for clinically suspected septicemia 62.55% were males and Females constituted 37.45% of the total no. of cases. Statistically this finding was highly significant. Maximum percentage of neonatal septicemia cases were seen in the 0-5 day age group (75.63%) followed by 6-10 day age group (11.28%). Least no. of cases were seen in the 21-25 day age group (2.72%). Culture positivity was seen in 102 cases (18.54%) whereas culture negativity was seen in 448 (81.46%) cases. EOS was observed clinically in 236 (42.91%) neonates of which 45 (44.11%) were culture positive while 314 (57.09%) had a LOS and 57 (55.89%) were culture positive. No of mortalities were found to be

higher in EOS (13.14%) and lower in LOS (5.09%).

Out of 550 neonates, 278 (50.55%) had an extramural delivery while 272 (49.45%) had intramural deliveries. Of the extramural deliveries, 67 (65.68%) were found to be culture positive and of intramural deliveries 35 (34.31%) were found to be culture positive and P value was found to be highly significant. Maximum number of Culture positive neonatal septicemia cases were seen in females with normal vaginal delivery (57.81%) followed by females with LSCS (38.54%) and by other methods including instrumentation and vacuum assisted delivery (3.63%). Culture positivity was more in neonates born to mothers with Meconium Stained Liquor (MSL) (31.63%) and Premature rupture of membrane (PROM) (26.90%) followed by neonates put on mechanical ventilation (8.36%) and having Twin delivery(1.27%). For the parameters tested P value was found to be statistically highly significant for meconium stained liquor and mechanical ventilation.

Gram negative organisms (67.5%) were most predominant in causing neonatal septicemia than gram positive organisms (32.5%). Out of 54 gram negative bacteria isolated, *Klebsiella pneumoniae* (50%) was the most predominant gram negative isolate followed by *Escherichia coli* (25.93%) and *Acinetobacter baumannii* (9.26%). *Enterobacter species* were (5.56%), *Burkholderia cepacia* accounted for (3.70%) while *Pseudomonas aeruginosa*, *Citrobacter freundii* and *Morganella morganii* were found to be the least common, (1.85%) each.

Out of 22 fungal isolates Non *albicans Candida* (86.37%) were the most predominant followed by *Candida albicans* (13.63%) and out of total 26 gram positive isolates CONS (46.15%) were the most

dominant species causing neonatal septicemia followed by *Enterococcus species* (23.07%) and *Staphylococcus aureus* (19.23%), least being *Streptococcus species* (11.53%).

Maximum (100%) resistance was seen in *Klebsiella pneumoniae* for Amoxi-Clav (AMC), Cefotaxime (CTX), Ceftazidime (CAZ), Amikacin (AN). 100% resistance for Amoxi-Clav (AMC) was also seen in *E.coli*, however for Ceftazidime the resistance was 92.85% little lower than that in *Klebsiella pneumoniae*. In *Klebsiella pneumoniae* least resistance was seen for Meropenem (MEM) whereas in *E.Coli* the least resistance was seen for Ciprofloxacin 50%.

Neonatal sepsis remains the unconquered frontier of modern neonatal medicine today, despite advances in knowledge, technology and therapeutic armamentarium available. It is one of the commonest causes of Neonatal mortality and morbidity (1).The etiological agents implicated in the causation of neonatal septicemia vary from place to place or from one particular set up to the other and it continues to change with time and antibiotic implicated (18). The pathogens most often implicated in neonatal sepsis in developing countries differ from those seen in developed countries. Overall, Gram negative organisms are more common and are mainly represented by *Klebsiella*, *Escherichia coli*, *Pseudomonas*, and *Salmonella*.

Clinical diagnosis of sepsis in new born infants is not easy because symptoms and signs are nonspecific. Clinical presentation of neonatal sepsis varies and there are no pathognomonic features (19). Blood culture has been the gold standard for confirmation of diagnosis but the results of the test are available only after 48-72 hours. The neonates with risk factors for neonatal sepsis

are thus treated with broad-spectrum antibiotics and require prolonged hospitalization (20).

The current study shows that out of the total study group of neonates studied for clinically suspected septicemia, males were predominant and constituted 62.72 % of the total no. of cases whereas female neonates constituted 37.28% of the total no. of cases. This is in concurrence with study by Afroza S and Begum F who have also reported high incidence of septicemia in male neonates (62%) than female babies (21). The high incidence in males can be attributed to low levels of resistance in males as compared to female neonates due to presence of mutant immunoregulatory genes on the X chromosome in females (22,23).

Maximum percentage of neonatal septicemia cases were seen in the 0-5 day age group (75.63%) in our study. Similar findings have also been reported by Mhada V T *et al* in their study in which 76.7% of cases were in the 0 – 6 day age group (19). The infections in this age group have been attributed to micro-organisms which have passed from the mother to the neonate most commonly through her genital tract and play an important role in the development of infection in the neonate. In our case the culture positivity was seen in 18.54% cases whereas culture negativity was seen in 81.46% cases. Similar findings have also been reported in studies by Afroza S Begum F wherein culture positivity has been reported to be 20% (21). The low culture positivity can be attributed to factors like prior exposure to antibiotic exposure, sampling error, insufficient volume for blood cultures, poor transport conditions and slow growing or fastidious bacteria. Moreover some of the culture negative patients might have had non bacterial sepsis. Fungi, viruses and parasites can also contribute to a significant proportion of

culture negative sepsis.

In the current study EOS was observed clinically in 42.91% neonates of whom 44.11% were culture positive while 57.09% had a LOS of which 55.89% were culture positive which is in concurrence with a study by Kuruvilla KA *et al* who have also reported a lower rate of EOS (24%) than LOS (76%) (24). This can be attributed to the fact that the neonates admitted in hospital with symptoms of sepsis were more than 3 days old and as such LOS was more common. The contribution of nosocomial infections from the staff and environment cannot also be neglected as contaminating organisms like CONS were found in preponderance in neonates with LOS. Regarding the high culture positivity in LOS neonates (55.89%) than in EOS neonates (44.11%) similar results have also been reported in studies from African and Asian countries (25,26,27). This can be attributed to the similar reasons of the nosocomial infections seen in admitted neonates with symptoms of sepsis.

Total no of mortalities were found to be 8.54%. No significant difference has been observed in EOS and LOS mortality rates. Significant difference is observed in culture positive cases with mortality (30.39%) as compared to culture negative cases with mortality of 3.57%. Our findings are in concurrence with study from Bangladesh by Raha B K *et al* wherein the mortality rate has been reported to be 9.38% (28). This may be attributed to presence of adequate supportive facilities in this study hospital since this is a tertiary care hospital with well-equipped NICU facilities and other logistic support.

In the Present research work out of 550 neonates, 50.55% had an extramural delivery while 49.45% had intramural deliveries. Of extramural deliveries 65.68%

were found to be culture positive and of intramural deliveries 34.31% were found to be culture positive. P value was found to be highly significant. This is similar to the findings in the study by Y R Khinchi *et al* (59 %) (29).

The reason could be unsafe or unclean delivery practices used for home deliveries particularly in rural areas where superstitions and mythic beliefs tend to contribute to high levels of sepsis cases from these areas. Our study shows maximum no of neonatal septicemia cases in females with normal vaginal delivery (57.81%) followed by females with LSCS (38.54%). By other methods including instrumentation and vacuum assisted delivery the rate was (3.63%). This is in concurrence with studies by Kayange N *et al* and Sharifun Naher B where more septicemia cases have been seen in vaginal deliveries rather than by LSCS ; 75% in vaginal deliveries in former and 53.33% in the latter study(30) (31). Unclean PV before delivery, prolonged rupture of membranes for >24 hrs and prolonged labour for >24 hrs have been reported as the commonest predisposing factors in developing definitive septicemia.

Our study shows culture positivity to be more in neonates born to mothers with meconium stained liquor (31.63%) and Premature rupture of membrane (26.91%) followed by neonates put on mechanical ventilation (8.36%) and the least in neonates born to the mother with twin delivery (1.27%). Statistically this was found to be highly significant. Similar findings have also been reported in a study from Tanzania by Kayange M *et al* and studies by Chacko and Sohi, Vinodkumar *et al*; Giorgiana *et al*; wherein PROM and Meconium stained liquor have been reported as significant risk factors for neonatal sepsis(30,32,33,34). There is also recent evidence supporting that

when there is meconium in amniotic fluid there is a greater chance of the fetus being born with low Apgar score, which unfortunately has earlier been associated with neonatal sepsis(35,36).

Bacterial infection was found to be higher (78.43%) in neonates followed by fungal infection (21.57%). Similar results have been reported in the study by Kumhar G D *et al* and Desai J K *et al* where bacterial isolates constituted 96.42% and 97.3% respectively of the study group and fungal isolates constituted 3.57% and 2.43% respectively (37, 38).

This research study shows that gram negative organisms (67.5%) are most predominant in causing neonatal septicemia than gram positive organisms (32.5%). This finding is similar to the results of Shrestha P *et al* and Vinod Kumar C S *et al* where Gram negative bacterial isolates 65% and 55.5% respectively were more than Gram positive isolates 35% and 33.5% respectively (39,33).

In the pre-antibiotic era, though the Gram-positive cocci like *Streptococci pyogenes* and *Pneumococci* were predominant but with the introduction of antimicrobial agents, Gram-negative organisms like and *Klebsiella*, *E.coli*, *Pseudomonas* are now leading the race and are proving to be a menace to the ill, fragile and debilitated new-borns in the neonatal intensive care units. *Klebsiella pneumoniae* was found to be the most predominant gram negative isolate (50%) followed by *Escherichia coli* (25.93%) and *Acinetobacter baumannii* (9.26%), the least frequently isolated species were *Pseudomonas aeruginosa*, *Citrobacter freundii* and *Morganella morganii* (1.85%) each. This study findings correlate with the findings of Desai KJ *et al* and Kumhar GD *et al* where *Klebsiella*

pneumoniae accounted for 47.14% in both respectively (38,37). This may be explained because of the ubiquitous nature of *Klebsiellae* spp. In humans, they have been found to colonize the skin, pharynx, gastrointestinal tract even sterile wounds and urine. Factors such as endotracheal intubation, impaired host defenses, and antimicrobial use have also been found to contribute to oropharyngeal carriage in this group of neonates. However maternal factors such as chorioamnionitis, urogenital infection and urinary tract infection in mother can also lead to infection by these organisms before and or during delivery.

The prevalence of *E. coli* after *klebsiella pneumoniae* as have been found in our study could be explained by the fact that these organisms colonize and are a part of intestinal and vaginal flora and most of the home deliveries occur presumably under conditions of poor hygiene. Gram-negative organisms like *Klebsiella*, *Pseudomonas*, and *Acinetobacter* can cause common-source outbreaks because they can live in multi-use medication vials, soap, and inadequately processed equipment.

In the study Enterobacteriaceae (85.81%) constituted the major gram negative isolate from neonatal septicemia cases, which correlates with the findings of Roy I *et al* and Kayange N *et al* where Enterobacteriaceae accounted for 88.71% and 82.75% respectively (40,30).

The present research work shows a high resistance pattern in the gram negative isolates particularly for *Klebsiella pneumoniae* and *Escherichia coli*. 100% resistance for Amoxi-Clav (AMC), Cefotaxime (CTX), Ceftazidime (CAZ), Amikacin (AN) was seen in *Klebsiella pneumoniae*. 100% resistance for Amoxi-Clav (AMC) was also seen in *E.coli*

however for Ceftazidime the resistance was 92.85% little lower than that in *Klebsiella pneumoniae*. For *Klebsiella pneumoniae* the least resistance was seen for Meropenem (MEM) whereas in *E.Coli* the least resistance was seen for Ciprofloxacin 50%. Findings of this study are in accordance with the previous studies showing more than 70% of *K. pneumoniae* and *E. coli* resistant to various antibiotics in India and Pakistani hospital (41,42).

In concurrence with Mane AK *et al* the *Klebsiella pneumoniae* isolates in our study have been found to be maximally sensitive to Meropenem as the least resistance was found for Meropenem (51.85%) (43). Movahedian AH *et al* has also reported a high degree of resistance to commonly used antimicrobials as penicillins and Gentamicin for *K.pneumoniae*, similar to our findings (42).

Since *K.pneumoniae* and *E.coli* are the major pathogens causing neonatal septicemia, they are also the most multidrug resistant as has also been mentioned in the research work by Mane AK *et al* (43).

The spread of these MDR isolates has been linked to inappropriate infection control practices. Various other factors that are incriminated are contaminated intravenous catheters, feeding tube and various environmental surfaces, colonized hands of staff, substandard sterilization and disinfection practices in NICUs and PICUs. Since neonates have immature immune system the spread of these highly resistant organisms is quite rapid in them. To this the superimposition of irrational and injudicious use of empirical therapy has contributed to the up scaling of these MDR infections in neonates.

Table.1 Sex Wise Distribution (N=550)

| Sex | Culture Negative | Culture Positive | Total | p≤0.05 (significant) |
|--------|------------------|------------------|-------------|-------------------------|
| Male | 270(60.27%) | 74(72.55%) | 344(62.55%) | |
| Female | 178(39.73%) | 28(27.45%) | 206(37.45%) | |

Table.2 Age Wise Distribution (N=550)

| Age | No. of neonates | Percentage |
|-----------|-----------------|------------|
| 0-5 day | 416 | 75.63% |
| 6-10day | 62 | 11.28% |
| 11-15 day | 37 | 6.72% |
| 16-20 day | 20 | 3.64% |
| 21-25 day | 15 | 2.72% |

Table.3 Blood Culture Results (N=550)

| Culture report | No. of cases | Percentage |
|------------------|--------------|------------|
| Culture negative | 448 | 81.46% |
| Culture positive | 102 | 18.54% |

Table.4 Risk Factors among Culture Positive Samples (N=550)

| Risk factors | Present | Absent | p≤0.05 (significant) |
|------------------------|-------------|-------------|-------------------------|
| MSL | 174(31.63%) | 376(68.37%) | Yes |
| PROM | 148(26.91%) | 402(73.09%) | Yes |
| Mechanical ventilation | 46(8.36%) | 504(91.63%) | yes |
| Twin delivery | 7(1.27%) | 543(98.72%) | No |

Table.5 Distribution of Gram Negative Isolates: (N=54)

| Gram negative bacilli | Number | Percentage |
|--------------------------------|--------|------------|
| <i>Klebsiella pneumoniae</i> | 27 | 50% |
| <i>Escherichia coli</i> | 14 | 25.93% |
| <i>Burkholderia cepacia</i> | 2 | 3.70% |
| <i>Acinetobacter baumannii</i> | 5 | 9.26% |
| <i>Pseudomonas aeruginosa</i> | 1 | 1.85% |
| <i>Citrobacter freundii</i> | 1 | 1.85% |
| <i>Morganella morganii</i> | 1 | 1.85% |
| <i>Enterobacter species</i> | 3 | 5.56% |

Table.6 Resistance Pattern of Gram Negative Isolates (n=54)

| Antibiotics | <i>Klebsiella pneumonia</i> (N=27) 50% | (N=14) 25.93% | <i>Acinetobacter baumannii</i> (N=5) 9.25% | <i>Enterobacter spp.</i> (N=3) 5.55% | <i>Burkholderia cepacia</i> (N=2) 3.70% | <i>Citrobacter freundii</i> (N=1) 1.85% | <i>Pseudomonas aeruginosa</i> (N=1) 1.85% | <i>Morganella morganii</i> (N=1) 1.85% |
|--------------------|---|--------------------------|---|---|--|--|--|---|
| Amoxi-Clav (AMC) | 27 (100%) | 14(100%) | 4 (80%) | 2 (66.66%) | 1 (50%) | 1 (100%) | 0 | 0 |
| Pip-Taz (TPZ) | 25 (92.6%) | 10 (71.42%) | 4 (80%) | 1 (33.33%) | 2 (100%) | 1 (100%) | 1 (100%) | 1 (100%) |
| Cefotaxime (CTX) | 27 (100%) | 11 (78.57%) | 4 (80%) | 1 (33.33%) | 0 | 0 | 0 | 0 |
| Ceftazidime (CAZ) | 27 (100%) | 13 (92.85%) | 3(60%) | 0 | 0 | 0 | 0 | 0 |
| Meropenem(MEM) | 14 (51.85%) | 9 (64.28%) | 3 (60%) | 2 (66.66%) | 0 | 0 | 0 | 1 (100%) |
| Aztreonam (ATM) | 25 (92.6%) | 10 (71.42%) | 3(60%) | 1 (33.33%) | 1(50%) | 1 | 0 | 1 (100%) |
| Gentamicin (GN) | 21 (77.77%) | 8 (57.14%) | 4 (80%) | 2 (66.66%) | 2 (100%) | 1 | 0 | 0 |
| Amikacin (AN) | 27 (100%) | 9 (64.28%) | 3 (60%) | 2 (66.66%) | 1 (50%) | 0 | 1 | 1 (100%) |
| Trim-Sulfam (SXT) | 21(77.77%) | 8 (57.14%) | 3(60%) | 2 (66.66%) | 1 (50%) | 0 | 0 | 0 |
| Ciprofloxacin | 24(88.88%) | 7 (50%) | 4 (80%) | 2 (66.66%) | 2 (100%) | 0 | 1 (100%) | 0 |

In conclusion, a need to understand the etiology of both maternal infections and colonization and neonatal infections in low- and middle-income countries is highly required. Improving the detection of maternal infections during the intrapartum period using new technologies that are cheap, fast, and highly sensitive and specific may allow health care workers to reach at-risk newborns sooner. In the meantime, improving identification of clinical signs and risk factors for maternal infection will have more immediate benefits, particularly in resource-limited settings. Longitudinal surveillance to describe the varied pathogens causing neonatal sepsis as well as their changing antibiotic susceptibility profile is important. Possible strategies to be considered might include intrapartum antibiotic prophylaxis, the use of antiseptic solution to disinfect the birth canal, and implementation of simple infection control methods of proven efficacy such as hand washing and barrier nursing, promotion of clean deliveries, exclusive breast feeding, restriction of antibiotic use, and rationalization of admissions to and discharges from neonatal units. Last but not least since the emergence of resistant bacterial strains to commonly used antibiotics in low resource settings is a serious problem it is recommended that there be a rational use of first line antibiotics in the management of neonatal sepsis with periodic evaluation of the bacterial ecology and sensitivity to antibiotics.

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