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ORIGINAL ARTICLE

Evidence-based awareness generation improves infection control practices in Neonatal Intensive Care Units at secondary-level government hospitals in Central India

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ABSTRACT

Background: Healthcare-associated infections are preventable yet a significant cause of neonatal mortality. Neonatal Intensive Care Units (NICU) are established in resource poor settings in India to reduce the neonatal mortality rate. However, inadequate infection control practices (ICP) at these NICUs may defeat its purpose. A study was designed to conduct an environmental microbiological surveillance of the NICUs to identify the infectious microbes and to use the results as an evidence to generate awareness among the NICU team members to improve ICP.

Methods: Environmental swabs were collected in pairs (before and after cleaning) from the NICUs in three rounds of sampling and were subjected to culture.

Results: Of the 1,284 swabs collected, 29.7% showed positive bacterial or fungal growth. Among the positive cultures 37% had known pathogens. Commonest were *Pseudomonas spp.* and *Acinetobacter spp.* followed by enteric bacilli. 15% of the non-fermenting gram-negative bacilli and 43% of coliforms were Multi Drug Resistant (MDR). The reports with possible solutions were shared with the respective NICU and a significant reduction in bio-load between pre and post-cleaning swabs ($p<.001$) were noted. Significant reduction ($p<.001$) in bio-load was recorded in the swabs collected in rounds two and three.

Conclusion: Environmental Microbiological Surveillance of intensive healthcare setting and sharing of the reports with possible solutions specific to the recorded findings, found to be an effective tool in motivating the NICU team members for improved ICP.

KEYWORDS:
NICU; infection control practices; surveillance; awareness

INTRODUCTION

Special New-born Care Unit is a facility established in some states of India with relatively higher infant mortality rate. These units are equivalent to Neonatal Intensive Care Units (NICU, in their objectives and functioning. Therefore, they would be referred as NICU in this article. Regionalized neonatal/perinatal care with good network at various levels is emerging as an effective strategy to manage neonatal disease burden [1, 2].

Therefore, the State of Chhattisgarh (a state in Central India) has also established 16 functional NICUs, one each at 15 district hospitals (secondary-level healthcare facility), and one at a medical college, with support from UNICEF. However, the presence of Hospital Acquired Infections (HAI) and emergence of drug resistance microbes at these NICUs has challenged its gains and positive contributions. The presence of HAI is attributed to inadequate infection control practices (ICPs) whereas the unmonitored and lack of evidence-based use of antibiotics is causing the emergence of drug resistance microbes.

The efforts were thus made to identify the gaps in the knowledge and practices regarding standard ICPs. The requirement of training in standard ICPs and sub-optimum ICPs across all levels of team members was a major gap identified from the discussions with the NICU team members.

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Among many published studies reporting the importance and role of NICUs in India in facilitating quality neonatal care [3-5], none were found to have delved into the hospital associated infections and infection control practices. A study thus was planned with 13 NICUs that were fully functional by then. As a first step, the study focused on microbiological environmental surveillance of NICUs, to generate and demonstrate the existence of microbes in the NICU environment; and the need for initiation and maintenance of adequate ICPs. This article discusses the results of the Microbiological Environmental Surveillance and its impact on ICPs.

METHODS

The study was conducted from February 2017 through August 2017 at the Department of Microbiology of All India Institute of Medical Sciences (AIIMS), Raipur, a tertiary level healthcare center-cum teaching institute, located at Raipur, the capital city of the State of Chhattisgarh. The study was approved by the institutional ethics committee.

The study started in February 2017 with a workshop for two days, which was attended by the Pediatrician-in-charge and the Chief Staff Nurse from each of the 13 NICUs. The hands-on sessions for various infection control practices were organized on the first day of the workshop. Day two was dedicated to sample collection, its packing and transportation to the laboratory.

Microbiological environmental samples from 13 NICUs were collected from high touch areas and patient care items by swabbing. Commercially available sterile swabs (Himedia, Mumbai) were used for the purpose. The surfaces swabbed included nursing station, cradle bar/frame, phototherapy hood, warmer basinet, suction tube, suction jar, oxygen humidifier, oxygen concentrator, oxygen hood, ventilator tubing, C-PAP instrument, ambu-bag, nebulizer mask, infusion pump, intravenous stand, water tap handle, door handle, medicine trolley, procedure trolley, and computer keyboard.

Through the period of the study three rounds of sample collection were undertaken. In each round the samples from every NICU was collected once. The duration between two rounds of sample collection at any of the participating NICU varied between 20 to 25 days. In each round of sample collection, following were collected:

a) A pair of surface swabs from each site – one pre-cleaning and another after 30 minutes of cleaning procedure.
b) Samples of disinfectant being used at the time of sample collection.

The collected samples were then transported (as per standard protocol) to the Department of Microbiology of AIIMS, Raipur by specially trained team members [6].

The swabs were cultured on Blood agar and MacConkey agar, incubated at 37°C for 18-24 hours. The results were categorized as: no growth (NG), growth of contaminants (C) or growth of pathogenic bacteria (P).

The pathogenic bacteria were identified to the species level by standard laboratory protocol. For all identified pathogenic bacteria antibiotic sensitivity test (AST) was conducted as per CLSI guidelines [7, 8].

The antibiotic sensitivity pattern was recorded. The MDR organisms thus identified were stocked for future studies.

The disinfectant was tested by in-use test [9].

Statistical analysis

Statistical analysis was done by applying chi-square test using on-line statistics calculator “open epi”. The p-value less than 0.01 (1%) was considered as statistically significant [10].

RESULTS

Among the total 1,284 swabs cultured, 381 (29.7%) showed positive bacterial/fungal growth. Out of these 381, 141 (37%) grew pathogenic bacteria while 240 (67%) were contaminants (Non-pathogenic) or environmental saprophytes. Mixed growth was noted in 33 (8.6%) samples.

Among the 1,284 swabs, 655 were collected prior to cleaning while 629 were post-cleaning swabs (Table 1). Nearly 30% of the samples showed growth of microorganisms. This comprised 19% non-pathogenic bacteria/fungus and 11% pathogenic bacteria.

The number of pre-cleaning swabs showing no-growth (NG) were 52%, 59%, and 71% in the first, second and third round of sampling, respectively. The number of post-cleaning swabs showing no-growth was 78% in the first round of sampling, 81% in the second and 82% in the third round of sampling.

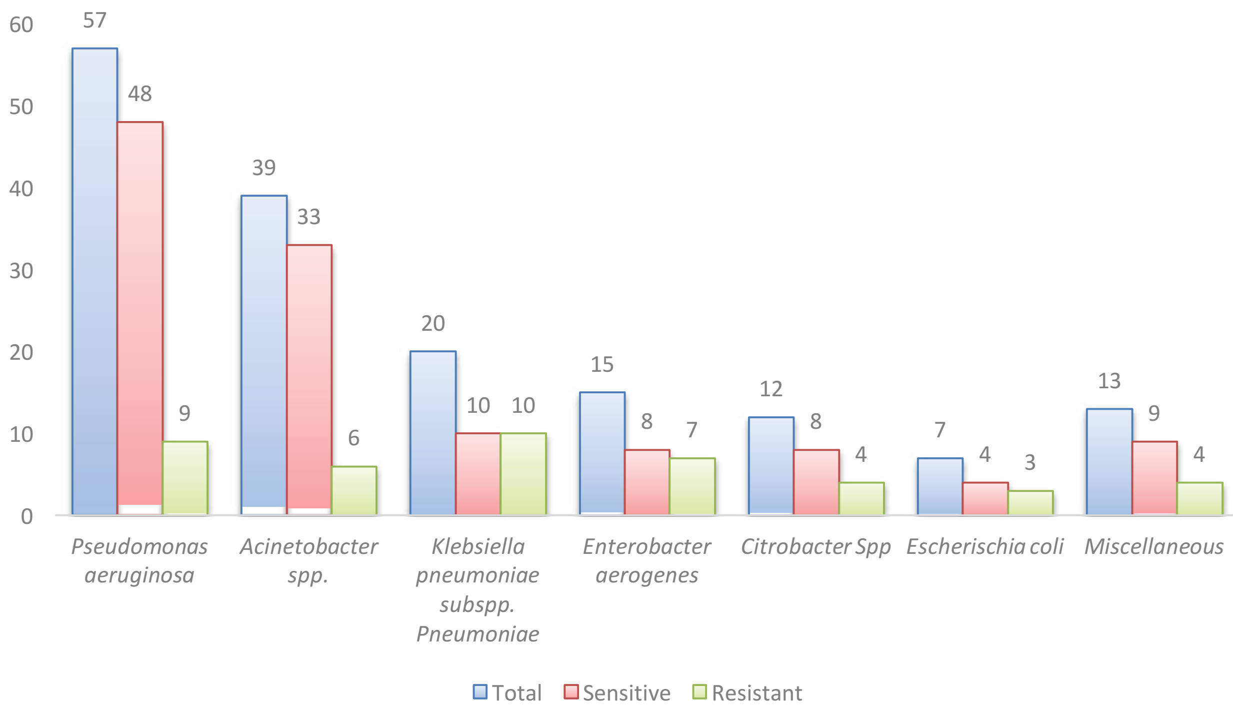
The number of pre-cleaning swabs showing growth decreased from 48% in the first round of sampling to 41% in the second and 29% in the third round of sampling. Growth in post-cleaning swabs decreased from 22% in the first round to 18% in the third round of sampling.

There was statistically significant difference in the results of the pre-cleaning swab cultures of the three rounds of sampling. There was, however, no significant difference in the results of the post-cleaning swab cultures in all three rounds of sampling (chi-square =1.141).

TABLE 1: Observation of surface swab cultures from NICUs of Central India

Swabs	Total	No growth		Pathogen		Contaminants	
		N	%	N	%	N	%
Pre-cleaning random swabs	655	396	60.4	95	14.5	164	25.2
Post-cleaning swabs	629	507	80.6	46	7.3	76	12.1
Total	**1284**	**903**	**70.3**	**141**	**10.9**	**240**	**18.7**

FIGURE 1: Spectrum of pathogenic bacteria and their antibiotic susceptibility pattern



A total of five swabs showed the growth of *Candida albicans*.

Majority of contaminants were Coagulase-negative Staphylococcus (CoNS).

The spectrum of microorganisms isolated were approximately similar for all NICUs.

The chi-square value of difference in NG samples between pre-cleaning and post-cleaning swabs was 30.98, 28.16, and 6.02 in the first, second and third rounds of sampling, respectively.

Among the patient care items, respiratory equipment including suction tube and suction jar, followed by oxygen concentrator showed maximum bioburden of both contaminants and pathogenic bacteria. The nursing station, medicine trolley, followed by procedure trolley and computer keyboard had the highest bioburden among the non-patient care high touch surfaces of the environment.

A predominance of gram negative bacilli was noted in the analysis of the spectrum of bacteria isolated from different sites. Among gram negative bacilli non-fermenters *Pseudomonas aeruginosa* and *Acinetobacter spp.* were the commonest, followed by the members of enterobacteriacae family. Among the family of enterobacteriacae, maximum were *Klebsiella pneumoniae subspp. pneumoniae,* followed by *Enterobacter aerogenes, Citrobacter spp*. and *Escherischia coli* (Fig. 1).

The analysis of antibacterial sensitivity pattern of the pathogenic bacteria revealed that 25.6% of the isolates were Multi-Drug Resistant (MDR), i.e., showing resistance to three or more than three classes of antimicrobial agents (Fig.1).

Further evaluation of the organism-wise antibiotic sensitivity pattern indicated that 15% of the non-fermenting gram negative bacteria were MDR, whereas 43% of the gram negative bacilli belonging to Enterobacteriacae family were MDR (Fig.1).

Of the disinfectants used at the NICUs, 87% were found to be acceptable, while 13% were unacceptable.

DISCUSSION

Neonates are vulnerable to various infections due to their weak immune system and this vulnerability depends on the maturity status of the neonate, birth weight, maternal health etc. The NICUs are therefore set up at district and block levels in resource poor settings of India, to provide specialized care to an increasing load of newborns due to a rise in institutional delivery and referrals under Integrated Management of Childhood Illness (IMNCI). Such regionalized neonatal care units with good network at various levels are emerging as an effective strategy to manage neonatal disease [1, 2]. Additionally, where advanced care units do not exist, the secondary level units can help lower NMR significantly [11, 12]. Towards mid-2016, 13 NICUs became functional in the state of Chhattisgarh.

It is thus important that the environment inside the NICU has minimum bioburden, which can be attained only by following standard infection control practices. Inadequate infection control practices make NICUs vulnerable to various hospital-acquired infections (HAIs).

During past years, several studies have been published to evaluate the impact of these NICUs. A study by Neogi et al. observed that aseptic practices critically determine the outcome of treatment a newborn received in the NICU [3].

In a review of 125 articles, Srivastava and Shetty emphasized the importance of raising awareness among the team members regarding infection control practices, especially in resource poor settings [13]. The NICUs in the present study are also located in resource poor settings with inadequate awareness regarding infection control practices among the team members and use of antibiotics as the only weapon to combat infections.

In the Indian context, the authors could not find any study that used laboratory-based evidence to indicate the presence of micro-organisms (bioburden) in the NICU and the impact of good ICPs in reducing it. The present study was planned according to the CDC recommended situations-research and quality assurance to evaluate the effect of infection control practices and commissioning newly established special care areas like NICUs [14, 15, 16, 17].

In the present study, about one third of the high touch surface swabs showed presence of either contaminants or pathogenic bacteria. A total of 11% of the swabs showed growth of pathogenic bacteria, among which 25.6% were MDR organisms. Isolation of such a high number of MDR bacteria was a cause of serious concern since they could be potential source of HAI to the neonates.

Among the pathogenic bacteria reported there was a preponderance of gram negative bacilli comprising non-fermenters like *Pseudomonas aeruginosa*, *Acinetobacter species* and members of enterobacteriaceae family, including *Klebsiella pneumoniae subspp. pneumoniae, Escherischia coli, Enterobacter spp.* and *Citrobacter spp.* etc. A review of 125 HAI related studies in India reported that gram positive cocci, viruses and fungi were predominant pathogens found from the advanced units, whereas gram-negative enteric rods, non-fermenting gram negative rods and fungi were commonly reported in patient samples collected from resource-limited settings [13]. These findings can be related to the presented study since these NICUs are also located in resource poor settings and showed predominance of non-fermenting gram-negative rods and enteric bacilli in the environment, which may be a potential source of HAIs among the neonates.

Another study by Pawa et al. from North India observed MDR *Klebsiella spp*. (68%) as the commonest pathogen (causing nosocomial septicemia and pneumonia), followed by *Pseudomonas aeruginosa* (13%) [18].

In a study from South India by Kamath et al., Extended Spectrum Beta Lactamase (ESBL) producing *Klebsiella spp.* was observed as the commonest nosocomial pathogen, followed by Methicillin Resistant *Staphylococcus aureus* (MRSA) [19].

Coagulase Negative Staphylococcus (CoNS) constituted the majority of contaminants. These bacteria can also act as a pathogen in neonates. Earlier studies established that 8-24% of CoNS isolated from blood were true pathogen. There is also a substantial body of evidence to demonstrate increasing antibiotic resistance by CoNS among neonates [20, 21, 22]. Thus isolation of large number of CoNS from the NICU environment reported in the present study is highly significant as it can be a potential pathogen, and secondly its widespread presence in the environment indicates suboptimum ICPs, especially poor hand hygiene among the team members.

The reported study observed that the growth of microorganisms decreased in the samples collected in the second and third round. During the first round of sampling, 48% of the swabs collected prior to cleaning showed bacterial growth. It reduced to 40% in the second round of sampling, and to 28% in the third round. The observed reduction in bacterial growth in the second and third rounds was statistically significant ($\chi^2 = 16.55$; $p < .001$).

The authors of the study prepared customized instructions as per the WHO and CDC guidelines to improve infection control practices for each NICU separately, which dealt specifically with the deficit/s found in each NICU's surveillance report. These customized instructions were not only based on the laboratory test results, but also on the resources that the NICUs had: e.g., which disinfectant or decontaminant was available, availability of PPE (Personal protective equipment), availability and skill of human resources and the work-load in each NICU. The team members at every NICU followed the ICP related specific instructions shared with them, which helped significantly in reducing the bioburden, thereby reducing the probability of HAIs in the respective units.

Significant reduction in the bioburden was also recorded in the post cleaning swabs as compared to swabs collected prior to cleaning. This was a consistent phenomenon across three rounds of sample collection. In the first and second rounds of sampling the difference between the pre and post-cleaning swab cultures were statistically significant with χ^2 values of 30.98 and 28.16 respectively. In the third round of sampling the difference in bioburden between pre and post-cleaning swabs reduced substantially. It indicates that the efforts of the NICU team members improved towards maintaining cleanliness consistently as per standard ICP protocol, resulting in reduced difference in bioburden in pre and post-cleaning swabs.

The equipment showing highest bioburden included suction tubing and suction jar followed by phototherapy hood, warmer basinet, other respiratory care items such as oxygen concentrator, oxygen humidifier, C-pap and oxygen hood, etc. Considering it as a potential source of infection to the neonates admitted in the unit, authors provided specific cleaning instructions to the NICU team members. By the third round of sampling, significant reduction in bioburden was also reported in the swabs collected from the surfaces of the NICU equipment. Among the non-patient items, highest bioburden was observed from nursing station and medicine trolley. Approximately 72% of swabs collected in the third round did not show any bacterial growth. It indicates improvement and consistency in the infection control practices followed for cleaning of equipment and non-patient care items in line with the specific suggestions made by the authors.

An earlier study by Gupta et al. has found that in the NICU, baby placements, resuscitation equipment, and cleansing solutions are significantly associated with HAI [23]. It is similar to the findings of the present study, which has also observed heavy contamination of respiratory care equipment with various microbes including MDR bacteria.

With regard to the presence of microbes reported in samples from inanimate environment and fomites, it is of importance to refer to a study by Brito et al., which concluded that lower sink: cot ratio (poor hand washing facility) and higher monthly admission rate resulted in higher rates of HAI [24].

The aim of the present study is to conduct an environmental microbiological surveillance of the NICUs to identify the infectious microbes and their niches and to use the results as evidence to generate awareness among the NICU team members to improve infection control practices, which was successfully attained.

Limitations of the study

The authors of the study depended on NICU team members for sample collection and its packing, while transportation from the NICUs to the microbiology laboratory at AIIMS Raipur was supported by a logistical partner.

CONCLUSION

Environmental Microbiological Surveillance of a new intensive healthcare setting would be an effective tool in motivating the team members for better infection control practices, thereby helping in reducing HAI and thus morbidity and mortality among neonates admitted in such units. The Environmental Microbiological Surveillance is also helpful in identifying the MDR microorganisms present in the healthcare environment and prevent its spread to the vulnerable neonates, well in time.

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