

# BMJ Open Quality Institution of an antibiotic stewardship programme for rationalising antibiotic usage: a quality improvement project in the NICU of a public teaching hospital in rural central India

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## ABSTRACT

Antibiotic misuse is the most common cause of antimicrobial resistance—a globally declared emergency. This necessitates the introduction of rational antibiotic usage management policy. The paediatrics department of a public teaching hospital with around 500 neonatal intensive care unit (NICU) admissions annually revealed 75% of NICU admission exposure to any antibiotics. The aim was to institute antibiotic stewardship programme (ASP) to optimise antibiotic usage from existing 75% to 40% in a 6-month period through a quality improvement (QI) project. A root cause analysis using fishbone diagram was performed to identify the possible reasons for the high antibiotic usage. Six Plan-Do-Study-Act cycles were conducted to implement the protocols for usage of antibiotics for well-defined indications; active laboratory engagement to decrease the turnaround time for blood culture results; a hard stop to all antibiotic orders after 72 hours; streamlining of antibiotic usage; strengthening universal aseptic practices; and confidence building of staff. The outcomes monitored were antibiotic exposure rates, average number of antibiotic days in all NICU admissions, sepsis rates and mortality. Institution of ASP had significantly reduced antibiotic exposure in NICU admissions, that is, from 75% in March to 41% in August 2018. Median (IQR) antibiotic days per infant in NICU went down from 3 to 0 (0–6). The per cent of NICU admission with culture-positive sepsis and all-cause mortality rate in NICU declined from 18% to 11.56% and 25% to 16%, respectively, over these 6 months. Thus, ASP for rationalising antibiotic usage was successfully instituted in NICU of a rural medical college in central India through QI, without any adverse effect on sepsis and mortality.

## INTRODUCTION

### Problem description

For sepsis, being a common cause of mortality among sick neonates, antimicrobial prescriptions are possibly the most frequent decision made in any intensive care unit. Non-adherence to the strict protocol dangerously increases antimicrobial resistance.

The neonatal intensive care unit (NICU) of Mahatma Gandhi Institute of Medical Sciences, a rural public teaching hospital in central India, reports 500 admissions annually. We were not different in practising the empirical antibiotic treatment. It was considered as a safe practice by our consultants and residents. Antibiotics which started in babies at the time of admission were continued until culture reported no bacterial growth. Antibiotic usage in sick babies was high, as escalation was based mainly on clinical deterioration without actively considering culture reports. More turnaround time of blood culture report had again strengthened these practices. In March 2018, the visiting neonatologist expressed his concern over not having antibiotic policies or standard operating procedures for NICU. He emphasised on the growing antimicrobial resistance due to antibiotic overuse and need for implementing antibiotic stewardship. The point prevalence of antibiotic usage at our set-up was found out to be 75%, which was quite high. In the departmental meeting, we decided to undertake measures to optimise the antibiotic usage and implement antibiotic stewardship. Quality improvement (QI) method was accepted as a suitable tool to implement our project, as the department had been recently trained in four-step Point of Care Quality Improvement (POCQI) by Nationwide Quality of Care Network (NQOCN). The four-step POCQI package developed by NQOCN and WHO South East Asia Regional Office included a facilitator manual<sup>1</sup> and a learner manual<sup>2</sup> which were used for training. They mentored many QI projects undertaken in the department to improve service delivery.

The NICU of this hospital has 23 beds with approximately 40–50 admissions per month. Four resident doctors are posted in NICU for 9 months during their residency, two in each unit, who do alternate day emergency duty. A total of 19 nurses are posted in NICU and they work in three shifts in a day. The nurse to baby ratio is approximately 1:4 (morning shift), 1:6 (afternoon shift) and 1:8 (night shift).

## BACKGROUND

The Centers for Disease Control and Prevention, the Infectious Diseases Society of America, the World Economic Forum and the WHO have declared antibiotic resistance to be a 'global public health concern'.<sup>3</sup> India carries one of the largest burdens of drug-resistant pathogens worldwide, and alarmingly high resistance among Gram-negative and Gram-positive bacteria.<sup>4,5</sup> One recent surveillance study reported high use of antibiotics in India with 40% of patients in the community on antibiotics.<sup>6</sup> Similarly, higher use of antibiotics, which is about 70%–80%, was reported in babies admitted to NICU in India.<sup>7,8</sup>

An antibiotic stewardship programme (ASP) is defined as 'ongoing efforts by a health care organization to optimize antimicrobial use among hospitalized patients in order to improve patient outcomes, ensure cost-effective therapy, and reduce adverse sequelae of antimicrobial use (including antimicrobial resistance)'.<sup>9</sup> The team involved in antibiotic stewardship is multidisciplinary and consists of an infectious disease physician, clinical pharmacologist/pharmacist, clinical microbiologist, infection control nurse and hospital administrator. ASPs implemented alongside infection prevention and control are more successful than when implemented alone which result in lower incidence of healthcare-related infections and thus lower antibiotic prescription rates.<sup>9</sup> These programmes have been shown to have both clinical and economic impact in hospitals.<sup>10</sup>

A NICU provides a high-quality skilled care to premature, low birthweight or critically ill newborns which involves the use of a multiplicity of medications among them. Antimicrobial agents are the most frequently prescribed.<sup>11</sup> Broad-spectrum antibiotic exposure has been associated with the emergence of multidrug-resistant Gram-negative bacilli and invasive candidiasis. Neonates are especially vulnerable to multidrug resistance, since they receive broad-spectrum antimicrobials much more frequently than older children due to early upgradation of antimicrobials to prevent morbidity and mortality.<sup>12</sup>

In addition, it necessitates blood sampling for therapeutic monitoring.<sup>13</sup> When cultures reveal growth for coagulase-negative staphylococcal species, distinguishing between infection and colonisation or contamination may be difficult. Thus, NICU clinicians often treat neonates with negative cultures for 'presumed late-onset sepsis' overlooking its adverse effects.<sup>13</sup> Treatment guidelines are often not established for neonates, particularly for preterm neonates. In order to avoid drug resistance,

adverse drug reactions and drug–drug interactions, neonates require more attention while prescribing antibiotics.<sup>14</sup> Hence, detailed rational knowledge of antibiotic-prescribing pattern must be implemented in clinical practice.

The specific aim was to optimise usage of antibiotics in neonates admitted to NICU from existing 75% to 40% in a 6-month period by the department of paediatrics through a QI project.

## Measurement

A baseline evaluation was carried out in NICU for a week to study the indications of admission, reasons for starting antibiotics and for obtaining data on number of antibiotic days per baby. The calculated point prevalence of antibiotic usage, that is, the number of babies receiving antibiotics in NICU at that point to the total number of babies admitted to NICU at that point, was found to be 75%. The process indicator was the point prevalence of antibiotic usage in NICU babies. The outcome indicators were median antibiotic duration per baby in days and all-cause mortality rate.

## Design

The study was designed to optimise the antibiotic usage in neonates through antibiotic stewardship by using QI methodology.

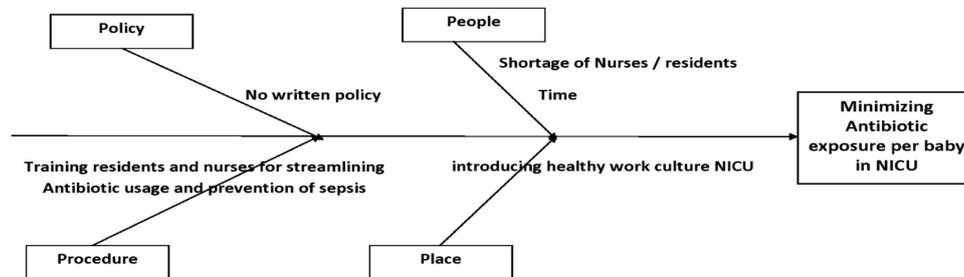
A small team of healthcare providers was identified (quality team). Broadly, the study was carried out in the following steps: (A) forming a team of consultants and nurses posted in NICU and data entry recorder, (B) measuring baseline rates of antibiotic usage, (C) analysing possible reasons for increased usage of antibiotics through root cause analysis, (D) conducting a series of Plan-Do-Study-Act (PDSA) cycles to test the change ideas generated by the team on a small scale initially and then expanding to a larger scale. Run charts were used to display and interpret the serial measurement of indicators and to study the impact of changes. Root cause analysis was performed using a fishbone diagram (figure 1). The various problems identified were:

- ▶ Absence of standard protocol for antibiotic usage.
- ▶ Not practising universal aseptic precautions duly.
- ▶ More turnaround time for culture validation.
- ▶ No streamlining of antibiotics as per culture reports.
- ▶ Shortage of manpower.
- ▶ Lack of confidence in doctors and nursing staff in managing babies without antibiotic.

## Strategy

After analysing the challenges with the help of fishbone diagram, the QI team planned PDSA cycles to implement different changes. With this premise, we planned a QI process involving a series of PDSA cycles to introduce antibiotic stewardship. Under the guidance of NQOCCN we formed improvement team comprising two paediatricians, two senior residents and two senior nursing staff.

The PDSA cycles undertaken were as follows.



**Figure 1** Fishbone diagram. NICU, neonatal intensive care unit.

### PDSA I: department policy plan for starting antibiotics

The team had formulated a policy plan for rational antibiotic usage under the guidance of the visiting neonatologist after reviewing the established protocols of the Indian Academy of Pediatrics and the Indian Council of Medical Research. Broad-spectrum antibiotics like ampicillin, or cefotaxime and gentamicin were standardised for empirical antimicrobial treatment for all admissions. Criteria for starting antibiotic, dose, dosing interval and duration were clearly mentioned. Vancomycin and amikacin were standardised as second-line antimicrobial regime for sick babies. Preauthorisation was made mandatory for residents before starting antibiotics in order to stop the empirical antibiotic treatment policy. The team circulated this policy to all residents and consultants managing NICU. Data were maintained on the antibiotics prescribed per NICU baby, indications for prescription, total duration of antibiotic per infant and blood culture report with growth and antibiotic sensitivity by the data operator on a daily basis. Every Sunday, the point prevalence of antibiotic usage was calculated by residents and presented on Monday departmental meet to have a check on implementation of policy.

The average antibiotic exposure started declining from 75% to 73.91% in a period of 1 month. The team analysed the data retrospectively and found that the culture-positive sepsis rate was 18% in that month. On interviewing the residents, the team found that antibiotic usage did not decrease much in that month as many babies got cross-infected because NICU was fully occupied.

### PDSA II: adaptation of universal aseptic precautionary measures

To tackle the problem of cross-infection, the team questioned the residents and nursing staff about the aseptic measures followed. The team noticed that aseptic measures were not duly followed by the staff. For strict adoption of universal aseptic precautionary measures like frequent sanitisation, minimum handling and use of nursing barriers, the team consulted the infection control committee of microbiology department. The infection control nurse was appointed for NICU on the request of the head of department. Her job was to conduct hand washing drills, collecting swabs from the hands of working staff and equipment and keeping an eye on fulfilment of aseptic measures during any procedure. She conducted hand washing drills every morning, after which she randomly asked anyone to demonstrate

in front of all NICU staff. A hand washing steps manual was also pasted above every washing area for memorisation. All NICU staff started following aseptic measures judiciously due to the fear of swab report being positive. Handholding was done and if there was any breach by any of the staff she was reminded by others. Hand washing was also taught to mothers visiting the babies in NICU. The team was contented with the performance and self-discipline shown by all working units. Though the infection control nurse was available in morning hours, this was continued in other shifts too. In the month of April, the total number of admissions in NICU was less, so the average antibiotic exposure rate declined to 33%. The percentage of culture-positive sepsis fell to 13% and median of antibiotic duration per baby was 1 day.

### PDSA III: discontinuation of antibiotics at 72 hours

The point prevalence of antibiotic exposure was 66% with increase in admissions in the month of May. Our prime goal was to decrease the duration of antibiotic exposure per baby in NICU. The baseline median of total antibiotic days per baby in our setting was calculated to be 3 days (0–6). It was observed that the first-line antibiotics were continued until the culture report validation. The team discussed the issue with the residents and found that the turnaround time for culture report validation was more than 72 hours and residents were not getting reports in the stipulated time. An email communication was sent to the head of microbiology department for the delay in validation of reports. They expressed their difficulty in validation of reports in time due to lack of manpower and inability to handle huge sample load. They agreed to prioritise the handling of culture samples sent from the NICU. The team decided to follow a strict hard stop to all antibiotics beyond 72 hours and tracing of culture report telephonically by 72 hours if not validated by then. Feasibility of these measures was studied by running a PDSA for a month. The team interviewed the residents after a month and found that residents were facing difficulty in stopping antibiotics and following the reports promptly at 72 hours in busy days. Residents also expressed their dilemma in stopping antibiotics at 72 hours in sick babies with culture reporting no growth. At the end of May, average antibiotic exposure rate declined to 60% with 2.5 median antibiotic days per baby. The all-cause mortality also declined to 21 from 25 deaths per 1000 live births of March 2018.

As both these issues needed equal attention, urgent meeting was called, where the team decided to conduct two PDSA cycles simultaneously.

#### PDSA IV: streamlining/de-escalation of antibiotics

As neonates deteriorate rapidly, escalation to second-line antimicrobials at clinically justified time in sick babies with cultures reporting no growth was justified, once on admission culture samples had been sent. The second team observed that consultants were advising to continue the same antibiotics in culture-positive sick babies showing improvement. As de-escalation of antibiotics based on culture sensitivity report had a role in preventing resistance, a meet was conducted with all the consultants to reach a consensus for de-escalation. Some expressed their hesitancy in de-escalation in babies with improvement. The team sought help from the hospital infection control committee. The faculties from microbiology department conducted a contact session of 1 hour. Discussion centred on data on antibiotic usage, duration, escalation and de-escalation of antibiotics. The team interviewed the posted resident doctors and consultants after this session. The consultant stated that this task had helped them in understanding what antibiotic stewardship means, residents quoted that their job now got easy, as they now knew how to streamline antibiotic therapy.

#### PDSA V: dissemination of responsibilities

As residents were failing in stopping antibiotics promptly at 72 hours due to lack of manpower, the team decided to hand over this responsibility to the nursing staff. A meeting of nursing staff with the head of department was arranged and responsibility was entrusted on them. It was planned that, every morning, while entering orders in their general order book, they had to remind residents and discontinue the drug in their order book after 72 hours. All the nursing staff were sensitised by the NICU in charge by regularly checking their order book and reminding them continuously, until it became a habit for them. It was observed that the nursing staff was also running short of manpower as some nurses had left the job. In the following meeting, the team members interviewed the staff about the feasibility in the present scenario; the senior nursing staff reported that the junior nurses were hesitant in communicating the same as residents forgot to pay attention to their reminders. To overcome this issue, the team decided to work on improving the work culture of NICU. After PDSA IV and V cycles, the antibiotic exposure rate and median antibiotic days per baby reported a dramatic downfall to 42% and 2 days, respectively.

#### PDSA VI: confidence building of nursing staff and residents

The team conducted two 45 min sessions to involve all the working staff on the first Saturday of August. The session began with team building activities (blind drawing, human knot) to initiate healthy communication. Later, the team sensitised the attendee about the importance

of teamwork, communication and coordination for the success of this QI project. The team members tried to emphasise the individual role in preventing sepsis in NICU. The team decided to conduct a meeting fortnightly with the NICU working staff (residents and nursing staff) to discuss their issues. These sessions were found to be beneficial in introducing healthy work culture to some extent so we continued the exercise. At the end of the sixth PDSA, our antibiotic exposure rate had fallen to 36% with zero median antibiotic days per baby. A rise in average antibiotic exposure rate of 47% was noted in the month end due to change in the posting of residents. The new recruits were trained by the senior resident doctors who helped in reverting back to original trend easily. The all-cause mortality rate was 16 per 1000 live births at the end of the month.

Weekly audits were performed by senior resident doctors and reported back to the team to ensure that all the interventions were being implemented.

#### Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

#### RESULT

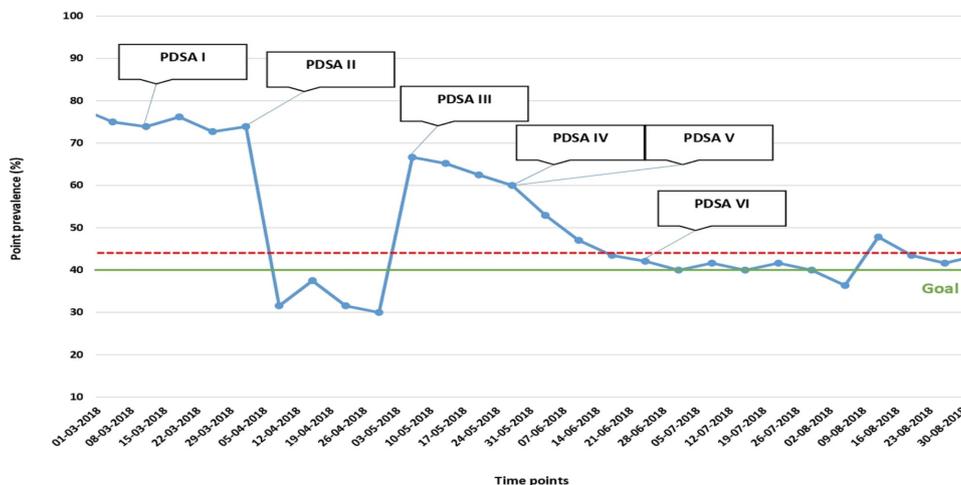
In the baseline survey, our average antibiotic exposure rate was 75% as shown in [figure 2](#). After six PDSA cycles, the rate declined to 40%. The result was sustained even after the last PDSA cycle, without additional interventions. The median antibiotic days per baby also showed a decline from 3 to 0 days. The all-cause mortality in inborn babies declined from 25 to 16 per 1000 live births.

[Figure 2](#) shows the run chart of average antibiotic exposure rate with PDSA plotted along the time line. The red line represents the median over the entire QI period. As the PDSA cycles were introduced, there was a declining trend in average exposure rate. A small deviation is noted in the middle of August due to change in postings of residents.

[Figure 3A](#) shows the run chart of median antibiotic duration in days per baby plotted along the time axis. The red line represents the median along the entire QI period. The median antibiotic days per baby also depicted a decreasing trend from 3 to 0 days.

[Figure 3B](#) shows the run chart of outcome measure, that is, all-cause mortality among all births plotted against the 6-month period. This showed a decline of 16 per 1000 live births over the 6-month period.

The assessment for sustainability for 2 years revealed that the average antibiotic exposure rate declined up to 20%. To ensure the smooth running of antibiotic stewardship, all the new recruits are primed with induction meeting on the work culture of NICU.



**Figure 2** Run chart on average antibiotic exposure rate (point prevalence). PDSA, Plan-Do-Study-Act.

## DISCUSSION

QI methods are being increasingly deployed in healthcare to support the delivery of high-quality patient care and improved patient outcomes. PDSA provides a structured experimental learning approach to testing changes.<sup>15</sup> In this QI initiative, we involved representatives of all stakeholders and front-line staff right from the beginning and used scientific methods to first diagnose the root causes of the problem in the local context. We engaged the front-line staff to bring out the possible solutions from within themselves and tested them objectively on a small scale as a team, to learn about the challenges of implementation. This helped us to adapt our approach to make it more acceptable and practically doable. We believed that this helped us to achieve sustained improvement.

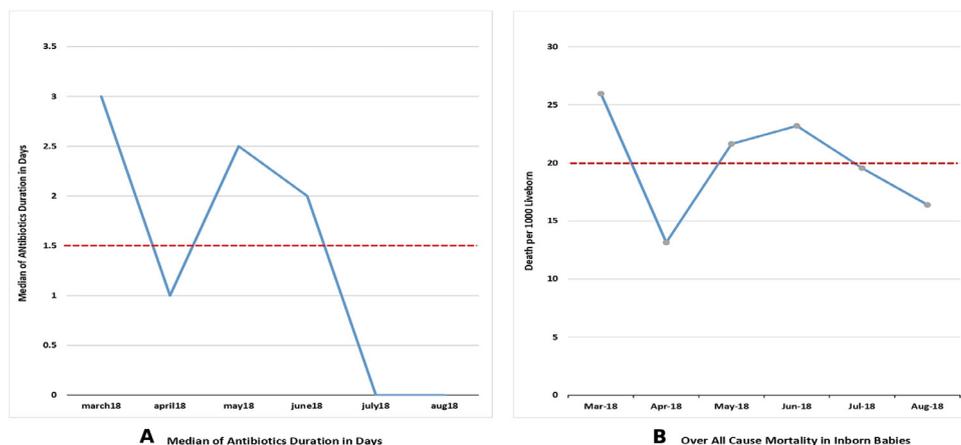
Literature on the subject similar to our settings is scarce. In a QI study, Makri *et al* reported a reduction in antibiotic usage rate of 43% (from 347 to 198 per 1000 patient-days) which is similar to our study.<sup>16</sup>

This QI project taught us a lot. The very first lesson that we learnt was making changes in healthcare setting requires patience, time and continuous enforcement of changes. It is difficult to implement interventions that require cultural change and workspace dynamics.

Introduction of antibiotic stewardship in NICU was a big challenge for all of us. Second, we learnt that 80% of problems need simple solutions like in our case adaptation of universal aseptic precautions, improving the communication and boosting the confidence of stakeholders. Third, QI taught us to introduce small steps at appropriate time, rather than targeting on a big goal. Fourth, it taught us how continuous collection of data can be used to bring improvement in our indicators of interest. Instead of studying the monthly data, we emphasised on presenting data in weekly meets, so that we can discuss our shortcomings and take measures at appropriate time. Appreciation of all those involved in the project directly or indirectly gave them a feeling of ownership which played a crucial role in smoothening our journey of success.

## Limitations

One of the limitations of our study was keeping a track on adoption of aseptic precautions in all shifts. It became a part of self-discipline. However, by continuing the morning drills and training of the new entries, we tried to inculcate these practices as rituals. Second, a hard stop to all antibiotics at 72 hours was difficult to sustain; frequent monitoring and reminder was the only key. Lastly,



**Figure 3** Run charts on outcome. (A) Median of antibiotic duration in days. (B) All-cause mortality in inborn babies.



sustaining gains has been a significant challenge especially due to routine manpower attritions and busy workload seasons. As new recruits learnt to adapt to the needs of the new environment, compliance with its correct and complete utility plunges. While local leadership proves instrumental at these times as a dedicated and reliable guiding presence, regular trainings and interactive feedbacks are also required to engage the team, which poses demands on the system. We continue to seek fresh inputs and feedbacks from new members to seek ways to address these limitations.

## CONCLUSIONS

The present study suggests that QI principles are feasible. It is a single-centre QI initiative performed with the involvement of existing caregivers and executed without any external funding in the form of manpower or financial assistance, which suggests the importance of simple and feasible QI principles using team approach. We describe a successful QI effort to reduce antibiotic exposure in NICU babies. This similar model can be replicated in health facilities across the country. To sustain a positive result for a longer time is a challenge, so extending the same practice to postnatal unit will be our next task. The greatest impact was improvement in morbidity and mortality.

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