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Assessment of Caesarean Section and Healthcare Staff Behavior as Determinants of Neonatal Infections: A Mixed-Methods Study in a Neonatal Unit, Brother Rahmani Hospital, Algeria

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Summary

Background: Neonatal infections are a leading cause of morbidity and mortality in neonatal intensive care units (NICUs), particularly in low- and middle-income countries. Caesarean section (C-section) and healthcare staff behavior have been proposed as potential risk factors for nosocomial infections in neonates. This study aimed to evaluate the association between childbirth mode and healthcare personnel practices with the occurrence of neonatal infections in the NICU of Brother Rahmani Hospital, Algeria.

Materials and Methods: A mixed-methods study was conducted, combining a retrospective case-control analysis of 70 neonates (35 cases, 35 controls) and a descriptive observational component involving healthcare staff. The quantitative analysis examined the relationship between mode of delivery and nosocomial infection, while the qualitative component assessed staff knowledge and adherence to infection prevention protocols through a structured questionnaire. Data were analyzed using EPI Info™ 7.2.7 with appropriate statistical tests, including Chi-square, Fisher's exact test, and logistic regression.

Results: No statistically significant association was found between caesarean delivery and nosocomial infection (OR = 1.6154, p = 0.2269). The Mantel-Haenszel test ruled out major confounding. However, staff questionnaire responses revealed inconsistencies in infection control practices: only 42.9% wore full medical attire, and 38.1% failed to adhere to incubator cleaning protocols. Misunderstandings about sterilization standards and zoning concepts were also identified.

Discussion: While caesarean delivery was not a significant independent risk factor, behavioral and procedural lapses among healthcare personnel may contribute more critically to infection risks. Findings align with other regional studies that highlight the importance of staff compliance and training in infection control.

Conclusion: Caesarean section alone may not significantly increase the risk of neonatal infection, but staff behavior and protocol adherence are crucial determinants. Targeted training, standardized procedures, and improved surveillance are essential to reduce infection rates in NICU settings.

Keywords: Neonatal Infection; Caesarean Section; Healthcare Staff Behavior; Infection Control Practices

Abbreviations: NICU: Neonatal Intensive Care Unit; C-section: Caesarean Section; HAI: Healthcare-Associated Infection; LMIC: Low- and Middle-Income Country; WHO: World Health Organization; IPC: Infection Prevention and Control; PPE: Personal Protective Equipment; OR: Odds Ratio; CDC: Centers for Disease Control and Prevention; ANOVA: Analysis of Variance

Introduction

Neonatal infections remain a leading cause of morbidity and mortality in neonatal intensive care units (NICUs), particularly in low- and middle-income countries (LMICs) [1]. In Algeria, health care-associated infections (HAIs) in neonates have been reported with varying prevalence rates, highlighting the need for comprehensive studies to identify contributing factors and inform pre-

ventive strategies [2]. Caesarean section (C-section) is a common mode of delivery in Algeria and other regions. While it is often performed to reduce maternal and foetal risks, studies have shown that neonates born via C-section may have an increased risk of developing infections compared to those delivered vaginally. This association may be due to factors such as prolonged hospital stays, antibiotic use, and potential breaches in infection control practices. A systematic review and meta-analysis of observational studies found that children delivered by C-section had an increased rate of hospital admission with infections overall and in three common clinical infection categories: upper respiratory infections, lower respiratory infections, and gastrointestinal infections [3].

In addition to clinical factors, healthcare staff behavior plays a crucial role in the prevention and control of neonatal infections. Adherence to infection prevention protocols, hand hygiene practices, and the use of sterile techniques are essential in minimizing the risk of HAIs [4,5]. However, lapses in these practices can contribute to the transmission of pathogens within the NICU environment. A systematic review and meta-analysis study conducted in the Maghreb assessed neonatal intensive care unit nurses' compliance with standard precautions of infection control and identified enabling factors. The study found that non-compliance was associated with an increased incidence of healthcare-associated infections in neonates [6]. This study aims to assess the role of childbirth mode and healthcare staff behavior as determinants of neonatal infections in the NICU of Brother Rahmani Hospital, Algeria. By employing a mixed-methods approach, including a case-control analysis and observational assessments of staff practices, this research seeks to provide a comprehensive understanding of the factors influencing neonatal infection rates and to inform targeted interventions for infection prevention.

Materials and Methods

This study employed a mixed-methods design, combining a retrospective analytical case-control approach with a descriptive observational component. The analytical component focused on clinical data from neonates, while the descriptive component assessed healthcare staff behaviors through a structured questionnaire, aiming to identify behavioral and procedural factors that may contribute to the risk of neonatal nosocomial infections.

Quantitative Component: Retrospective Case-Control Study

The retrospective case-control analysis was conducted in the Neonatal Unit of Brother Rahmani Hospital, Algeria. The case group consisted of neonates who developed a confirmed nosocomial infection during their hospital stay, as defined by the World Health Organization (WHO). The control group included neonates hospitalized during the same period and under similar clinical conditions but those who did not develop any nosocomial infections.

Target Population

- **Cases:** Neonates diagnosed with a nosocomial infection during hospitalization.
- **Controls:** Neonates who received care under similar conditions but did not develop nosocomial infections.
- **Matching Criteria**: Both groups were matched based on age, birth weight, gestational age, and initial health status.
- A total of 70 neonates were included based on predefined inclusion and exclusion criteria.

Inclusion Criteria

- Cases: Neonates diagnosed with a nosocomial infection as defined by the WHO.
- Controls: Neonates admitted during the same period without signs of nosocomial infection.
- Consent: Written informed consent from a parent or legal guardian.

Exclusion Criteria

- Neonates with congenital anomalies or pre-existing medical conditions unrelated to nosocomial infections.

Qualitative Component: Observational Descriptive Study

To complement the clinical data, a descriptive observational study was conducted among healthcare personnel (nurses, midwives, and physicians) working in the Neonatal Unit. A standardized questionnaire was administered to assess their knowledge, attitudes, and practices regarding infection prevention and control (IPC) measures, including:

- Hand hygiene
- Use of personal protective equipment (PPE)
- Aseptic techniques during procedures
- Awareness of nosocomial infection risks

The purpose of this component was to explore potential behavioral factors contributing to infection transmission, and to triangulate these findings with clinical outcomes observed in neonates.

Exploitation and Statistical Analysis of Data

EPI Info™ software (version 7.2.7 March 9, 2025, CDC, Atlanta, Georgia, USA) was used for data entry, correction, and analysis. For comparison, we used the Chi2 test (χ^2) and, if necessary, the Fisher two-tailed exact test for the comparison of percentages and The Student's t-test and ANOVA were used for the comparison of means. The measurement of the intensity of the association between a factor and the occurrence of an IN was estimated by calculating the odds ratio (OR) and its 95% confidence interval, the significance threshold was set at a value of $\alpha = 5\%$.

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Results

Questionnaire Results

66.7% were nurses, highlighting their central role in neonatal care. Results reflect mainly the perspective of paramedical staff, introducing some observational bias. Most respondents had limited experience, which may increase infection risks if not balanced by continuous training. 100% of staff reported washing hands, indicating strong awareness of basic infection prevention. Only 42.9% wore full medical attire, exposing a hygiene compliance gap. Antiseptic use varied (alcohol: majority; chlorhexidine: minority), suggesting lack of standardized protocol and possible inappropriate use (e.g., alcohol on premature infants). 61.9% saw incubator cleaning as mandatory, but 38.1% did not posing a hygiene concern. Discrepancies in handling oxygen masks (57.1% disinfect, 33.3% discard, 9.5% sterilize) reflect inconsistent practices, likely due to unclear protocols. 61.9% had managed nosocomial infections, suggesting significant exposure and awareness. Management strategies focused mainly on curative approaches (antibiogram: 61.9%, antibiotics: 57.1%) rather than preventive actions like reporting or identifying sources (38.1% each), showing gaps in surveillance and prevention culture. Only 38.1% correctly identified the Spaulding classification for sterilization. Many confused it with non-relevant tools like Bowie-Dick (33.3%) or Ishikawa diagrams (28.6%), underscoring a lack of understanding in sterilization standards. For Zoning concept, Zones 01 and 03 were chosen as the highest risk (28.6%), Zone 02 followed (23.8%), while zone 04 was perceived as the safest and this is false.

Case-Control Study

The strength of the association between factors such as cesarean delivery—and the occurrence of nosocomial infection was estimated by calculating the odds ratio (OR = 1.6154) with a 95% confidence interval. The significance threshold was set at $\alpha = 5\%$. Fisher's exact test yielded a p-value of 0.2269, and the Chi-square test gave $\chi^2 = 0.5620$, indicating that the association was not statistically significant in this sample of 70 neonates. The Mantel-Haenszel test value was 0.9669, confirming no major confounding factors affecting the relationship between caesarean section and infection in the studied population. These associations were evaluated using multivariate logistic regression analysis, including variables with a p-value ≤ 0.25 in the bivariate analysis.

Discussion

The findings revealed several areas of concern regarding infection prevention practices among healthcare personnel, which are consistent with studies conducted in similar settings. The study found that 100% of the staff reported washing their hands, indicating strong awareness of basic infection prevention. However, this self-reported data may not accurately reflect actual practices. A study in a neonatal intensive care unit (NICU) in Egypt observed that healthcare workers' hand hygiene compliance was 46% before an educational intervention, which improved to 69% post-intervention, suggesting that actual compliance may be lower than reported [7]. Only 42.9% of staff wore full medical attire, exposing a hygiene compliance gap. Additionally, the use of antiseptics varied, with the majority using alcohol-based solutions and a minority using chlorhexidine. A study in a NICU in Bangladesh found that alcohol-based hand rubs were commonly used, but compliance with recommended hand hygiene practices was still suboptimal [8]. Furthermore, the use of chlorhexidine in neonates requires caution, as it has been associated with chemical burns in premature infants when used improperly [9]. The study found discrepancies in handling oxygen masks and incubator cleaning, with 61.9% considering incubator cleaning mandatory, but 38.1% not adhering to this practice. A study in a NICU in France found that despite implementing a steam pulverization disinfection protocol, discrepancies in cleaning practices persisted, highlighting the importance of staff adherence to established protocols [10].

While 61.9% of staff had managed nosocomial infections, management strategies focused mainly on curative approaches rather than preventive actions. An intervention study in a NICU in Iran found that training healthcare providers on hand hygiene and infection control practices significantly reduced healthcare-associated infections and mortality rates [11]. Only 38.1% of staff correctly identified the Spaulding classification for sterilization, with many confusing it with non-relevant tools. This lack of understanding underscores the need for comprehensive training on sterilization standards. A study in Turkey found that nurses' knowledge of infection control practices was inadequate, emphasizing the importance of continuous education and training [12]. The study revealed misconceptions regarding the zoning concept, with Zone 04 perceived as the safest, which is contrary to established infection control practices. This highlights the need for clear communication and training on infection control measures. A study in Egypt found that proper training and adherence to infection control protocols were associated with reduced nosocomial infection rates in NICUs [13].

Case-Control Study

In the current study, the association between cesarean delivery and the occurrence of nosocomial infection in neonates was examined using several statistical approaches. The odds ratio (OR = 1.6154) suggested a 61.5% increase in the odds of infection among neonates delivered via cesarean section compared to those delivered vaginally. Despite this apparent increase, the association did not reach statistical significance, as indicated by Fisher's exact test ($p = 0.2269$) and the Chi-square test ($\chi^2 = 0.5620$). The 95% confidence interval for the odds ratio (not specified here) likely includes null value, further emphasizing the lack of a significant effect. Moreover, the Mantel-Haenszel test value (0.9669) indicated no major confounding factors influencing the relationship between cesarean delivery and infection in this sample of 70 neonates. Multivariate logistic regression was employed to control for potential confounders, including all variables with $p \leq 0.25$ in the bivariate analysis, yet cesarean delivery did not emerge as an

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independent risk factor. These findings align with several previous studies that found no statistically significant association between mode of delivery and nosocomial infection after adjusting for confounding variables such as prematurity, birth weight, and exposure to invasive procedures. For example, Schuchat et al. [14] emphasized that gestational age and NICU-related interventions, rather than delivery mode, were more predictive of infection risk. Similarly, Tsai et al. [15] concluded in a metal-analysis that cesarean delivery alone was not a significant predictor of neonatal sepsis when other clinical factors were considered.

However, other studies have identified a potential link between the cesarean section and increased risk of neonatal infection, particularly in settings with high rates of emergency procedures and limited infection control measures. For instance, Stoll et al. [16] reported a higher incidence of late-onset sepsis among preterm infants delivered via cesarean section in a Prospective surveillance, and Vergnano et al. [17] noted that delivery by cesarean may increase exposure to environmental pathogens due to prolonged hospital stays and more frequent NICU admission. Taken together, the evidence suggests that while cesarean delivery may be associated with a modest increase in infection risk, it is not consistently identified as an independent risk factor in multivariate analyses. The non-significant findings in the current study may be attributable to the small sample size, which limits statistical power. Larger-scale studies or pooled data may be necessary to definitively assess the impact of delivery mode on neonatal infection risk.

Conclusion

This mixed-methods study found no statistically significant association between cesarean delivery and nosocomial infections among neonates, though a modest increase in risk was observed. The small sample size may have limited statistical power. However, the qualitative findings revealed notable gaps in healthcare staff practices, including inconsistent hygiene measures, improper use of antiseptics, and limited understanding of sterilization protocols. These behavioral factors likely contribute more significantly to infection risk than delivery mode alone. Improving infection prevention training, standardizing procedures, and reinforcing compliance among staff are essential steps to reduce neonatal infections in hospital settings.

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