Original Article

Infection Control in the NICU: Addressing the Threat of *Elizabethkingia meningoseptica* and Multidrug-Resistant Organisms

Vidya Ravi[1,*], Aditi Sondhi[2], Gurpreet Singh Bhalla[2], Nandita Hazra[2], G Shridhar[3], Amit Sood[4], Leo Praveen Kumar[1]

[1]Department of Microbiology, Armed Forces Medical College, Pune, India
[2]Department of Microbiology, Command Hospital Southern Command, Pune, India
[3]Department of Paediatrics, Armed Forces Medical College, Pune, India
[4]Department of Paediatrics, Command Hospital Western Command, Chandimandir, India

***Correspondence:** vidyaravi1986@gmail.com

DOI
10.21276/apalm.3678

Article History
Received: 18-08-2025
Revised: 11-02-2026
Accepted: 12-03-2026
Published: 06-04-2026

How to cite this article
Ravi V, Sondhi A, Bhalla GS, Hazra N, Shridhar G, Sood A, et al. Infection Control in the NICU: Addressing the Threat of *Elizabethkingia meningoseptica* and Multidrug-Resistant Organisms. Ann Pathol Lab Med. 2026;13(4):A172-A177.

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Abstract

Background: *Elizabethkingia meningoseptica* is an opportunistic, intrinsically multidrug-resistant gram-negative bacillus increasingly implicated in neonatal intensive care unit (NICU) outbreaks.
Methods: This retrospective case series with environmental surveillance describes two NICU outbreaks (September 2023 and February – March 2024) involving four neonates in a tertiary care hospital. Environmental samples were collected from various sites within the NICU on two occasions following the outbreaks. Cultures and antimicrobial susceptibility testing (AST) were done as per standard protocols to isolate the pathogen and to report its AST profile.
Results: *Elizabethkingia meningoseptica* was isolated from blood and cerebrospinal fluid of affected neonates and from NICU water-associated sites confirming its role in the outbreaks. Targeted infection control interventions resulted in complete containment of the outbreak.
Conclusion: This study documents a NICU outbreak of *Elizabethkingia meningoseptica* linked to environmental water sources. Early environmental surveillance and prompt multidisciplinary infection control interventions successfully terminated the outbreak. Sustained environmental surveillance of NICU is essential to prevent recurrence.

Keywords: elizabethkingia meningoseptica; NICU; environmental surveillance

Introduction

Elizabethkingia meningoseptica, a gram-negative bacillus commonly found in soil and water, poses significant challenges in healthcare settings due to its resistance to multiple antibiotics and its ability to cause severe infections, particularly in vulnerable populations such as newborns and individuals with compromised immune systems and patients in intensive care unit (ICU) settings on ventilator support.[1, 2, 3, 4, 5]

The bacterium's resilience in both natural and clinical environments underscores its clinical significance, especially in healthcare facilities where patients are at an increased risk of infection and its complications.[5, 6, 7, 8] Despite its infrequent

isolation, *Elizabethkingia meningoseptica* outbreaks have been documented globally, often associated with contaminated hospital water systems or medical equipment.[4, 5, 6, 7, 8, 9, 10, 11, 12, 13]

Efforts to control outbreaks caused by highly resistant pathogens such as this are crucial for preventing serious health consequences and minimizing healthcare costs. Regular surveillance and prompt intervention measures are essential for identifying early and containing outbreaks.[6, 12, 14, 15]

Investigations into these outbreaks have highlighted the importance of environmental control, emphasizing the need for regular maintenance and disinfection of hospital water systems.[7] Treatment protocols targeting the pathogen's resistance to conventional antibiotics typically involve combination therapies.[8, 16, 17]

Environmental sampling in healthcare facilities, particularly in areas like Neonatal Intensive Care Units (NICUs), is essential for identifying reservoirs of *Elizabethkingia meningoseptica* and implementing effective infection control strategies. Recent outbreaks have underscored the challenge of promptly detecting the bacterium's origin, emphasizing the need for thorough environmental assessments.[2, 18]

Materials and Methods

This study was conducted as a retrospective case series with environmental surveillance in the Neonatal Intensive Care Unit (NICU) of a tertiary care hospital. Two distinct outbreaks of *Elizabethkingia meningoseptica* infection were identified, each involving two neonates—one in September 2023 and another during February–March 2024. Since *Elizabethkingia meningoseptica* has never been isolated from patients in NICU or from environmental samples, even a single case was considered as an outbreak.

Neonatal sepsis was defined based on compatible clinical features with microbiological confirmation, while meningitis was defined by isolation of *Elizabethkingia meningoseptica* from cerebrospinal fluid. Environmental surveillance was undertaken following both outbreaks. Despite repeated sampling during the September 2023 outbreak, the organism could not be isolated from environmental sources. Subsequently, after the recurrence of cases in February 2024, a repeated and multi-sample environmental survey was conducted during February and March 2024. Samples were collected using sterile swabs from predetermined moisture-prone sites within the NICU, including water taps, sinks, laminar flow units, and kangaroo mother care areas. Swabs were inoculated onto 5

Grey, shiny, moist, non-haemolytic colonies were observed on blood agar with scant growth on MacConkey agar [Figure 1]. The isolates were catalase- and oxidase-positive. Identification and antimicrobial susceptibility testing, including determination of minimum inhibitory concentrations (MICs), were performed using the Vitek2 Compact® system (bioMérieux, France), with MIC breakpoints referenced from a study by Comba I et al and Chiu T et al.[19, 20, 21] The MIC breakpoints for all antibiotics except that for Vancomycin, were referenced from CLSI breakpoints for enterobacterales. For Vancomycin, E test was performed with the MIC breakpoints for *Enterococcus* species as per CLSI. All isolates of *Elizabethkingia meningoseptica* (from patients and environmental samples) had similar AST profile and hence were assumed to be of a common origin as reflected in Table 1. However, molecular typing methods such as pulsed-field gel electrophoresis or whole-genome sequencing were not performed; therefore, clonal relatedness of clinical and environmental isolates could not be confirmed.

Table 1: Antibiotic susceptibility pattern of *Elizabethkingia meningoseptica* isolated from patient samples and environmental samples.

Sample	Pip-Tazo MIC (μg/mL)		Ceftazidime MIC (μg/mL)		Cefepime MIC (μg/mL)		Aztreonam MIC (μg/mL)		Imipenem MIC (μg/mL)		Meropenem MIC (μg/mL)	
Patient 1	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R
Patient 2	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R
Patient 3	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R
Patient 4	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R
NICU Sink	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R
KMC Room	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R
Laminar Flow Room	≥32	R	≥16	R	≥16	R	≥16	R	≥4	R	≥4	R

Sample	Amikacin MIC (μg/mL)		Gentamicin MIC (μg/mL)		Ciprofloxacin MIC (μg/mL)		Levofloxacin MIC (μg/mL)		Minocycline MIC (μg/mL)		Vancomycin MIC (μg/mL)	
Patient 1	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S
Patient 2	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S
Patient 3	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S
Patient 4	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S
NICU Sink	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S
KMC Room	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S
Laminar Flow Room	≥16	R	≥16	R	≤0.25	S	≤0.5	S	≤4	S	≤2	S

The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from the parents or legal guardians of all affected neonates. The details with regards to the patients is as reflected in table 2.

Figure 1: Grey, shiny, moist, non-hemolytic colonies of *Elizabethkingia meningoseptica* on 5% sheep blood agar.

Table 2: Details of patients in outbreak (S. no. 1 & 2 occurred in September 2023 and S. no. 3 & 4 occurred in February – March 2024).

Case	Patient Details	Diagnosis	Specimen	Organism	Susceptible to	Antibiotics given	Outcome	Remarks
1	39 weeks 4 days, Male, 2.8 kg	Late Onset Neonatal Sepsis	CSF	*Elizabethkingia meningoseptica*	Ciprofloxacin, Levofloxacin, Vancomycin, Minocycline	Vancomycin, Levofloxacin	Discharged	Residual deficit and on follow up
2	33 weeks 1 day, Female, 1.48 kg	Early Onset Neonatal Sepsis	CSF	No Growth	—	—	Discharged	No Residual Deficit
			Blood	*Elizabethkingia meningoseptica*	Minocycline, Ciprofloxacin, Levofloxacin, Vancomycin	Vancomycin, Levofloxacin		
3	32 weeks 1 day, Male, 1.37 kg	Late Onset Neonatal Sepsis	CSF	*Elizabethkingia meningoseptica*	Minocycline, Ciprofloxacin, Levofloxacin, Vancomycin	Vancomycin, Levofloxacin	Discharged	No Residual deficit and on follow up
			Blood	*Elizabethkingia meningoseptica*				
4	34 weeks 3 days, Male, 1.76 kg	Late Onset Neonatal Sepsis	CSF	*Elizabethkingia meningoseptica*	Minocycline, Ciprofloxacin, Levofloxacin, Vancomycin	Vancomycin, Levofloxacin	Discharged	Residual deficit and on follow up
			Blood	*Elizabethkingia meningoseptica*				

Results

Results of environmental sampling post outbreaks of *Elizabethkingia meningoseptica* in February – March 2024 are given in table 3. The sampling revealed the critical finding of isolation of *Elizabethkingia meningoseptica* from three different locations in the NICU.

Elizabethkingia meningoseptica was not isolated from sampling done in September 2023.

Table 3: Results of environmental sampling (details in text).

S. No.	Date of Sampling	Location	Site of Isolation	Remarks
1.	21 Feb 2024	NICU and Labour Room	Nil	Nil
2.	04 Mar 2024	NICU and Labour Room	Sink in NICU extension	Changed the Sink design to prevent accumulation of water and prevent back splashes
3.	12 Mar 2024	NICU and Labour Room	Sink at Laminar flow room; Sink in Kangaroo Mother Care room	Changed the Sink design to prevent accumulation of water and prevent back splashes

Interventional strategies

Post isolating this pathogen from two different locations in the NICU, following interventional strategies were implemented to control future outbreaks:

Education Programme: A targeted education program for physicians and nursing staff was rolled out, focusing on enhancing hand hygiene practices within the NICU. This program included monitoring compliance to ensure effectiveness.

Reinforcement of Standard Precautions: Standard precautions in the NICU were reinforced, including the use of personal protective equipment (PPE) and protocols for handling potentially contaminated materials.

Cleaning of Water Reservoirs: Intensive cleaning and disinfection of water tanks, taps, and sinks in the NICU were undertaken to eliminate any environmental reservoirs of the bacterium.

Terminal Cleaning: A comprehensive terminal cleaning of the NICU was conducted, which is a deep cleaning procedure performed after confirming or suspecting the presence of highly transmissible pathogens. It involved removal of all detachable equipment followed by thorough cleaning and disinfection of high-touch and low-touch surfaces using hospital-approved disinfectants in a systematic top-to-bottom approach. Reusable medical devices were decontaminated/sterilized as per protocol, and the area was allowed adequate contact time and ventilation before reuse to ensure complete pathogen elimination.

Follow-up survey

A follow-up environmental survey was conducted in April 2024 after the implementation of these strategies, and *Elizabethkingia meningoseptica* could not be isolated from any of the sampled sites. Also, no further case of infection with the pathogen has occurred in the hospital since.

This outcome suggests that the interventions were successful in controlling the outbreak, highlighting the importance of swift and targeted response measures in the management of hospital-acquired infections.

Discussion

Isolation of *Elizabethkingia meningoseptica* in Neonatal Intensive Care Units (NICUs) underscores the critical need for effective infection control measures.

It is a Gram-negative, rod-shaped bacterium known for inhabiting moist environments, including hospital water systems. First identified by microbiologist Elizabeth O. King in 1959, it has since been recognized as an opportunistic pathogen, particularly in healthcare settings.[1] This bacterium is notorious for causing severe infections such as meningitis in neonates, bacteraemia, pneumonia, and endocarditis, primarily affecting immunocompromised individuals, including premature infants, the elderly, and patients with underlying health conditions. One of the most challenging aspects of *Elizabethkingia meningoseptica* infections is its high level of resistance to multiple antibiotics, including beta-lactams, aminoglycosides, and carbapenems, necessitating the use of alternative treatments like trimethoprim-sulfamethoxazole and fluoroquinolones.[13, 14, 15, 16, 17, 19]

Environmental sampling post-outbreaks of *Elizabethkingia meningoseptica* has reinforced the understanding that moist environmental niches within NICUs harbour not only this pathogen but also other multidrug-resistant organisms. These findings emphasize the numerous possible origins of healthcare-associated infections (HAIs) and the continuous threat they pose to susceptible neonatal populations.[2, 9, 14]

In the complex environment of a NICU, the susceptibility of neonates to infections, coupled with the presence of multidrug-resistant organisms, makes infection control paramount.[14] One of the key strategies to enhance infection prevention and

improve patient outcomes is fostering robust collaboration among microbiologists, infection control teams, and clinical staff. This interdisciplinary approach can significantly optimize both the detection and management of potential infection risks.[2, 14]

Effective communication between microbiologists, infection control professionals, and clinical staff is crucial for the timely interpretation and action of environmental sampling results. Microbiologists play a vital role in identifying pathogens like *Elizabethkingia meningoseptica* and providing detailed insights into their characteristics and resistance profiles, which are essential for developing targeted interventions. When this critical information is seamlessly communicated to infection control teams and clinical staff within the NICU, it ensures that findings are quickly translated into actionable strategies.[2, 8, 14]

Interdisciplinary Collaboration for Infection Control

Swift communication of sampling results allows infection control teams to promptly implement necessary interventions, such as enhanced cleaning protocols or isolation measures, to prevent the spread of identified pathogens. Regular updates from clinical staff on the effectiveness of implemented measures provide microbiologists and infection control teams with real-time feedback, enabling continuous improvement of infection control strategies.[12, 14, 18]

An interdisciplinary approach not only facilitates effective communication but also fosters a comprehensive understanding of infection dynamics within the NICU environment. Each discipline brings a unique perspective and expertise that, when integrated, can lead to more effective infection prevention strategies. Combining the expertise of microbiologists with the practical insights of treating physicians create a rich knowledge base for understanding and combating infections in the NICU. Interdisciplinary teams are better positioned to innovate, whether in developing new sterilization technologies, refining antibiotic stewardship programs, or implementing novel environmental decontamination techniques.[18]

Implementation of Infection Control Measures

The overarching goal of infection control strategies is the improvement of patient outcomes. Interdisciplinary collaboration in the NICU directly contributes to this goal by enhancing the efficacy of infection prevention measures. Effective teamwork can lead to more precise and timely interventions, significantly reducing the incidence of hospital-acquired infections among neonates.[14, 18] With a proactive infection control strategy, neonates receive care in a safer environment, which is critical for their delicate health and development. This not only improves immediate health outcomes but also reduces long-term complications associated with infections.[18, 22]

Proposed Measures for NICUs

Utilizing the knowledge acquired from this study, we propose the implementation of the measures discussed below for NICUs worldwide.

Consistent Environmental Sampling: It is essential to regularly and continuously monitor the environment in NICUs to promptly detect and address potential infection sources.

Infrastructure Assessment: Hospitals should conduct regular evaluations of their infrastructure to ensure that it facilitates appropriate hygiene procedures, especially in regions with archaic infrastructure.

Improved Training and Protocols: Continuous education and training for all NICU personnel are essential. Protocols should be periodically revised following the most recent research and technological advancements in infection control.

Interdisciplinary Teams: Formulate enduring interdisciplinary groups specialized in infection prevention, guaranteeing the inclusion of diverse viewpoints in the decision-making process to safeguard the health and safety of newborns.

By implementing these measures, NICUs can better manage and prevent infections caused by *Elizabethkingia meningoseptica* and other multidrug-resistant organisms, ultimately improving patient outcomes and ensuring a safer environment for neonates.

Conclusion

This study contributes valuable knowledge to the field of neonatal care, particularly underscoring the importance of infection control practices in healthcare settings as well as that of surveillance. As we continue to confront the challenges posed by HAIs, the lessons learned here should guide future efforts to safeguard the health of some of the most vulnerable members

of our society—newborn infants. By adhering to and expanding upon the recommendations provided, healthcare facilities can enhance patient outcomes and uphold the highest standards of care in neonatal units.

Acknowledgements: Staff of department of Paediatrics, Infection control staff and laboratory technicians of our hospital.

Funding: No funding was received for this work.

Competing Interests: Authors declare that they have no conflict of interest.

Consent: Informed consent was taken from the patients next of kin and the study was approved by the institutional ethics committee.

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