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CHARACTERIZATION OF NOSOCOMIAL INFECTIONS AND ANTIBIOTIC RESISTANCE IN PAEDIATRIC PATIENTS AT ADDINGTON HOSPITAL, DURBAN, KWAZULU-NATAL: A RETROSPECTIVE COHORT STUDY.

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Abstract

Background

Nosocomial infections are a significant threat in pediatric healthcare, particularly in South Africa, where prevalence rates in pediatric wards can reach up to 16.5%. Children are especially vulnerable due to underdeveloped immune systems and frequent exposure to invasive procedures. Common pathogens include methicillin-resistant *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii*, many usually exhibit multidrug resistance. This study investigates the prevalence and identity of nosocomial pathogens in pediatric patients at Addington Hospital and assesses their antibiotic susceptibility patterns.

Methods

This study utilized a retrospective cross-sectional design with a quantitative approach, analyzing 761 clinical samples from pediatric patients aged 0–14 years admitted to Addington Hospital, Durban, between March 2022 and April 2023. Pathogen identification was performed using conventional microbiological techniques. Antibiotic susceptibility testing employed the disk diffusion method, interpreted according to Clinical and Laboratory Standards Institute guidelines. Data analysis was conducted using SPSS version 26.

Results

Staphylococcus species were the most prevalent pathogens (62%), followed by *Bacillus* spp. (9.6%), *Viridans streptococcus* (3.4%), and *Klebsiella pneumoniae* (2.8%). Alarmingly high resistance rates were observed for beta-lactam antibiotics (93.8%) and gentamicin (50%), with *K. pneumoniae* showing 76.2% resistance to gentamicin. *Streptococcus agalactiae* displayed complete resistance to clindamycin. Nonetheless, meropenem and vancomycin remained universally effective (100%) against Gram-negative and Gram-positive pathogens, respectively.

Conclusion

The findings highlight a significant burden of antimicrobial resistance among pediatric patients with nosocomial infections. There is an urgent need for reinforced infection control measures, continuous antimicrobial resistance surveillance, and implementation of antimicrobial stewardship programs. These efforts are vital to curb the spread of multi-drug resistant organisms and improve clinical outcomes in pediatric care environments.

Recommendations

Research into alternative treatments, such as plant-derived agents, should also be encouraged for managing resistant infections.

Keywords: *Nosocomial Infection; Antimicrobial Resistance; Methicillin-Resistant Staphylococcus aureus; Klebsiella pneumoniae; Infection Control.*
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Introduction and Background

Nosocomial infections (NIs), or hospital-acquired infections, are a significant public health challenge, especially for children who are vulnerable due to weakened immune systems, prolonged hospitalizations, and dependence on medical devices like ventilators and catheters (Alemayehu et al., 2019). NIs can be caused by bacterial, viral, or fungal pathogens and typically manifest more than 48 hours post-admission (Saba & Balwan, 2023). These infections lead to higher morbidity

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rates, prolonged hospital stays, and added strain on healthcare resources (McKay, 2022). The rates of NIs vary globally, affecting approximately 10% of pediatric patients in developed countries and up to 20% in developing countries (WHO, 2020).

A growing concern is antimicrobial resistance (AMR), which has increased infections caused by multidrug-resistant organisms, including carbapenem-resistant *Enterobacteriaceae* (CRE). This has severely limited treatment options, as traditional antibiotics become ineffective (Radebe, 2019). The rise of resistant pathogens further complicates disease management and contributes to higher mortality rates (Khazaei et al., 2020; Jain et al., 2021). The misuse and overuse of broad-spectrum antibiotics, particularly in Gram-negative bacteria like *Klebsiella pneumoniae* and *Escherichia coli*, have been identified as primary drivers of AMR (Mamishi et al., 2019). These bacteria produce enzymes such as extended-spectrum beta-lactamases (ESBLs) and carbapenemases that break down antibiotics and hinder effective treatment (Alizadeh et al., 2020). This issue not only increases morbidity and mortality but also escalates healthcare costs, highlighting the critical need for collaborative efforts to combat antimicrobial resistance(Nsele & Thembane, 2023). At Addington Hospital, many pediatric patients are admitted with hospital-acquired infections, but limited data exist on their incidence and resistance patterns. This gap makes it challenging for clinicians to implement targeted infection control measures and optimize treatment strategies (Khazaei et al., 2020). This study aims to address this gap by identifying the prevalent nosocomial pathogens and their resistance profiles in the pediatric ward of Addington Hospital. The findings will assist in developing more effective infection prevention and control strategies.

Understanding the epidemiology of hospital-acquired infections is crucial for effective infection control and antimicrobial stewardship (McKay, 2022). Adopting proper infection control practices, such as hand hygiene and aseptic techniques, along with antimicrobial stewardship programs, is essential in curbing AMR and preventing further resistance development (Majumder et al., 2020). This research will focus on children aged 0–14 years diagnosed with nosocomial infections at Addington Hospital between March 2022 and April 2023. The study's findings will provide valuable insights into local resistance trends and guide future clinical practices. Ongoing surveillance and research into resistance trends are essential for addressing the growing threat of antimicrobial resistance (Logan & Weinstein, 2017). By identifying prevalent pathogens and their resistance profiles, this study will support improved infection prevention strategies and guide antibiotic treatment protocols for pediatric patients. The findings are expected to reduce the incidence of hospital-acquired infections at Addington Hospital and enhance the management of pediatric infections, thereby contributing to improved healthcare quality and patient outcomes. The objective of this study is to investigate the prevalence and antibiotic resistance patterns of nosocomial pathogens in pediatric patients at Addington Hospital, Durban.

Methods

This study employed a retrospective cross-sectional design and a quantitative research approach, conducted at Addington Hospital, a public tertiary healthcare facility in Durban, KwaZulu-Natal, South Africa, renowned for its specialization in pediatric care, internal medicine, surgery, and infectious disease management. Data collection was conducted between March 2022 and April 2023, drawing on electronic clinical records and the National Health Laboratory Service (NHLS) database. Key data parameters included patient age and gender, specimen types, pathogen identification, and antibiotic susceptibility profiles. Pathogen identification was carried out using standard microbiological techniques, including Gram staining, culture, and Vitek 2 automation. Antibiotic susceptibility testing was performed using the disk diffusion method and interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. A total of 761 pediatric patient records and corresponding laboratory samples were analyzed for the study.

Statistical Analysis

Descriptive statistics were used to summarize demographics, infection types, and pathogen prevalence. Percentages and frequency distributions assessed trends in antibiotic susceptibility. T-tests and chi-square tests were used to compare resistance rates across pathogens. All analyses were performed using SPSS version 26.

Ethical Clearance

Ethical approval for the study was granted by the Mangosuthu University of Technology Research Ethics Committee on 15 February 2023 (Ethical Clearance Number: REC-2023-0215). The study proceeded under the supervision of the assigned supervisor. There was no physical interaction with study participants or patients, and as such, no informed consent was required. When gathering patient information, confidentiality was strictly maintained. Specific details, such as hospital episode numbers in the dataset that could potentially identify patients, were removed to ensure anonymity.

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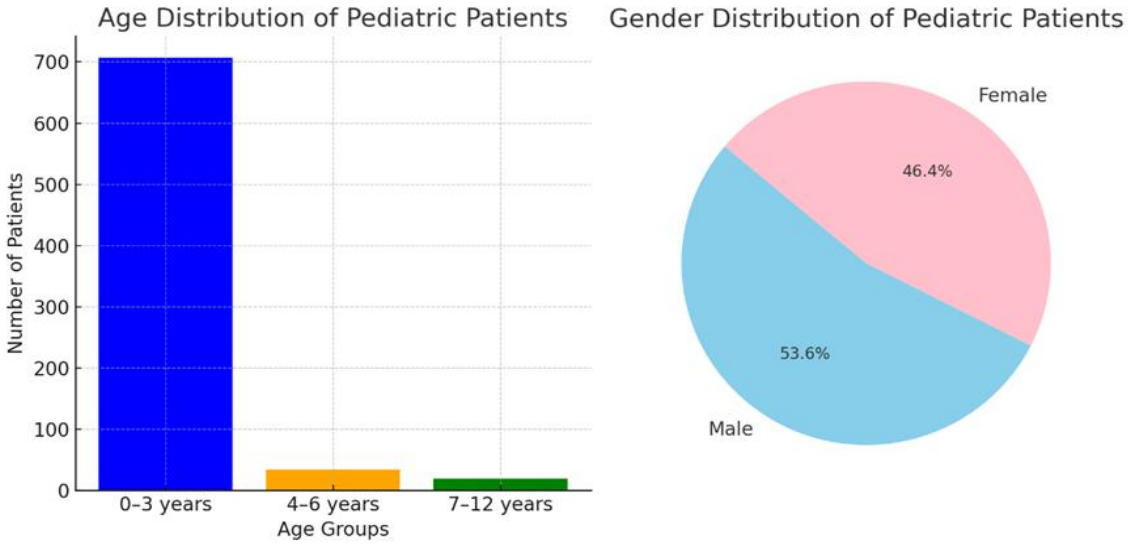
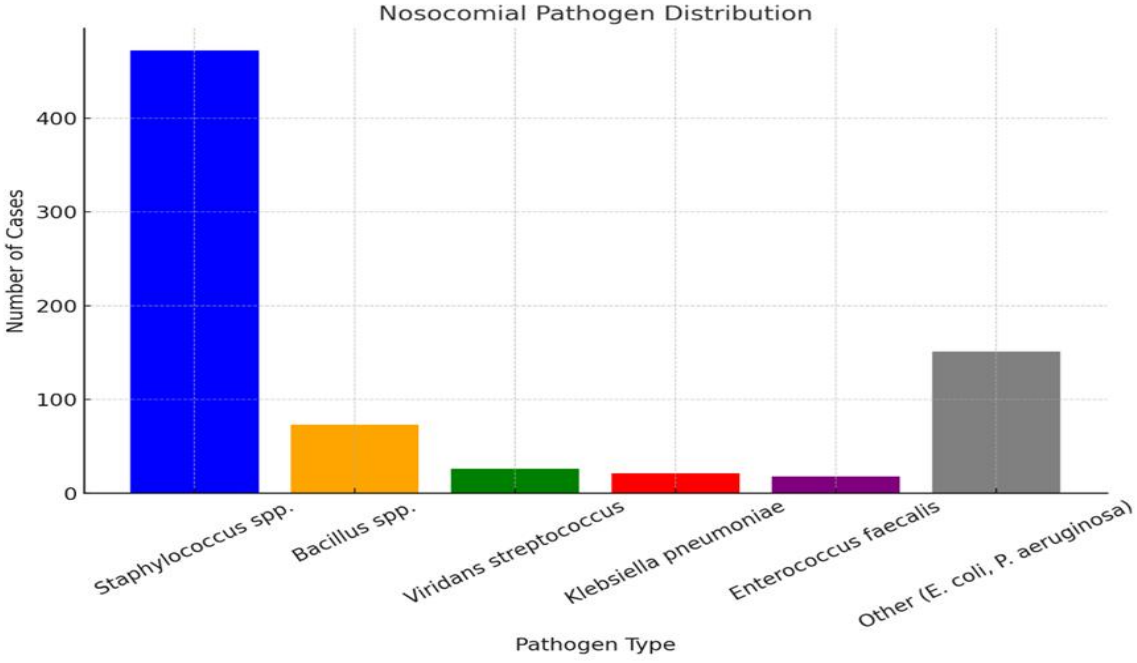
Results

Figure 1. Age and Gender Distribution



The study included 761 pediatric patients, with a slightly higher proportion of males (53.6%) compared to females (46.4%), resulting in a male-to-female ratio of approximately 1.15:1. Most patients were aged 0–3 years (92.9%), while fewer patients fell within the 4–6 years (4.5%) and 7–12 years (2.6%) age groups. This age distribution highlights a significant prevalence of hospital-acquired infections among infants and toddlers, likely due to their developing immune systems and greater exposure to invasive medical procedures. These findings are consistent with existing research, which underscores the vulnerability of young children to nosocomial infections

Figure 2. Distribution of Nosocomial Pathogens



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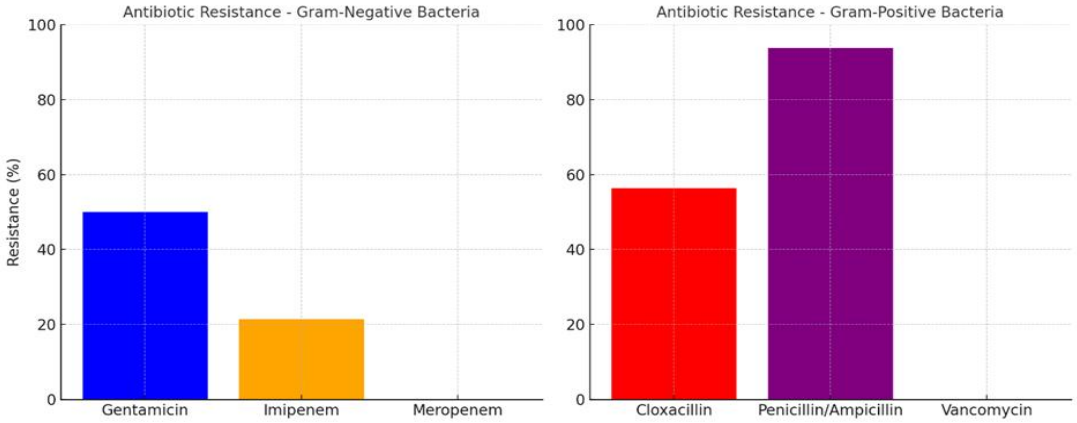
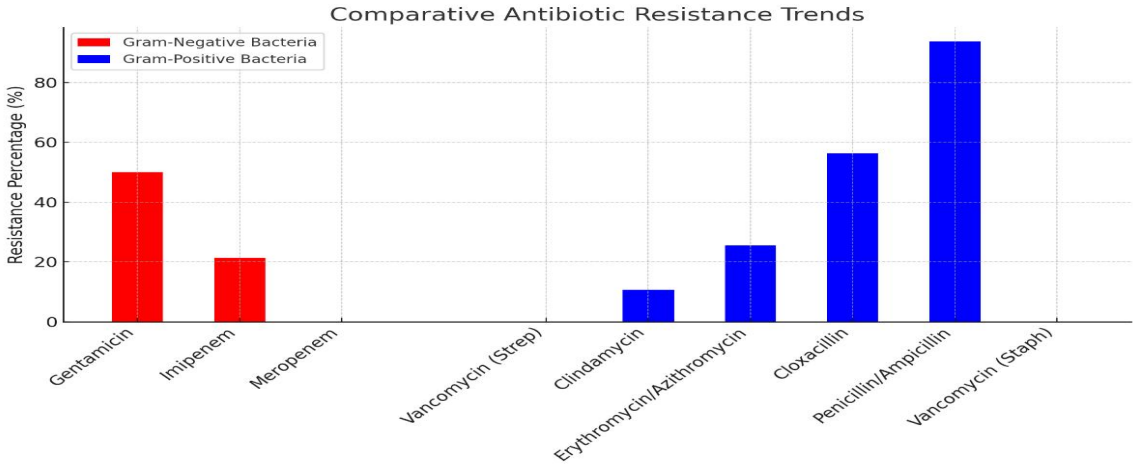
In the analysis of 761 clinical samples, *Staphylococcus aureus* and coagulase-negative *Staphylococci* (CoNS) were the most isolated pathogens, accounting for 62% of the cases. Other frequently identified pathogens included *Bacillus species* (9.6%), *Viridans streptococcus* (3.4%), *Klebsiella pneumoniae* (2.8%), and *Enterococcus faecalis* (2.4%). Less frequently encountered organisms, each comprising less than 1% of the isolates, included *Escherichia coli*, *Serratia marcescens*, and *Pseudomonas aeruginosa*. The predominance of *S. aureus* and CoNS suggests a significant burden of skin- and device-related infections, while the presence of *K. pneumoniae,* a multidrug-resistant pathogen, underscores the critical need for enhanced antibiotic stewardship and robust infection control practices to reduce the risk of hospital-acquired infections.

Figure 3. Antimicrobial Resistance Patterns



The antimicrobial resistance patterns observed in this study raise significant concerns about treatment efficacy. Among Gram-negative *Enterobacteriaceae*, gentamicin resistance was notably high at 50%, with *Klebsiella pneumoniae* showing the highest resistance rate at 76.2%. While imipenem remained effective in 78.6% of cases, the 21.4% resistance rate indicates emerging carbapenem resistance. In contrast, meropenem showed 100% sensitivity, reinforcing its importance as a last-resort treatment. For Gram-positive bacteria, *Streptococcus species* exhibited complete sensitivity to vancomycin, and clindamycin remained effective in 89.4% of cases, except for *Streptococcus agalactiae*, which was fully resistant. Sensitivity to erythromycin and azithromycin was 74.5%, though some strains showed intermediate resistance. Among *Staphylococcus species*, resistance to cloxacillin (56.3%) and penicillin/ampicillin (93.8%) was high, reflecting widespread beta-lactam resistance. However, vancomycin retained 100% efficacy, confirming its role as a reliable treatment for *Staphylococcus aureus*, including methicillin-resistant strains (MRSA). These findings emphasize the need for continuous surveillance and effective antibiotic stewardship programs to limit the spread of resistance.

Figure 4. Comparative Antibiotic Resistance



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The results reveal concerning antibiotic resistance trends among nosocomial pathogens, particularly in Gram-negative bacteria, with 50% resistance to gentamicin and a notable 21.4% resistance to imipenem, indicating emerging carbapenem resistance. However, meropenem remained fully effective. For Gram-positive bacteria, *Staphylococcus species* showed significant beta-lactam resistance (56.3% for cloxacillin and 93.8% for penicillin/ampicillin), while *Streptococcus species* exhibited resistance to clindamycin (10.6%) and macrolides (25.5%). Despite these resistances, vancomycin remained universally effective against both groups. These findings underscore the critical need for strengthened antimicrobial stewardship, infection control measures, and tailored treatment strategies to prevent further resistance development and optimize patient care.

Discussion

Prevalence and Resistance Patterns of Nosocomial Pathogens

The study identified *Staphylococcus species* as the dominant nosocomial pathogens, consistent with global research on hospital-acquired infections (HAIs) in pediatric populations (Al-Haqan et al., 2020). The high prevalence of *Bacillus species* and *Viridans streptococcus* suggests that non-traditional pathogens may also contribute to nosocomial infections in hospitalized children. The presence of opportunistic pathogens like *Enterococcus faecalis* and *Klebsiella pneumoniae* aligns with international reports highlighting their increasing role in antimicrobial resistance (Fusco et al., 2018).

Gram-negative bacteria, particularly *Klebsiella pneumoniae*, demonstrated high resistance to gentamicin (76.2%), reinforcing concerns about aminoglycoside resistance due to enzymatic modifications or efflux pumps (Lepe & Martínez-Martínez, 2022). However, *Serratia marcescens* retained full sensitivity to gentamicin, which may indicate a lower prevalence of resistance genes in this specific population. The universal sensitivity of *Enterobacteriaceae* to meropenem (100%) supports existing research on carbapenems' effectiveness but also emphasizes the importance of preserving these last-resort antibiotics (Fuyane & Shangase, 2024). Among *Streptococcus species*, vancomycin exhibited 100% efficacy, confirming its continued role as a critical treatment option.

However, resistance to clindamycin in *Streptococcus agalactiae* (100%) and intermediate susceptibility to erythromycin/azithromycin in certain isolates highlights the increasing risk of macrolide-resistant Streptococci, which could complicate empirical therapy in pediatric settings (Rampersadh et al., 2024). For *Staphylococcus species*, beta-lactam resistance remains a significant concern, with 93.8% resistance to penicillin/ampicillin and 56.3% resistance to cloxacillin. This resistance profile aligns with global data showing the widespread occurrence of penicillinase-producing staphylococci, particularly in MRSA and MRCONS (Issa & Muhsi, 2023). Despite this, vancomycin maintained universal efficacy (100%), reinforcing its importance as the preferred treatment for methicillin-resistant infections (Kawasuji et al., 2023).

Comparison with Literature

The findings of this study align with global trends in nosocomial infections and antimicrobial resistance (AMR) in pediatric hospital settings. *Staphylococcus aureus* and Coagulase-Negative Staphylococci (CONS) were the most prevalent pathogens, consistent with international studies highlighting their role in hospital-acquired infections due to their ability to form biofilms and resist antimicrobial treatments (Al-Haqan et al., 2020). The high prevalence of *Staphylococcus species* (62%) supports research identifying MRSA as a dominant nosocomial pathogen, particularly in pediatric populations (Masri et al., 2020). Additionally, the high resistance of *Enterobacteriaceae* to beta-lactam antibiotics (93.8%) aligns with reports from South Africa and other low-resource settings, where Extended-Spectrum Beta-Lactamase (ESBL)-producing organisms have emerged due to inappropriate antibiotic use (Alizadeh et al., 2020; Tilahun et al., 2021). Despite the 100% sensitivity of *Enterobacteriaceae* to meropenem, the potential emergence of carbapenem-resistant *Enterobacteriaceae* (CRE) remains a major concern, emphasizing the need for continuous surveillance to prevent reliance on last-line antibiotics (Chiotos et al., 2020; Radebe, 2019). Similarly, *Streptococcus species* exhibited universal sensitivity to vancomycin, reinforcing its role in treating resistant gram-positive infections (Raabe & Shane, 2019). The study identifies a 100% resistance rate to clindamycin and intermediate susceptibility to erythromycin in *Streptococcus agalactiae* isolates, indicating a growing threat of macrolide-resistant Streptococci. This trend aligns with findings from Ethiopia and the United States (Sahiledengle et al., 2020; Francisco et al., 2021), where increasing resistance to these antibiotics has been reported. For *Staphylococcus* species, a 93.8% resistance rate to penicillin/ampicillin corresponds with global trends of widespread penicillinase production. However, vancomycin remains fully effective, underscoring its continued importance in managing MRSA and MRCONS infection (Kawasuji et al., 2023).

The study highlights the economic burden of antimicrobial resistance (AMR) in pediatric hospitals, noting longer stays, higher costs, and increased

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morbidity and mortality, especially in resource-limited settings like South Africa. It contributes to the WHO's call for localized epidemiological data (WHO, 2020) by providing AMR data from Addington Hospital, which can guide infection control policies and antimicrobial stewardship programs to address rising resistance trends.

Generalizability

The study's findings have limited generalizability due to its single-center design at Addington Hospital, which may not reflect practices in other healthcare settings. Regional differences in pathogen prevalence, antimicrobial resistance, and retrospective data collection introduce potential biases. Additionally, the focus on pediatric inpatients aged 0–14 years restricts applicability to adults, outpatient settings, or other regions. Therefore, caution is needed when extrapolating these results without further multi-center validation.

Conclusions

This study provides critical insights into the prevalence and antimicrobial resistance patterns of nosocomial pathogens in pediatric patients at Addington Hospital. The high prevalence of *Staphylococcus species* (62%), along with significant beta-lactam resistance (93.8%), raises concerns about the growing burden of AMR in hospital settings. The universal sensitivity of *Enterobacteriaceae* to meropenem (100%) and the continued efficacy of vancomycin (100%) offer promising treatment options, but the potential emergence of carbapenem-resistant *Enterobacteriaceae* (CRE) and vancomycin-resistant *Staphylococcus aureus* (VRSA) necessitates strict antimicrobial stewardship (Chiotos et al., 2020; Kawasuji et al., 2023). Addressing nosocomial infections and the rise of antimicrobial resistance requires a multifaceted approach. Strengthening infection control measures, implementing robust antimicrobial stewardship programs, and enhancing surveillance efforts are critical in mitigating the spread of resistant pathogens. Additionally, continuous training of healthcare professionals on responsible antibiotic use and further research into alternative treatment options are essential to reducing the burden of therapy-resistant infections. By adopting targeted, evidence-based interventions, healthcare institutions, particularly those specializing in pediatric care, can significantly improve patient outcomes and reduce infection rates.

Limitations of the Study

While this study provides valuable insights into the prevalence and antimicrobial resistance patterns of nosocomial infections in pediatric patients at Addington Hospital, several limitations should be acknowledged:

- **Single-Centre Design**: The research was conducted at a single tertiary healthcare facility, which limits the generalizability of the findings. Nosocomial infection rates and resistance profiles may differ significantly in other hospitals, especially those with different infrastructure, infection control policies, patient demographics, and antibiotic stewardship practices.
- **Scope and Statistical Constraints**: The study focused on pediatric patients aged 0–14 years, limiting its applicability to adults or neonates with different clinical profiles. Despite analyzing 761 patient records, the low frequency of certain pathogens hindered robust statistical comparisons, potentially masking emerging resistance trends in these groups.
- **Lack of Molecular Characterization**: The study relied on phenotypic methods for pathogen identification and antibiotic susceptibility testing. Molecular techniques, such as PCR for resistance gene detection or whole-genome sequencing, were not employed, which could have provided more precise insights into resistance mechanisms and strain-relatedness.
- **Absence of Clinical Outcome Data**: The study did not assess clinical outcomes such as length of hospital stay, treatment success, or mortality rates. As a result, the direct impact of antimicrobial resistance on patient prognosis remains unexplored.

Recommendations

Based on the findings of this study, the following recommendations are proposed to mitigate the burden of nosocomial infections and antimicrobial resistance in pediatric healthcare settings:

- **Strengthen Infection Prevention and Control (IPC) Measures**: This includes regular hand hygiene audits, sterilization of medical equipment, routine environmental cleaning, and isolation of infected patients when necessary to prevent cross-transmission of pathogens.
- **Enhance Antimicrobial Stewardship Programs**: A multidisciplinary team should oversee antibiotic use, promote rational prescribing, and provide healthcare worker training. Emphasis should be placed on using narrow-spectrum antibiotics and limiting broad-spectrum agents to clinically justified cases.
- **Continuous Surveillance**: Ongoing monitoring of resistance patterns is essential for early

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detection of emerging strains. Hospitals should maintain an updated antibiogram and align laboratory data with clinical decision-making.

- **Introduce Molecular Diagnostics**: Adopting molecular techniques, such as PCR and whole-genome sequencing, enables rapid detection of resistance genes and supports targeted therapy, particularly in high-risk areas like pediatric intensive care units.
- **Healthcare Worker Training and Education**: Regular workshops should be conducted to keep healthcare staff informed on the latest infection prevention and control (IPC) guidelines, resistance mechanisms, and best practices in antimicrobial prescribing.
- **Public Awareness Campaigns:** Educating caregivers and the public on proper antibiotic use and treatment adherence helps reduce community-acquired resistance affecting hospitals**.**
- **Explore Alternative Therapies:** Given the increasing resistance to conventional antibiotics, further research into alternative treatments, such as plant-derived antimicrobial agents, is recommended. These may provide complementary or synergistic effects against multidrug-resistant pathogens (Nsele et al., 2024).

Author Biography

1. **Sibahle Mtimbeni** is a biomedical science graduate from Mangosuthu University of Technology in Durban, South Africa. Her research interests focus on antimicrobial resistance, nosocomial infections, and the application of molecular diagnostics in pediatric populations.
1. **Siyabonga Protus Radebe** is a lecturer and researcher in the Department of Biomedical Sciences at Mangosuthu University of Technology (MUT) in Durban, South Africa. His expertise encompasses clinical pathology, with research interests focusing on antibiotic stewardship, traditional medicine, ethnopharmacology, public health, and translational research aimed at enhancing infection control in public healthcare settings**.**

Author Contributions

1. **Sibahle Mtimbeni** contributed to the study design, data collection, laboratory analysis, and manuscript drafting.
2. **Siyabonga Protus Radebe** supervised the project, performed data analysis, and provided critical revisions to the manuscript. Both authors read and approved the final version of the manuscript.

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List of Abbreviations

- **AMR** – Antimicrobial Resistance
- **CLSI** – Clinical and Laboratory Standards Institute
- **CoNS** – Coagulase-negative *Staphylococci*
- **CRE** – Carbapenem-Resistant *Enterobacteriaceae*
- **ESBL** – Extended-Spectrum Beta-Lactamase
- **HAI** – Hospital-Acquired Infection
- **IPC** – Infection Prevention and Control
- **MDRO** – Multidrug-Resistant Organism
- **MRCONS** – Methicillin-Resistant Coagulase-Negative *Staphylococci*
- **MRSA** – Methicillin-Resistant *Staphylococcus aureus*
- **MSSA** – Methicillin-Sensitive *Staphylococcus aureus*
- **NHLS** – National Health Laboratory Service
- **NI** – Nosocomial Infection
- **SPSS** – Statistical Package for the Social Sciences
- **VRSA** – Vancomycin-Resistant *Staphylococcus aureus*
- **WHO** – World Health Organization

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to patient confidentiality agreements. However, anonymized data may be made available from the corresponding author upon reasonable request and with appropriate institutional approvals.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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