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Original article

ANTIMICROBIAL RESISTANCE PATTERNS IN PAEDIATRIC PATIENTS: A RETROSPECTIVE ANALYSIS OF MICROBIAL ISOLATES AND ANTIBIOTIC SUSCEPTIBILITY.

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Abstract

Introduction:

This study aimed to determine the frequency and antibiotic resistance patterns of various organisms isolated from paediatric samples in a South African hospital. Antibiotic resistance is a growing concern in healthcare, particularly in paediatric patients who are more vulnerable to infections. It was conducted in an attempt to address the lack of data on the prevalence of antibiotic-resistant organisms in South African paediatric patients.

Methodology:

A retrospective study was conducted on microbiological results of paediatric samples obtained between 2017 and 2018 at a tertiary hospital in South Africa. Organisms were identified using standard microbiological techniques, and their antibiotic susceptibility patterns were determined using the Kirby-Bauer disc diffusion and Vitek method.

Results:

Of the 165 organisms isolated, the most common were Acinetobacter baumannii (20.6%), Klebsiella pneumoniae (16.3%), and Enterobacter cloacae (10.9%). High rates of resistance were observed to commonly used antibiotics, including amikacin, ciprofloxacin, and augmentin. Candida albicans and Candida spp. showed high resistance rates to fluconazole.

Conclusion:

This study underscores the importance of continued surveillance of antibiotic resistance patterns in paediatric patients in South Africa. The high prevalence of antibiotic-resistant organisms and limited treatment options emphasize the need for implementing antibiotic stewardship programs, strengthening infection control measures, and conducting ongoing surveillance. Additionally, investment in research and development, along with promoting education and awareness, is crucial for effectively managing antimicrobial resistance in this population.

Recommendation:

These recommendations will guide the selection of empiric therapy and aid in the development of antibiotic stewardship programs in South African hospitals.

Keywords: Antimicrobial resistance, Paediatrics, Bacterial infections, Drug resistance, Hospital-acquired infections., Submitted: 2023-06-07 Accepted: 2023-06-17 https://doi.org/10.51168/sjhrafrica.v4i6.467

1. Background:

Antibiotics were originally called "magic bullets" for their ability to kill bacteria. However, the emergence of bacterial resistance shortly after the introduction of penicillin highlighted the limitations of this approach. The term "antibiotic" comes from the Greek word meaning "against living organisms", but in medical science, it is defined as a substance that can eliminate or inhibit bacteria. The concept of "susceptibility" is used to describe the response of microorganisms to antibiotics, whereas "resistance" is derived from the Latin word meaning "to withstand" and refers to the situation where bacteria continue to grow and multiply despite the presence of antimicrobial agents. Recent research highlights the global public health challenge posed by antibiotic resistance, with new strains of antibiotic-resistant bacteria emerging and posing a threat to human health (Ventola, 2015; Levy et al., 2021).

Antibiotic resistance is a significant global public health issue, leading to increased morbidity, mortality, and healthcare costs (World Health Organisation (WHO), 2020). Studies have linked prolonged hospital stays with the development of antibiotic-resistant bacteria, such as methicillin-resistant *Staphylococcus aureus* (MRSA), penicillin-resistant *Streptococcus pneumoniae*, and Extended Beta-Lactamase-Producing (ESBL) *Escherichia coli* and *Klebsiella* spp (WHO, 2020; Saini et al., 2021). Limited diagnostic capacity and antimicrobial resistance surveillance in Sub-Saharan Africa contribute to the problem (Moyo et al., 2023). Monitoring prevalence and antimicrobial susceptibility patterns is crucial for modifying treatments and hospital policies, especially in paediatrics (Habyarimana et al., 2021). The urgent need for global efforts to combat antibiotic resistance is underscored by increasing resistance rates and associated fatalities worldwide (WHO, 2021; Hunter, 2020). Factors contributing to antimicrobial resistance include over-prescription of antibiotics, non-compliance, poor hygiene, inadequate surveillance, and limited research (WHO, 2021). The cost implications of antibiotic resistance are high, particularly in developing countries, necessitating effective prevention strategies and increased research (Achi et al., 2023; Moyo et al., 2023).

1.1. *The rationale for the study:*

Bacterial infections in low-income and developing countries are a major contributing factor to morbidity and mortality, according to WHO (2021). The resistance of bacteria to antibiotics further delays the treatment and management of infectious diseases in these regions. Additionally, there is the problem of the availability of antibiotics without prescription, and the frequent use of antibiotics in developing nations, with profound repercussions for antibiotic resistance in nations that have limited health budget allocations due to lack of or expensive alternative medicine. Notwithstanding the importance of antimicrobial resistance particularly in paediatric samples, there is scarce published scholarly information on this topic. Moyo (2023) points out that the available data in the African continent indicates a significant antimicrobial resistance. Therefore, the proposed study aims to gain more knowledge of the antimicrobial resistance patterns of paediatric samples at King Edward VII Hospital.

1.2. *Aim of the study*

This study aimed to collect and analyse data on bacterial strains with antimicrobial resistance during a specific period, classify ineffective antibiotics against the bacterial isolates, and determine the extent of antimicrobial resistance in paediatric samples.

2. Methodology:

2.1. *Study Design:*

The research design distinctly outlines the significant activities of the study during the research process. The study utilized a quantitative, retrospective, and descriptive cohort design.

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2.2. *Study Setting:*

The research was conducted at the paediatric ward in King Edward VIII Hospital, located in KwaZulu Natal, Durban, South Africa. This tertiary hospital setting was selected for its availability of pediatric patients and the necessary diagnostic laboratory facilities.

2.3. *Sampling Strategy, collection methods, and tools:*

The study employed a convenience sampling strategy, where the researchers selected specimens from patients who were admitted to a tertiary hospital in South Africa. The specimens were collected from various sources, including blood, urine, sputum, and wound swabs. The collection methods involved standard aseptic techniques, and the samples were processed and identified using standard microbiological techniques. The tools used in the study included antimicrobial susceptibility testing, which involved the use of various antibiotics such as Amikacin, Augmentin, Ciprofloxacin, Colistin, Imipenem, Meropenem, Tazobactam, and Fluconazole.

The diagnostic laboratory understudy employed two methods, namely the Vitek and Kirby Bauer methods, in carrying out antimicrobial susceptibility testing. The use of a convenience sampling strategy allowed the researchers to collect specimens from readily available patients, which was a cost-effective and efficient approach. However, this strategy may introduce selection bias since the patients selected may not be representative of the general population. Additionally, the study relied on samples collected from a single hospital, which may not be generalizable to other healthcare settings or populations. Overall, the collection methods and tools used in the study were selected due to being standard and reliable, which ensured the accuracy and validity of the results.

2.4. *Data Analysis:*

The study utilized percentages and frequencies to organize and quantify the data collected. Percentages and frequencies were used to describe the distribution of variables, identify patterns in the data, summarize key findings, evaluate data, and arrive at valid, relevant, and reasonable conclusions.

2.5. *Ethical considerations:*

This study adhered to ethical principles by obtaining permission from the clinical laboratory to access relevant information while ensuring confidentiality, privacy, and anonymity of patients. Only barcoded samples received from the paediatric ward were used, and the data extracted included sample number, age, and results.

The study was subjected to review and approval by an Institutional Research Committee of the Mangosuthu University of Technology, and consent was obtained from the clinical laboratory management to access the data.

3. Results and Discussion

The study analysed a total of 165 samples collected from the paediatric ward to determine the antimicrobial resistance patterns in paediatric patients. The gender distribution showed that 67% (n=111) of the samples were from females, while 33% (n=54) were from males. Notably, both genders were represented in the sample.

The organisms listed in **Table 2** are Acinetobacter baumannii, Acinetobacter haemolyticus, Acinetobacter spp, Citrobacter koseri, Enterobacter cloacae, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Pseudomonas spp, Serratia marcescens, Stenotrophomonas maltophilia, Morganella morganii, Candida albicans, and Candida spp. The antibiotics listed are Amikacin, Augmentin, Ciprofloxacin, Colistin, Imipenem, Meropenem, Tazobactam/Pipercillin, and Fluconazole. **Table 2** shows the number of organisms that are resistant to each antibiotic.

Acinetobacter baumannii has high resistance to several antibiotics, including Augmentin, Ciprofloxacin, Imipenem, Meropenem, and Tazobactam/piperacillin. *Klebsiella pneumoniae* also shows high resistance to several antibiotics, including Amikacin, Ciprofloxacin, Colistin, and Meropenem. These findings are consistent with recent studies that have shown an increasing

Table 1: Depicts various organisms isolated from paediatric samples during the period under study. There were 68 % (n=112), 24 % (n=40), and 8 % (n=13) microorganisms isolated, namely, Gram-negative, Gram Positive, and lastly yeasts.

ORGANISMS	Frequency (n)	Percentage (%)
Acinetobacter spp	1	0.6
Stenotrophomonas maltophilia	1	
Streptococcus Group G	1	
Staphylococcus haemolyticus	1	
Acinetobacter haemolyticus	2	1.21
Morganella morganii	2	
Citrobacter koseri	2	
Enterococcus faecium Pseudomonas spp	2	
	2	
Candida albicans	3	1.81
Pseudomonas aeruginosa	5	3.0
Serratia marcescens	9	5.4
Streptococcus pneumoniae	7	4.24
Enterococcus faecalis	6	3.6
Serratia marcescens	9	5.4
Candida spp	10	6.06
Staphylococcus aureus	14	8.4
Escherichia coli	16	9.6
Enterobacter cloacae	18	10.9
Klebsiella pneumoniae	27	16.3
Acinetobacter baumannii	34	20.6

prevalence of multidrug-resistant bacteria in hospitals, particularly in intensive care units and paediatric wards (Perez-Palacios et al., 2023). The emergence of antibiotic-resistant strains is a major concern, as it limits the effectiveness of current treatments and poses a threat to public health.

Secondly, *Klebsiella pneumoniae* showed resistance to multiple antibiotics. However, *K. pneumoniae* is nearly always resistant to commonly prescribed drugs, like, ampicillin, amoxicillin, cephalosporin, aminoglycosides, and β-lactam antimicrobial agents (Saha, 2019). The choice of antibiotic for treating Klebsiella infections depends on factors like strain, infection site, severity, and susceptibility. Common options include carbapenems, cephalosporins, aminoglycosides, and fluoroquinolones (Prince et al., 1997). Quinolines which include ciprofloxacin, play a significant role in *K. pneumoniae* treatment (Wang et al., 2022). Previous studies have reported the effectiveness of amikacin against carbapenem-resistant Klebsiella pneumoniae infections (Rodrigues et al., 2021). However, resistance to amikacin, augmentin, ciprofloxacin, and tazobactam limits treatment options. Alternative antibiotics must be considered.

In addition, the high prevalence of *Candida spp*. resistance to fluconazole is also a matter of concern, as this drug is commonly used to treat fungal infections in paediatric patients (Tortorano et al., 2021). These findings highlight the need for ongoing surveillance of antibiotic resistance patterns and the development of new treatment strategies

Table 2: **The organism and their antimicrobial resistance patterns**

Organisms	n	THE ANTIBIOTICS AND THEIR RESPECTIVE RESISTANT ORGANISMS							
		Amikacin	Augmentin	Ciprofloxacin	Colistin	Imipenem	Meropenem	Tazobactam	Fluconazole
Acinetobacter baumannii	**34**	9	34	2	2	31	31	34	0
Acinetobacter haemolyticus	**2**	0	0	0	0	2	2	2	0
Acinetobacter spp	**1**	1	1	1	0	1	1	1	0
Citrobacter koseri	**2**	0	0	0	0	0	0	0	0
Enterobacter cloacae	**18**	0	18	4	0	2	5	7	0
Escherichia coli	**14**	5	9	8	0	0	0	0	0
Klebsiella pneumoniae	**27**	19	25	24	1	9	9	23	0
Pseudomonas aeruginosa	**5**	0	5	0	0	0	0	0	0
Pseudomonas spp	**2**	0	2	0	0	0	0	0	0
Serratia Marcescens	**9**	0	9	6	8	6	6	6	0
Stenotrophomonas Maltophilia	**1**	0	1	1	0	0	0	1	0
Morganella morganii	**2**	0	0	0	0	0	0	0	0
Candida albicans	**3**	0	0	0	0	0	0	0	0
Candida spp	**10**	0	0	0	0	0	0	0	3

to combat multidrug-resistant organisms.

Table 1 presents the distribution of various organisms isolated from paediatric samples during the period under study. Among the isolated organisms, *Acinetobacter baumannii* was the most frequently isolated (20.6%), followed by *Klebsiella pneumoniae* (16.3%) and *Enterobacter cloacae* (10.9%). Other gram-negative bacteria such as *Escherichia coli* (9.6%), *Serratia marcescens* (5.4%), and *Pseudomonas aeruginosa* (3.0%) were also isolated.

The gram-positive bacteria isolated were *Staphylococcus aureus* (8.4%), *Streptococcus pneumoniae* (4.24%), and *Enterococcus faecalis* (3.6%). Additionally, *Candida spp* (6.06%) and *Candida albicans* (1.81%) were isolated as well.

These findings are consistent with recent studies that have identified *Acinetobacter baumannii* and *Klebsiella pneumoniae* as common causes of nosocomial infections in paediatric patients (Hung et al., 2022). The high frequency of *Enterobacter cloacae* is also noteworthy, as it has been associated with outbreaks in neonatal intensive care units (Moyo et al., 2023). Additionally, the isolation of *Candida spp* is in line with other studies that have reported an increase in the incidence of candidemia in paediatric patients (Kilpatrick et al., 2022).

The results highlight the diversity of organisms that cause infections in paediatric patients. The identification of specific organisms and their frequencies is crucial in guiding empiric antimicrobial therapy and implementing infection control measures to prevent outbreaks. The results of the study showed that various organisms were isolated from paediatric samples during the period under study.

Among the most prevalent organisms isolated were *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Enterobacter cloacae*. These findings are consistent with a recent study that identified these organisms as common causes of hospital-acquired infections in paediatric patients in Kenya (Patil et al., 2022).

Resistance patterns of the isolated organisms were also assessed against different antibiotics. The results showed that most organisms exhibited resistance to multiple antibiotics, with *Acinetobacter baumannii* being the most resistant organism to all tested antibiotics except for fluconazole. This is a concerning finding, as it highlights the challenge in treating infections caused by these organisms, especially in settings with limited treatment options.

One potential explanation for the high prevalence of multi-drug resistance observed in this study could be the overuse and misuse of antibiotics in paediatric patients. It is essential to have appropriate antibiotic stewardship programs to ensure the rational use of antibiotics to prevent the development of antibiotic resistance.

In addition, other interventions, such as infection control measures, can be used to prevent the spread of infections caused by resistant organisms. In conclusion, the study highlights the prevalence of resistant organisms in paediatric patients and the need for appropriate interventions to combat the issue of antibiotic resistance. Clinicians and healthcare institutions should implement proper antibiotic stewardship and infection control measures to prevent the spread of resistant infections and improve patient outcomes.

4. Conclusion:

The study analyzed 165 samples from the paediatric ward and identified various organisms with antimicrobial resistance patterns. The most frequently isolated organisms were Acinetobacter baumannii, Klebsiella pneumoniae, and Enterobacter cloacae, indicating their significance as causative agents of hospital-acquired infections in paediatric patients. The study also revealed high levels of resistance among these organisms to multiple antibiotics, limiting treatment options. Furthermore, Candida spp. demonstrated a concerning resistance to fluconazole, commonly used to treat fungal infections in paediatric patients. These findings emphasize the urgent need for ongoing surveillance of antimicrobial resistance and the development of alternative treatment strategies to combat multidrug-resistant organisms.

5. Recommendations:

Based on the study findings, it is recommended to implement antibiotic stewardship programs and strengthen infection control measures in healthcare institutions to ensure rational antibiotic use and prevent the spread of resistant organisms. Ongoing surveillance of antimicrobial resistance patterns should be conducted to guide treatment decisions and detect outbreaks early. Investment in research and development is needed to identify new treatment strategies against multidrug-resistant organisms. Public education campaigns should raise awareness about appropriate antibiotic use and infection prevention practices. Implementing these recommendations will contribute to the effective management of antimicrobial resistance, improve patient outcomes, and preserve the effectiveness of antibiotics for future generations.

6. Limitations:

Several limitations to this study should be considered. First, the study only includes data from one hospital over a limited period. This means that the findings may not be representative of other hospitals or regions, and the results cannot be generalized to a broader population. Second, the study only focused on paediatric patients. The resistance patterns in adult patients may differ from those seen in paediatric patients. Third, the study did not collect data on the patient's previous antibiotic use or underlying medical conditions. These factors can impact the incidence and types of infections seen, as well as the resistance patterns observed. Finally, the study did not investigate the mechanisms underlying the antibiotic resistance observed in the bacterial isolates. Further studies are needed to explore the molecular mechanisms of resistance and the spread of resistant strains. Overall, while this study provides valuable information on the antibiotic resistance patterns of bacterial isolates in a paediatric population, its limitations highlight the need for further research to fully understand the scope and complexity of antibiotic resistance.

7. Signiftcance of the study:

The significance of this study lies in its contribution to the understanding of the microbial profile and antibiotic resistance patterns in paediatric patients. By identifying the most prevalent organisms and their resistance patterns, this study can inform clinical decision-making and guide appropriate antibiotic therapy for paediatric patients.

Additionally, the study highlights the importance of continued surveillance of antibiotic resistance patterns to monitor trends over time and to inform the development of effective antibiotic stewardship programs. As antibiotic resistance becomes an increasingly urgent public health concern, studies like this one are critical for guiding efforts to address this issue.

8. Future research opportunities:

Based on the limitations of this study, several suggestions for future research could help to address some of these limitations and expand upon the current findings. Some of these suggestions include:

The larger sample size limitation of this study is the relatively small sample size. Future research could benefit from larger sample sizes, which would increase the generalizability of the findings and allow for more robust statistical analyses.

8.1.

8.1.1. Multicenter study:

This study was conducted in a single hospital, which may limit the generalizability of the findings to other hospitals and regions. A multicenter study involving multiple hospitals could provide a more representative sample and allow for comparisons between different hospitals and regions.

8.1.2. Longitudinal study:

This study was cross-sectional, meaning that data were collected at a single point in time. A longitudinal study that follows patients over time could provide more information on the dynamics of antibiotic resistance patterns and help to identify risk factors for the development of resistance.

8.1.3. Comparative analysis of different age groups:

This study focused on paediatric patients, but it would be interesting to compare antibiotic resistance patterns between different age groups, such as adults and the elderly. This could provide insights into differences in risk factors, treatment approaches, and outcomes between different populations.

By addressing these limitations and conducting further research, we can gain a more comprehensive understanding of antibiotic resistance patterns and develop more effective strategies for the prevention and treatment of antibiotic-resistant infections.

Overall, this study contributes to the broader understanding of antibiotic resistance patterns in paediatric patients and underscores the importance of continued research and surveillance in this area.

8.1.4. Dating Sharing Statement:

The data utilized in the study will be availed if required while adhering to ethical standards.

9. Acknowledgements:

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10. Conflict of interest:

The authors report no conflict of interest for the work presented.

11. Source of funding:

The study did not receive any form of funding from public or private agencies.

12. List of abbreviations:

- ESBL - Extended Beta-Lactamase-Producing
- MRSA - Methicillin-Resistant Staphylococcus aureus
- WHO - World Health Organisation

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