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The Prevalence, Patterns, and Trend of Antimicrobial Resistance among Patients at Kumi Orthopaedic Center: A Retrospective Study

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Abstract

Background: Antimicrobial Resistance (AMR) has been recognized as a global public health problem of utmost importance that needs to be tackled. Low-income countries such as Uganda have the greatest burden of severe and life-threatening infections and are most likely to suffer more from the spread of untreatable resistant bacteria. Despite the generally increasing trends in AMR, there is hardly any documented data on AMR in orthopedic care. **Methods:** We analyzed data from the pathogenic isolates from pus and tissue from the laboratory from 2019 to 2023. We calculated the proportions of isolates resistant to commonly used antimicrobial classes. We used the chi-square test for trends to evaluate changes in AMR across the study period. **Results:** Out of the 286 isolates, 104 (43.5%) were from pus, 112 (46.9%) were from tissue samples and the remaining 9.6% were from different fluid aspirates like synovial fluid. Most of the isolates were from males (64.2%) and aged between 19 and 45 years (46.2%). The distribution of whether the bacteria were gram-positive or negative was relatively equal with 114 (45.2%) being gram-negative and 120 (47.6%) gram-positive. Generally, there was increased AMR across all antibiotics from 2019 to 2021 *e.g.* for Imipinem, it went from 0% in 2019 to 70.8% in 2021 and for Amoxyclav, it went from 10% in 2019 to 93.2% in 2021. There was a general decline in AMR noted from 2021 to 2023. However, currently, the highest resistance is noted in ceftriaxone (80.0%) and the lowest in Imipinem (11.76%). **Conclusion:** There is a general decreasing trend in AMR, most probably due to increasing policies governing the use of antibiotics. However, there is still high resistance to commonly used and affordable antibiotics. Continuous monitoring of AMR is still recommended to reduce the AMR problem in Uganda at large through public health policy and planning.

Keywords

Antimicrobial Resistance, Prevalence, Trend

1. Introduction

Antibiotics have revolutionized medicine, including improving orthopedic surgical and implant outcomes, in many respects, and have transformed human health and well-being for the better.

Before the use of antibiotics, the fatality rate for *Staphylococcus aureus* (*S. aureus*) bacteremia was high and most wound infections were treated by amputation; for instance, approximately 70% of amputations in World War I were a result of wound infections [1]. The introduction of antibiotics has dramatically improved the fate of infected patients and has changed the way various diseases and surgical procedures are treated. The ability of antibiotics to treat and cure infection has dramatically reduced the number of incidences of infection, significantly improving the quality of life for numerous patients, reducing childhood mortality, increasing life expectancy, and saving numerous lives. Unfortunately, the discovery and increasingly widespread use (especially the misuse) of antibiotics have led to the rapid appearance of antibiotic-resistant strains today; more and more infections are caused by microorganisms that fail to respond to conventional treatments.

Antimicrobial resistance is an important threat to international health. Antimicrobial Resistance (AMR) has been recognized as a global public health problem of utmost importance that needs to be tackled urgently [2]. AMR not only impacts healthcare directly, causing numerous deaths in Europe and around the world, but also diminishes quality of life leading to substantial direct and indirect costs [3]. Unless action is taken, it is estimated that by 2050, up to 10 million people will die each year because of AMR. AMR is a problem that concerns every country irrespective of its level of income and development as resistant pathogens do not respect borders. Higher AMR rates have been documented in several low and middle-income countries compared to rates in high-income countries [4] [5].

Low-income countries, such as Uganda, have the greatest burden of severe and life-threatening infections and are most likely to suffer more from the spread of untreatable resistant bacteria.

Therapeutic guidelines for empirical treatment of common life-threatening infections depend on available information regarding microbiology etiology and antimicrobial susceptibility. However, there is limited information on the prevalence of antibiotic-resistant strains especially in orthopaedic medicine for a low-income country like Uganda providing a need for this study.

2. Methods

2.1. Study Design

This was a hospital-based retrospective cohort study conducted in Kumi Orthopaedic Center between January 2014 and December 2023. The hospital is the only specialized orthopedic center in the region serving a majority of people.

The study population consisted of patients who developed orthopedic-related infections as diagnosed clinically and had samples taken for culture and sensitivity testing.

2.2. Data Collection and Laboratory Procedures

Demographic and clinical characteristics from patients were collected using a structured data abstraction tool. The infected site was cleaned using normal saline and sterile gauze, and then a sample was taken from the patient and immediately transported to the laboratory.

Samples were processed in Kumi Orthopaedic Center Laboratory immediately after collection. The sample was inoculated into MacConkey agar and incubated for 24 - 48 hours aerobically or anaerobically. Then the colonies were used to make smears for gram staining to qualify as either gram positive or gram negative. Identification of bacteria was not done.

Following the qualification of the bacteria, a standard disc diffusion technique for drug susceptibility test (DST) was performed as recommended by Clinical and Laboratory Standards. Data collected was then analyzed for means and percentages using Stata statistical software version 17.0.

2.3. Ethical Issues

Ethical approval and waiver of consent were granted by Mbale Regional Referral Hospital Research and Ethics Committee (Ref no MRRH-2024-417). All patient information was kept confidential in password-protected computers and locked cabinets.

3. Results

Of the 286 participants, the average age was 31.6 years (SD: 201.1). Majority were male 183 (64%) and the females were 103 (36%). The most common specimen used was tissue from the site of infection 112(46.9%). The culture positivity rate was 82.4% with the catch rate in pus (83.2%) being higher than that in tissue samples (81.75%). The Gram-positive cocci and Gram-negative rods were approximately equal constituting 50.4% and 49.6% respectively. Almost all the cultures were incubated aerobically (98.8%) (**Table 1**).

Generally, there was increased resistance among the gram-negative bacteria compared to the gram-positive bacteria across most of the antibiotics tested (Figure 1).

Table 1. Socio-demographic and Clinical characteristics of the 286 participants.

Variable	Frequency	Percentage (%)
Age (years) (Mean, SD)	31.6 (20.1)	
Sex		
Male	183	64
Female	103	36
Specimen		
Pus swab	104	43.5
Tissue	112	46.9
Wound swab	15	6.3
Synovial	2	0.8
Aspirate	4	1.7
Urine	2	0.8
Gram type		
Gram cocci	136	50.4
Gram rods	134	49.6
Colonies		
Aerobic	253	98.8
Anaerobic	3	1.2

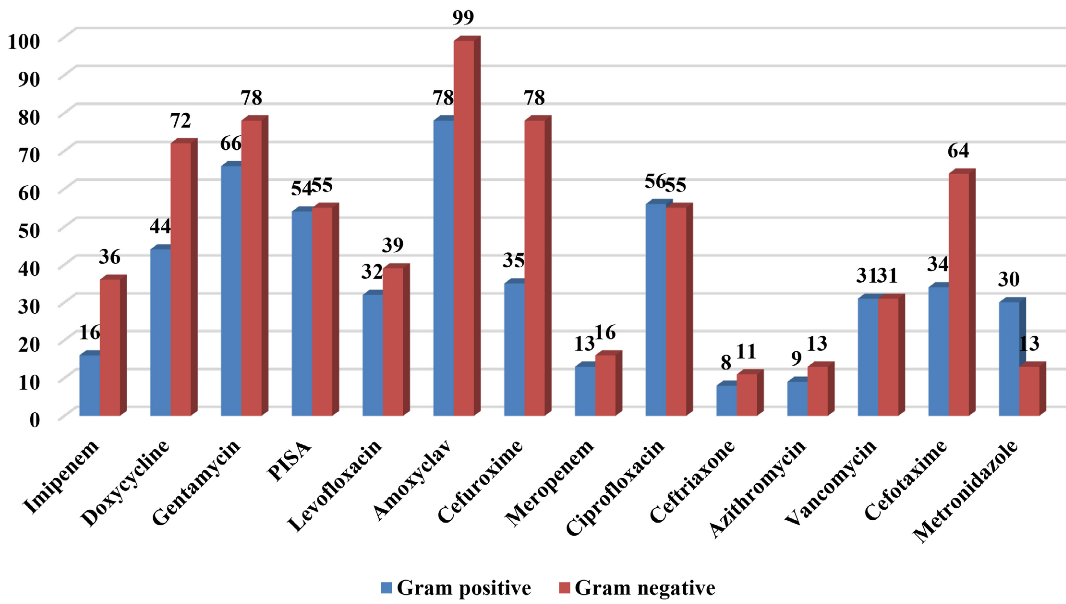

Figure 1. Comparison of Resistance among gram-negative and gram-positive bacteria to commonly used Antibiotics.

There was generally an increase in AMR across all antibiotics from 2019 to 2021 and then a decline in AMR was noted from 2021 to 2023. The highest resistance was noted in Ceftriaxone (80.0%) followed by Amoxyclav (70.1%). The antibiotics with the least resistance were Imipenem (11.8%) followed by Meropenem (12.9%) (Table 2, Table 3, Figure 2).

Table 2. Comparison of Resistance among gram-negative and gram-positive bacteria to commonly used Antibiotics.

Drug	Resistance in gram-negative bacteria	Resistance in gram-positive bacteria	P-value
Imipenem	36	16	**0.005**
Doxycycline	72	44	**0.000**
Gentamycin	78	66	0.062
PISA	55	54	0.969
Levofloxacin	39	32	0.203
Amoxyclav	99	78	**0.001**
Cefuroxime	78	35	**0.000**
Meropenem	16	13	0.526
Ciprofloxacin	55	56	0.938
Ceftriaxone	11	8	0.327
Azithromycin	13	9	**0.010**
Cefotaxime	64	34	**0.000**
Vancomycin	31	31	0.107
Metronidazole	13	30	0.781

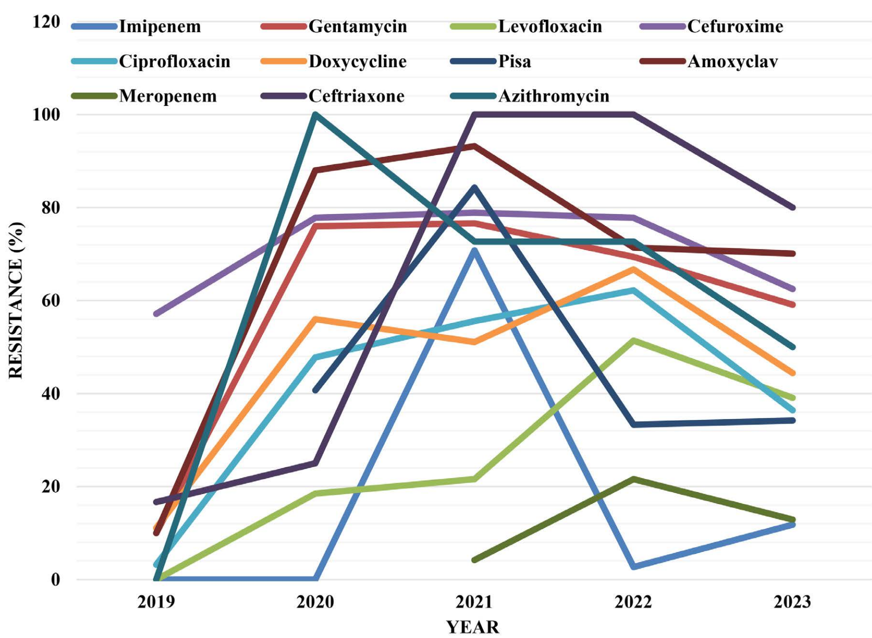

Figure 2. Graphical representation of Trends of AMR at KOC over the last 5 years.

Table 3. Trends of AMR for commonly used antibiotics over the past 5 years.

Year	2019	2020	2021	2022	2023	P-value
Imipenem	0	0	70.8	2.7	11.8	**0.000**
Gentamycin	10	76	76.6	69.4	59.1	**0.000**
Levofloxacin	0	18.5	21.6	51.4	39.1	**0.000**
Cefuroxime	57.14	77.8	78.9	77.8	62.5	0.373
Ciprofloxacin	3.2	47.8	55.6	62.2	36.4	**0.000**
Doxycycline	11.1	56	51.1	66.7	44.4	**0.003**
PISA		40.7	84.3	33.3	34.2	**0.000**
Amoxyclav	10	88	93.2	71.4	70.1	**0.000**
Meropenem			4.2	21.6	12.9	**0.037**
Ceftriaxone	16.67	25	100	100	80	**0.003**
Azithromycin	0	100	72.7		50	0.078

4. Discussion

AMR is a challenge in both developed and developing countries. However, AMR prevalence varies considerably geographically in different continents, regions, and countries.

The Sub-Saharan African region is disproportionately affected by AMR, in part owing to the prevailing high levels of poverty which result in a high burden of infectious diseases, poor regulation of antimicrobial use, and lack of alternatives to ineffective antimicrobials.

AMR in Africa has led to severe infections, increased morbidity, treatment failure, increased length of hospital stay, higher healthcare costs, and decreased labor supply and efficiency.

This study reported the prevalence, trends, and patterns of AMR to commonly used antibiotics for treatment in mainly Orthopaedic-related infections. We found a high prevalence of AMR at 49.7% with higher resistance noted in gram-negative bacteria (55.7%)compared to the gram-positive bacteria (44. 3%). This is similar to findings by studies in Ethiopia [6] and India [7]. The high AMR prevalence could be attributed to the fact that most of the cases handled at the hospital are referral cases that could have earlier been exposed to several antibiotics and could have developed resistance to them. Over-the-counter medication access in developing countries such as Uganda is one of the drivers of AMR [8].

The culture positivity rate was 82.4%. This was similar to what is reported in literature that ranges from 75% to 93% [6] [9]. The culture positivity rate was observed more in pus swabs than in tissue cultures. Similar outcomes were reported in previous studies conducted in the United States and Greece [10] [11]. In contrast, studies conducted in China and Italy found tissue culture more effective in isolating causative pathogens compared to swab cultures [12] [13]. In addition, a systematic review found tissue cultures and biopsies superior to swab cultures in detecting infection, especially for deep wound infections [14]. The differences in findings compared to those in this study could be explained by the technique used in collecting the swab sample, wound types, and participants' baseline characteristics.

Antibiotic sensitivity testing demonstrated that most isolated pathogens were resistant to ceftriaxone and Amoxyclav. This is similar to the findings of a study that reviewed antimicrobial resistance in East Africa. It showed that most pathogens were resistant to ampicillin, gentamycin, and ceftriaxone [15]. High resistance to these antibiotics could be due to their frequent use as first-line antibiotics. Most of the isolated pathogens were sensitive to Imipenem and Meropenem. The resistance to these antibiotics was low because they are expensive and hence rarely used by most patients in the population.

There was a general increase in AMR across all commonly used antibiotics noted at KOC from 2019 to 2021. Thereafter, there was a general decrease in resistance from 2021 to 2023. A similar trend was noted in national antimicrobial surveillance data in Uganda from 2018 to 2021 [16]. The general increase could be attributed to misuse and overuse of antimicrobials, self-medication, overprescription of antibiotics, high infection rates, use of antibiotics in livestock and fish farming, inadequate access to clean water facilities, sanitation and hygiene for man and animals, poor infection prevention and control strategies in the community, inadequate access to medical supplies like diagnostics, vaccines and effective drugs, ignorance, lack of medicine regulatory policies and poor enforcement of health regulation policies by relevant authorities, hunger and malnutrition, civil conflicts and poverty [17] [18].

This high resistance to commonly used antibiotics signifies a declining range of treatment options. It therefore necessitates that surgeons carry out culture and sensitivity tests for all individuals so as to ascertain the particular antibiotics to prescribe to the different patients. This is very crucial especially in surgical patients because effective antibiotic use is required for infection prevention. Incorrect choice of antibiotics used in these patients often leads to longer treatment durations, increased treatment failures, increased morbidity and mortality, extended hospital stays, higher healthcare costs, and generally increased infection control burdens.

The limitations in our study were that the study only used secondary data from records, which is limited in terms of variables to be studied especially concerning patient history of past medications and comorbidities. There was limited technology and therefore could not carry out the identification of the bacteria. The study was also a single-center study and therefore subject to information bias.

5. Conclusion

This study highlights a still concerning high prevalence of AMR in Uganda across different classes of antibiotics for both positive and gram-negative bacteria encountered in orthopedics. This still increased resistance particularly to commonly used antibiotics like ceftriaxone makes adhering to the WHO's Access, Watch, and Reserve category more critical. It also emphasizes how important it is to guard against the threat of AMR by appropriately using medicines especially those commonly abused.

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Conflicts of Interest

We do not have any conflict of interest to disclose.

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