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Determination of Antimicrobial Resistance Patterns in Bacterial Isolates from Wound Swabs at Dodoma Regional Referral Hospital, Tanzania

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ABSTRACT

Background: Bacterial infections in wounds pose significant challenges in healthcare, contributing to increased morbidity, mortality, and healthcare costs. Monitoring antimicrobial resistance (AMR) patterns among key pathogens such as *Escherichia coli, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa* and *Staphylococcus aureus* isolated from wound swabs are essential for effective infection control and appropriate treatment. Understanding AMR trends, particularly at Dodoma Referral Hospital, can inform treatment decisions and improve patient outcomes. This study aims to evaluate AMR patterns in bacterial isolates from wound swabs in order to optimise treatment strategies and enhance the quality of healthcare delivery.

Methods: In a retrospective cross-sectional study, we gathered information on wound swab samples from records maintained by the microbiology laboratory. The study also involved a review of 2,045 patient databases and files for individuals admitted to surgical wards or who visited the surgical clinic at Dodoma Regional Referral Hospital between 2020 and 2024.

Results: Between 2020 and 2024, the DRRH microbiology laboratory collected 2,045 wound swab samples, primarily from inpatients. The number of inpatient samples was 156 (54.7%) in 2020, 239 (66.8%) in 2021, 243 (62.5%) in 2022, 328 (52.3%) in 2023, and 172 (44.6%) in 2024, showing a predominance of male patients. Single-isolate growth rates increased over the years, from 255 (89.5%) in 2020 to 338 (87.6%) in 2024. The most frequently tested antimicrobials were meropenem (1145 tests, 66.0%), amikacin 1066 (60.5%), and gentamicin 989 (56.7%). Bacterial resistance patterns varied: Escherichia coli showed 121 (76%) resistance to ceftriaxone and 21 (7%) to meropenem; *Pseudomonas aeruginosa* had 27 (14%) resistance to amikacin; *Klebsiella pneumoniae* showed 128 (82%) resistance to ceftriaxone; and *Staphylococcus aureus* exhibited 5 (9%) resistance to trimethoprim/sulfamethoxazole and 78 (44%) to gentamicin.

Conclusion: *Staphylococcus aureus* is a priority Gram-positive bacterium that generally demonstrates lower levels of antimicrobial resistance compared to Gram-negative species such as *Escherichia coli* and *Pseudomonas aeruginosa*. These gram-negatives exhibit high resistance rates to ceftriaxone, but carbapenems and aminoglycosides remain effective. Strong infection prevention measures and tailored treatment strategies are essential.

BACKGROUND

Wound swabs are vital for antimicrobial susceptibility testing (AST) to determine antimicrobial resistance (AMR) patterns[1]. They are linked to surgical and skin infections, with priority bacteria including *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*.[2,3,4] The prevalence of AMR varies by bacteria and region. A 2024 study in Ethiopia reported *Escherichia coli* as the most prevalent at 29%, followed by *Klebsiella pneumoniae* at 14%. Between 2021 and 2022, studies in northern, western, and eastern Africa revealed varying prevalence rates for bacteria isolated from wounds: *Escherichia coli* (50%-29.3%), *Pseudomonas aeruginosa* (10%-16.7%), *Klebsiella pneumoniae* (17.5%-9.8%), and *Staphylococcus aureus* (15%-42.6%).[1,5,6] Additionally, the 2024 Ethiopian study found *Klebsiella pneumoniae* exhibited high antibiotic resistance, including 100% to cefepime, ceftriaxone, ceftazidime, and amoxicillin-clavulanic acid.[7] A study in Uganda reported all *Escherichia coli* samples resistant to ceftriaxone, with 97.7% of *Klebsiella pneumoniae* also resistant.[10] A 2022 study in Tanzania

found high antibiotic resistance in surgical site infections: 84.2% of *Escherichia coli* and 78% of *Klebsiella pneumoniae* were resistant to ceftriaxone[5]. *Staphylococcus aureus* showed 68.4% resistance to amoxicillin-clavulanic acid but was sensitive to gentamicin (87.9%) and chloramphenicol (97.1%).[5, 8] Enterobacterales had variable sensitivity, while *Acinetobacter baumannii*. showed moderate sensitivity to piperacillin-tazobactam and meropenem.[8]

A study conducted at Muhimbili National Hospital in Tanzania revealed that 22% of surgical site infections (SSIs) occurred in the urology ward between 2015 and 2016[5], while a district hospital reported an incidence of 24%.[9] Despite advancements in infection prevention, SSIs continue to represent a significant category of hospital-acquired infections.[9] The implications of SSIs arise from extended hospital stays, delayed recovery, additional diagnostic tests, treatment costs, the need for reoperation, readmission, and potential transient or permanent loss of function in the affected area, which can even lead to death.[10] Understanding AMR patterns within hospitals, such as Dodoma Referral Hospital, is essential for enhancing treatment options, improving patient outcomes, and strengthening antimicrobial stewardship (AMS) interventions. This study aims to evaluate AMR patterns in bacterial isolates obtained from wound swabs, with the goal of optimising treatment strategies and improving overall healthcare quality.

METHODS

Study design and duration

A single-centre retrospective cross-sectional study was conducted in Dodoma Regional Referral Hospital (DRRH) in Dodoma, Tanzania, from January 2020 to December 2024.

Study Area

This study was conducted at the DRRH, a notable public healthcare facility located in the Madukani area of Dodoma Municipal Council. Established in 1922, DRRH is one of the oldest hospitals in Tanzania and serves as a central referral centre for the Central Zone, with approximately 500 beds. As a government-run institution under the Ministry of Health, it offers a wide array of comprehensive medical services and specialised care. Beyond its primary healthcare services, DRRH functions as a teaching hospital, collaborating with local universities and colleges to educate the next generation of healthcare professionals.

The study focus was the hospital laboratory and diagnostic section, which is equipped to perform clinical chemistry; microbiological testing, including local antibiograms generated annually per Clinical and Laboratory Standards Institute (CLSI) guidelines; serological assays; histopathology; and blood transfusion services. Specifically, our investigation involved a retrospective analysis of antimicrobial susceptibility testing (AST) data from wound swabs collected from both inpatient and outpatient populations within the microbiology laboratory. This analysis aimed to enhance the understanding of microbial resistance patterns, thereby improving treatment outcomes for patients.

Study Population

Our study focused on a comprehensive analysis of data collected from patients in the surgical wards and those attending the surgical clinic at DRRH. The study population comprised all AST data for wound swabs obtained from the microbiology laboratory, including records from both inpatients and outpatients spanning from 2020 to 2024. This study sought to provide a deeper understanding of microbial resistance and susceptibility patterns to inform and improve clinical approaches to wound management.

Inclusion Criteria

Samples with complete data for all required variables collected between 2020 and 2024 were included. Wound and pus swab specimens were analysed to identify bacterial isolates. For the development of antimicrobial susceptibility testing (AST) trends, the total number of isolates was used as the denominator, and the number of resistant isolates as the numerator. Surveillance of antimicrobial resistance (AMR) in wound and pus swabs focused on key pathogens as defined by the National AMR Surveillance Guidelines and the National AMR Action Plan, including *Escherichia coli*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Staphylococcus aureus*.[2, 3]

Exclusion Criteria

Data from contaminated antimicrobial susceptibility testing (AST) samples were excluded from the analysis. Records with incomplete or missing information were also omitted. Consistent with the Tanzania AMR surveillance framework, non-priority (low-risk) pathogens, including certain Gram-negative and Gram-positive bacteria commonly associated with wound infections, were excluded from the study.[2, 3]

Sample Size Estimation

The minimum sample size for this study was determined using the Taro Yamane formula (1967): $n = N / (1 + N(e)^2)$, where n is the sample size, N represents the average number of isolates collected per month, and e is the margin of error, set at 5% (0.05). Using an average of 35 isolates per month ($N = 35$), the calculated sample size was $n = 35 / (1 + 35 \times 0.05^2) = 32.18$. This value was rounded to 32 isolates per month. To estimate the total sample size for the study period (2020–2024), the monthly sample size was multiplied by the total number of months, resulting in 1,920 isolates overall, or an average of 384 isolates per year.

To ensure reliable antimicrobial susceptibility patterns, at least 30 isolates were included for each reported species. Isolates were collected over the study period, and only final, verified antimicrobial susceptibility testing (AST) results were used in the analysis. The dataset included only diagnostic isolates; surveillance isolates were excluded. In addition, only the first isolate obtained from each patient during the study period was considered, regardless of specimen type or susceptibility profile. Results were presented as the percentage of resistant isolates, with particular emphasis on this measure to support clinical decision-making and to discourage the use of antibiotics when results indicated intermediate susceptibility.

Sampling Techniques

The study utilised data previously archived at DRRH. The research design comprised a retrospective review of records related to AST from 2020 to 2024. The investigation focused on AST data from wound swabs of patients exhibiting signs of SSIs, including those admitted to or attending a surgical ward or clinic due to suspected wound infections, delayed healing, or wound gapping. Data on antimicrobial resistance were obtained from the hospital microbiology laboratory repository for the period 2020–2024. The methodologies and tools employed adhered to international protocols to ensure compliance with relevant indicators.

Data Processing and Analysis

Creating reliable antibiograms requires a minimum of 30 isolates per reported species, a crucial requirement for accurately tracking antimicrobial susceptibility trends. Only final and verified AST results were evaluated, analysed, and utilised to generate AMR trends[2]. Standard antibiotics were tested and categorised according to the WHO's AWaRe classification (Access, Watch, and Reserve).[11] The findings were expressed as percentages of susceptibility. The CLSI guidelines were followed for interpreting antibiotic susceptibility test results.[12] All relevant data were collected and analysed utilising a Microsoft Excel Workbook (.xlsx), version 16.78 (23100802), licensed in 2019, developed by Microsoft in Redmond, Washington, United States of America. The cleaned data were scrutinised to derive demographic information, sample growth patterns, the hospital wards where samples were collected, and trends in antimicrobial susceptibility. Descriptive statistics were used to summarise key characteristics of the patients, the isolates, and the AST results.

Laboratory Testing Procedure

The microbiology laboratory at DRRH employed specific methodologies for microbiological testing. Bacterial identification was conducted with precision using various standard microbiological techniques. This process involved culturing wound and pus swab samples on selective and differential media to promote the growth of specific bacterial species. Following this, Gram staining was utilised to classify the bacteria by cell wall characteristics. A series of biochemical tests, including catalase, oxidase, indole, citrate, and urease tests, was employed to further elucidate the metabolic capabilities and identities of the isolates. For antimicrobial susceptibility testing, the Kirby–Bauer disc diffusion method was performed in accordance with CLSI guidelines, enabling assessment of each bacterium's resistance or susceptibility to various antibiotics.[13,14] Although our study did not involve direct testing of wound or pus swabs, we analysed data from the laboratory's repository, which reflects routine and daily sample testing.

Ethical Approval

The Internal Ethical Review Committee of St John's University of Tanzania issued an ethical clearance certificate for the study, referenced as SJUT/RCF002, on May 21, 2024. Furthermore, the DRRH is obtaining a permit for data collection and research at a public hospital under the auspices of the Tanzania Mainland Ministry of Health. This permit application was issued on April 19, 2024, and was assigned the reference number REF. NO.PB.22/1307/02/10, specifically for the Dodoma region of Tanzania.

RESULTS

Demographic and Wound Swabs Growth Patterns.

Over a five-year period from 2020 to 2024, the DRRH microbiology laboratory analysed a total of 2,045 wound swab samples. The majority of these samples came from inpatients, highlighting a consistent trend over the years: 156 (54.7%) in 2020, 239 (66.8%) in 2021, 243 (62.5%) in 2022, 328 (52.3%) in 2023, and 172 (44.6%) in 2024. Notably, male patients represented the largest proportion of those admitted and sampled. Throughout this period, the growth rate of single isolates remained relatively stable. The numbers showed an overall upward pattern: 255 (89.5%) in 2020, 289 (80.7%) in 2021, 310 (79.7%) in 2022, rising to 529 (84.4%) in 2023, and 338 (87.6%) in 2024. Table 1 provides a more detailed view of these trends.

Resistance Rates of Key Pathogens and Their Most Resistant Antimicrobials

During a five-year surveillance at DRRH, the antimicrobials subjected to the highest frequency of testing included meropenem (1145, 66.0%), amikacin (1066, 60.5%), gentamicin (989, 56.7%), ciprofloxacin (968, 56.1%), and amoxicillin/clavulanic acid (903, 52.1%). More detailed statistics are provided in Table 2.

Bacterial isolates from wound swabs exhibited varying resistance patterns to most tested antimicrobials at DRRH over a five-year period. *Escherichia coli* demonstrated an average resistance rate of 121 (76%) to ceftriaxone and 21 (7%) to meropenem. *Pseudomonas aeruginosa* showed a resistance rate of 27 (14%) to amikacin. *Klebsiella pneumoniae* exhibited resistance to ceftriaxone 128 (82%) and amikacin 25 (14%). Additionally, *Staphylococcus aureus* had a resistance rate of 5 (9%) to trimethoprim/sulfamethoxazole and 78 (44%) to gentamicin (Table 3).

TABLE 1: Demographic and Wound Swabs Growth Patterns

Variables	2020 (N=285)	2021 (N= 358)	2022 (N=389)	2023 (N= 627)	2024 (N=386)
Age (Mean)	41.3 ± 19.8	39.0 ± 21.7	36.5 ± 21.7	36.2 ± 21.3	37 ± 20.2
Age groups (Years)	Number (%)	Number (%)	Number (%)	Number (%)	Number(%)
< 2	12(4.2)	16 (4.5)	15 (3.8)	37 (5.9)	20(5.2)
3-5	9(3.2)	8 (2.2)	10 (2.6)	21 (3.3)	15(3.9)
6-15	14(4.9)	29 (8.1)	47 (12.1)	64 (10.2)	19(4.9)
16-20	16(5.6)	21 (5.9)	21 (5.4)	49 (7.8)	26(6.7)
21-45	131(46.0)	159 (44.4)	161 (41.4)	258 (41.2)	180(46.6)
>46	103(36.1)	125 (34.9)	135 (34.7)	198 (31.6)	126(32.6)
Patient type					
Inpatients	156(54.7)	239 (66.8)	243 (62.5)	328 (52.3)	172(44.6)
Outpatient	129(45.3)	119 (33.2)	146 (37.5)	299 (47.7)	214(55.4)
Sex					
Male	169(59.3)	214 (59.8)	229 (58.9)	390 (62.2)	219(56.7)
Female	116(40.7)	144 (40.2)	160 (41.1)	237 (37.8)	167(43.3)
Sample survey					
Swabs with no bacteria growth	21(7.4)	51 (14.3)	60 (15.4)	81 (12.9)	31(8.0)
Swabs with bacteria growth	255(89.5)	289 (80.7)	310 (79.7)	529 (84.4)	338(87.6)
Swabs with mixed growth and contamination	9(3.2)	18 (5.0)	19 (4.9)	17 (2.7)	17(4.4)

TABLE 2: Proportions Of Tested Cases in Each Antimicrobial for Five Years, 2020 (N=255), 2021 (N=281), 2022 (N=310), 2023 (N=529) And 2024 (N=338)

S. No	Antibiotic	2024 n (%)	2023 n (%)	2022 n (%)	2021 n (%)	2020 n (%)	Total case (%)
e1.	Meropenem (W)	217 (64.2)	379 (71.6)	204 (65.8)	152 (52.6)	193 (75.7)	1145 (66.0)
2.	Amikacin (A)	240 (71.0)	365 (69.0)	171 (55.2)	138 (47.8)	152 (59.6)	1066 (60.5)
3.	Gentamicin (A)	192 (56.8)	332 (62.8)	170 (54.8)	144 (49.8)	151 (59.2)	989 (56.7)
4.	Ciprofloxacin (W)	234 (69.2)	289 (54.6)	171 (55.2)	127 (43.9)	147 (57.6)	968 (56.1)
5.	Amoxicillin/ beta lactamase inhibitor (A)	207 (61.2)	274 (51.8)	171 (55.2)	93 (32.2)	158 (62.0)	903 (52.4)
6.	Ceftriaxone (W)	229 (67.8)	328 (62.0)	82 (26.5)	113 (39.1)	73 (28.6)	825 (44.8)
7.	Azithromycin	52 (15.4)	255 (48.2)	153 (49.4)	178 (61.6)	10 (3.9)	648 (35.5)
8.	Ceftazidime (W)	83 (24.6)	76 (14.4)	97 (31.3)	104 (36.0)	118 (46.3)	478 (30.5)
9.	Cephalexin (A)	11 (3.3)	165 (31.2)	68 (21.9)	131 (45.3)	45 (17.6)	420 (23.9)
10.	Clindamycin (A)	94 (27.8)	127 (24.0)	96 (31.0)	52 (18.0)	41 (16.1)	410 (23.4)
11.	Trimethoprim/Sulfamethoxazole (NR)	76 (22.5)	164 (31.0)	85 (27.4)	41 (14.2)	24 (9.4)	390 (20.9)
12.	Tetracycline (A)	149 (44.1)	104 (19.7)	86 (27.7)	16 (5.5)	5 (2.0)	360 (19.8)
13.	Ampicillin/Cloxacillin (NR)	65 (19.2)	194 (36.7)	95 (30.6)	0 (0.0)	0 (0.0)	354 (17.3)
14.	Doxycycline (A)	83 (24.6)	118 (22.3)	117 (37.7)	10 (3.5)	0 (0.0)	328 (17.6)
15.	Penicillin (A)	22 (6.5)	118 (22.3)	91 (29.4)	12 (4.2)	33 (12.9)	276 (15.1)
16.	Cefepime (W)	107 (31.7)	33 (6.2)	28 (9.0)	19 (6.6)	4 (1.6)	191 (11.0)
17.	Amoxicillin (A)	1 (0.3)	14 (2.6)	154 (49.7)	16 (5.5)	4 (1.6)	189 (11.9)
18.	Cefotaxime (W)	81 (24.0)	47 (8.9)	2 (0.6)	24 (8.3)	12 (4.7)	166 (9.3)
19.	Erythromycin (A)	64 (18.9)	6 (1.1	1 (0.3)	20 (6.9)	26 (10.2)	117 (7.5)
20.	Piperacillin/ Tazobactam (W)	42 (12.4)	0 (0.0)	0 (0.0)	36 (12.5)	0 (0.0)	78 (5.0)
21.	Ampicillin (A)	0 (0.0)	0 (0.0)	27 (8.7)	14 (4.8)	26 (10.2)	67 (4.8)
22.	Cefoxitin (W)	1 (0.3)	0 (0.0)	26 (8.4)	35 (12.1)	1 (0.4)	63 (4.2)
23.	Chloramphenicol (A)	1 (0.3)	0 (0.0)	6 (1.9)	26 (9.0)	1 (0.4)	34 (2.3)
24.	Cefixime (W)	0 (0.0)	0 (0.0)	0 (0.0)	18 (6.2)	3 (1.2	21 (1.4)
25.	Oxacillin (A)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (3.1)	8 (0.6)

A, Access antimicrobial; W, Watch antimicrobial; NR, Not Recommended antimicrobial; N, representing the total number of tested cases, and n, denoting the number of tests conducted within a specified antimicrobial category. The denominator indicates the total number of cases tested for each antimicrobial agent. Dash (-) means not tested

TABLE 3: Resistance Trend of Six Most Commonly Tested Antibiotics Over the Five Years (2020-2024) Based on Total Cases

Priority Organism	Antimicrobials	Resistance Rate 2024	2023	2022	2021	2020	Average %*
			Gram-Negative Bacteria				
Escherichia coli	Ceftriaxone (W)	160(70%)	230(70%)	66(80%)	87(77%)	62(85%)	121 (76%)
	Amikacin (A)	-	-	-	5(4%)	23(15%)	14 (9%)
	Ciprofloxacin (W)	129(55%)	176(61%)	113(66%)	127(55%)	85(58%)	126(59%)
	Gentamycin (A)	77(40%)	47(14%)	82(48%)	42(29%)	110(73%)	72(41%)
	Amoxicillin-Clavulanic acid (A)	208 (85%)	145(53%)	97(57%)	59(63%)	131(83%)	128 (68%)
	Meropenem (W)	43 (2%)	4(1%)	-	24(16%)	13(7%)	21(7%)
Pseudomonas aeruginosa	Ceftriaxone (W)	163 (71%)	305(93%)	35(43%)	68(60%)	44(60%)	123(65%)
	Amikacin (A)	38 (16%)	-	29(17%)	14(10%)	-	27(14%)
	Ciprofloxacin (W)	63(27%)	101(35%)	53(31%)	55(43%)	-	68(34%)
	Gentamycin (A)	56(29%)	73(22%)	73(43%)	62(43%)	26(17%)	58(31%)
	Meropenem (W)	69(32%)	57(15%)	-	50(33%)	-	59(27%)
Klebsiella pneumoniae	Ceftriaxone (W)	-	302(92%)	60(73%)	88(78%)	63(86%)	128(82%)
	Amikacin (A)	-	11(3%)	-	-	38(25%)	25(14%)
	Ciprofloxacin (W)	-	220 (76%)	74(43%)	42(33%)	131(89%)	117(60%)
	Gentamycin (A)	192 (100%)	146(44%)	56(33%)	29(20%)	85(56%)	102(51%)
	Amoxicillin-Clavulanic acid (A)	240 (100%)	159(58%)	103(60%)	82(88%)	158(100%)	148(81%)
	Meropenem (W)	-	49(13%)	-	46(30%)	96(50%)	64(31%)
			Gram-Positive Bacteria				
Staphylococcus aureus	Azithromycin (W)	18 (35%)	84(33%)	44(29%)	52(29%)	7(68%)	41(39%)
	Trimethoprim-Sulfamethoxazole (NR)	8 (10%)	7(4%)	3(4%)	2(4%)	6(24%)	5(9%)
	Ciprofloxacin (W)	68(29%)	107(37%)	75(44%)	41(44%)	60(41%)	70(39%)
	Gentamycin (A)	77(40%)	63(19%)	88(52%)	75(52%)	85(56%)	78(44%)
	Tetracycline (A)	42 (28%)	25(24%)	34(40%)	34(40%)	2(34%)	27(33%)
	Doxycycline (A)	11(13%)	5(4%)	-	-	-	8(12%)

A, Access antimicrobial; W, Watch antimicrobial; NR, Not Recommended antimicrobial; The dash (-) signifies that the item was not tested; *The average across all five years; The denominator refers to the number of tested cases for each antimicrobial, as indicated in Table 2

DISCUSSION

Our study conducted at Dodoma Regional Referral Hospital from 2020 to 2024 identified the most frequently tested antimicrobials as meropenem, amikacin, gentamicin, ciprofloxacin, and amoxicillin/clavulanic acid. We observed that *Escherichia coli* exhibited 76% resistance to ceftriaxone and 7% resistance to meropenem. *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* demonstrated resistance rates of 14% to amikacin and 82% to ceftriaxone, respectively. *Staphylococcus aureus* showed 9% resistance to trimethoprim/sulfamethoxazole and 44% resistance to gentamicin. These results reveal a concerning rise in ceftriaxone resistance among gram-negative bacteria, whereas Staphylococcus aureus remains susceptible to the tested antimicrobials. Overall, the findings suggest that the effectiveness of ceftriaxone is diminishing as bacterial resistance continues to increase. Surgical site infections can result in extended hospital stays and higher healthcare costs, highlighting the importance of understanding antimicrobial resistance (AMR) patterns to optimise treatment strategies and improve patient outcomes.

Consistent with prior research, antimicrobials such as penicillin and ceftriaxone, exhibited markedly high resistance rates among clinically significant Gram-negative pathogens, including *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, all of which are prioritized owing to their strong association with surgical site infections (SSIs).[8,15] Additionally, *Staphylococcus aureus* exhibited noteworthy fluctuations in resistance rates to several antibiotics, including azithromycin, erythromycin, and cephalexin SSIs.[8,15]

Research by Mutonga et al. (2019) highlighted a concerning statistic: 40% of gram-negative organisms are classified as multi-drug-resistant organisms (MDROs), reflecting the urgent need for more effective treatment options and better management strategies.[16] In comparison, studies have shown that gram-positive isolates, particularly those of *Staphylococcus aureus*, exhibit a high susceptibility rate of 97.1% to commonly used antimicrobials such as penicillin G, erythromycin, cefoxitin, gentamicin, and chloramphenicol.[8,17] This susceptibility underscores the potential efficacy of conventional treatments for infections caused by gram-positive bacteria, as in our findings. On the other hand, isolates of *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* present a significant therapeutic challenge. They have shown resistance to a wide array of frequently prescribed antibiotics, including but not limited to ampicillin, amoxicillin, cefepime, ceftazidime, cefuroxime, clindamycin, erythromycin, piperacillin-tazobactam, tetracycline, and trimethoprim-sulfamethoxazole.[18] This stark contrast in resistance patterns highlights the pressing need for more comprehensive research and a reevaluation of prioritisation in antibiotic stewardship programmes, ensuring that gram-positive bacteria are not overshadowed by the rising threat of gram-negative MDROs.

Furthermore, evidence from our study indicates that specific antimicrobial agents consistently maintained their sensitivity patterns against bacteria isolated from wound swabs. These notable agents include amikacin, known for its efficacy against a variety of Gram-negative bacteria; meropenem, a broad-spectrum beta-lactam antibiotic effective against resistant strains; piperacillin/tazobactam, which combines a penicillin and a beta-lactamase inhibitor; and vancomycin, an essential glycopeptide antibiotic primarily used to treat serious Gram-positive infections.[8,17,19] This finding aligns with results from a comprehensive study conducted at Bugando Medical Centre in Tanzania, as well as recent research from Malawi and Ethiopia published in 2025, underscoring the regional persistence of these antibiotics' effectiveness against common pathogens.[8,17,19]

Evidence from our study, along with findings from other research, highlights the increasing challenges posed by antimicrobial resistance (AMR) in pathogens such as *Escherichia coli*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* against a wide range of antimicrobials. Monitoring of bacterial isolates from wounds is essential for the effective management of surgical site infections (SSIs). This careful surveillance enables healthcare professionals to identify potential pathogens, adjust treatment protocols, and ultimately improve patient outcomes. Our extensive findings from a retrospective surveillance study conducted over five years demonstrate significant variability in AMR trends. This variability underscores the paramount importance of careful antimicrobial selection and application in effectively addressing SSIs at the zonal referral hospital.

Strengths and Limitations of the Study

This study looked at all the antimicrobial susceptibility test results from wound swabs collected in the microbiology laboratory over the past five years, including samples from both hospitalised patients and those visiting as outpatients. Our goal was to identify which microbes are more likely to resist or respond to different treatments, providing insights that can inform strategies to improve wound care in healthcare settings. To our knowledge, this is the first study of its kind at DRRH, establishing a baseline that can inform future research on the effectiveness of different intervention strategies. However, the study has several important limitations. As a retrospective analysis of laboratory records, the study was limited by the absence of data on variables such as the types of surgical procedures performed, patients' lengths of hospital stay, and distinctions among different wound types. Wound swabs are also prone to contamination, often resulting in mixed microbial growth. Additionally, some data were recorded in hard-copy registers, leading to incomplete records that had to be excluded from the analysis. These limitations restricted our ability to fully assess the impact of antimicrobial resistance (AMR) on the treatment of surgical site infections (SSIs), skin and soft tissue infections (SSTIs).

CONCLUSION

Staphylococcus aureus is the only gram-positive bacterium identified as a priority, and it exhibits significantly lower levels of antimicrobial resistance than its gram-negative counterparts. These gram-negative bacteria, which include E*scherichia coli*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, exhibit a much more complex resistance profile, leading

to an over-prioritisation of gram-negative organisms in clinical settings. Rates of resistance to ceftriaxone among key gram-negative organisms are alarmingly high, while carbapenems and aminoglycosides remain effective against priority gram-negative pathogens. In particular, meropenem, amikacin, and gentamicin have been extensively studied as antimicrobials, although their classification as reserved or watch-list drugs may be affected by health insurance pre-authorisation requirements.

RECOMMENDATIONS

We recommend implementing a prospective cohort study involving all patients on surgical wards, alongside comprehensive surveillance of AMR through surgical clinics. The primary objective of this study is to assess the necessity of antimicrobial prescribing while utilising real-time AST to inform the selection of appropriate antimicrobials. It will also take into account a range of influencing factors, including the timing of surgeries, wound types, patient characteristics, and comorbidities. Additionally, we propose developing evidence-based surgical prophylaxis protocols and hospital policies for SSIs and SSTIs. These measures should inform AST requirements and guide therapeutic leadership in selecting antimicrobials. A multicentre study should be conducted, incorporating both retrospective and prospective components, to identify the prevalence and incidence of AMR and to devise national or zonal strategies for managing wound infections. This study underscores the importance of strengthening and enhancing infection prevention and control (IPC) programmes. This includes the routine collection of swabs from surgical wards and operating theatres, which will aid in monitoring environmental contaminants predominantly linked to SSIs and SSTIs within the hospital environment. Addressing these multifaceted challenges is essential; therefore, it is vital to deepen understanding of factors influencing wound healing, antimicrobial prescribing patterns, AMR profiles, and hospital AMS policies. We advocate for the establishment of clear, evidence-based guidelines for antimicrobial prescribing.

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