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Antimicrobial susceptibility patterns of bacteria isolated from infected wounds at Mbale regional referral hospital, Uganda

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ABSTRACT

Background: Wound infections are a major cause of morbidity and are increasingly complicated by antimicrobial resistance. This study determined the bacterial etiology and antimicrobial susceptibility patterns of wound infections at a regional referral hospital in Eastern Uganda. **Methods:** A laboratory-based cross-sectional study was conducted at Mbale Regional Referral Hospital between May and August 2023. Wound swabs from 210 patients with clinically suspected wound infections were cultured, bacterial isolates identified using standard microbiological methods, and antimicrobial susceptibility testing performed according to CLSI 2023 guidelines. **Results:** Bacterial growth was detected in 41.9% (88/210) of wound swabs. Gram-negative organisms predominated, accounting for 61.4% (54/88) of isolates. The most common pathogens were *Escherichia coli* (22/88, 25.0%), *Staphylococcus aureus* (18/88, 20.5%), coagulase-negative staphylococci (14/88, 15.9%), and *Klebsiella pneumoniae* (13/88, 14.8%). MRSA prevalence among *S. aureus* isolates was 61.1% (11/18; 95% CI: 35.8-82.7%). High resistance was observed to ampicillin, ceftriaxone, gentamicin, and ciprofloxacin. Overall, 28.4% (25/88) of isolates were multidrug resistant. **Conclusion:** Wound infections at Mbale Regional Referral Hospital were characterized by Gram-negative predominance and substantial antimicrobial resistance, including high MRSA and multidrug resistance rates. Routine microbiological testing, infection prevention measures, and antimicrobial stewardship are needed to support effective wound infection management.

Introduction

Wound infections remain a major cause of illness in low- and middle-income countries, where trauma, burns, surgical procedures are common [1-3]. Disruption of the skin barrier allows bacterial colonization that may delay healing and increase the risk of sepsis, prolonged hospitalization, and death [4-6]. In many sub-Saharan African healthcare settings, limited resources, delayed healthcare seeking, and gaps in infection prevention further increase the burden of wound-related infections [7,8]. The management of wound infections has become increasingly complicated by antimicrobial resistance (AMR). Resistance to commonly used antibiotics such as ampicillin, ceftriaxone, and ciprofloxacin reduces treatment effectiveness and limits therapeutic options [9-12]. Resistant pathogens including methicillin-resistant *Staphylococcus aureus* (MRSA), extended-spectrum beta-lactamase

(ESBL)-producing Enterobacteriaceae, and carbapenem-resistant organisms have increasingly been reported in wound infections globally and across Africa [13-16].

Studies from Ugandan referral hospitals have identified *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella* species among the leading causes of wound infections, with increasing multidrug resistance reported among these pathogens [17-20]. However, many available studies have focused on specific wound categories such as burns or surgical site infections, limiting broader understanding of wound pathogens encountered in routine clinical practice. This study therefore aimed to characterize bacterial isolates from infected wounds at Mbale Regional Referral Hospital and determine their antimicrobial susceptibility patterns to inform clinical management and local antimicrobial stewardship efforts.

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Methods

Study Design and Setting

This was a laboratory-based, descriptive cross-sectional study conducted at Mbale Regional Referral Hospital (MRRH) in Eastern Uganda. The hospital serves as a major referral center for over 16 districts and a population of more than four million people. The study was carried out between May and August 2023 in surgical, orthopedic, maternity, and outpatient wards where patients with wounds were managed.

Study Population and Sampling

The study population included both inpatients and outpatients presenting with clinical signs of wound infection. Patients of all ages with wounds showing evidence of infection (such as pus, increased swelling, or delayed healing) were eligible. Critically ill patients, those in intensive care, and individuals with mental incapacity to consent were excluded.

Sample size was calculated using the Kish and Leslie formula (1965), with an assumed wound infection prevalence of 16.4% from previous regional data [21], yielding a total sample of 210 participants.

Sample Collection and Transport

Following informed consent, wound swabs were aseptically collected using sterile cotton-tipped applicators. Samples were immediately placed into sterile containers, sealed in zip-lock bags, and transported in cold chain conditions to the MRRH Microbiology Laboratory for analysis. Each sample was accompanied by a unique identification code and laboratory request form.

Microbiological Analysis

Swab samples were inoculated onto Blood agar, MacConkey agar, and Chocolate agar, and incubated aerobically at 37°C for 24 hours. Chocolate agar plates were placed in anaerobic jars to enhance recovery of fastidious bacteria. Colony morphology was examined, and isolates were subjected to Gram staining.

Gram-positive bacteria were identified using catalase, coagulase, and DNase tests. Gram-negative bacteria were differentiated using biochemical tests including Indole, Voges-Proskauer, Urease, Simmons Citrate, Triple Sugar Iron (TSI), and Oxidase tests [15, 19, 22].

Antimicrobial Susceptibility Testing (AST)

All significant isolates underwent AST using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar, in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines, 2023 edition. A 0.5 McFarland standard suspension was prepared for each isolate.

The following antimicrobial discs were used for susceptibility testing: ampicillin (10 µg), amoxicillin/clavulanic acid (20/10 µg), ceftriaxone (30 µg), gentamicin (10 µg), ciprofloxacin (5 µg), meropenem (10 µg), vancomycin (30 µg), ceftazidime (30 µg), clindamycin (2 µg), tetracycline (30 µg),

erythromycin (15 µg), piperacillin (100 µg), and piperacillin/tazobactam (100/10 µg). Zones of inhibition were measured using a Vernier caliper and interpreted according to CLSI 2023 guidelines.

Detection of MRSA

Methicillin-resistant *Staphylococcus aureus* (MRSA) was detected phenotypically using Cefoxitin (30 µg) discs as a surrogate marker. Testing was performed on Mueller-Hinton agar supplemented with 4% NaCl. A 0.5 McFarland bacterial suspension was uniformly swabbed onto the agar, and Cefoxitin discs applied. Plates were incubated at 37°C for 24 hours, and inhibition zones measured. Resistance was defined as a zone ≤ 21 mm.

Quality Control

To ensure accuracy, standard control strains were used: *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 25923), *Pseudomonas aeruginosa* (ATCC 27853).

Strict adherence to Standard operating procedures was maintained throughout sample collection, culture preparation, and AST.

Data Collection and Analysis

Sociodemographic and clinical data were collected using a structured questionnaire. Laboratory data were compiled and analyzed using STATA version 12. Descriptive statistics summarized frequencies and proportions. Chi-square tests were used to assess associations between categorical variables, with statistical significance set at $p < 0.05$.

Ethical Considerations

The study was approved by the Mbarara University of Science and Technology Research Ethics Committee (MUST-REC: MUST-2023-795). Administrative clearance was obtained from the Mbale District Health Office and the Mbale Regional Referral Hospital Research Committee. Written informed consent was obtained from all adult participants prior to enrollment. For participants younger than 18 years, written informed consent was obtained from a parent or legal guardian, and assent was obtained where appropriate. Participation was voluntary, and participants were informed of their right to decline or withdraw from the study at any time without affecting their care. To maintain confidentiality, participant identifiers were not recorded on laboratory forms or study databases, and all study data were stored in password-protected files accessible only to the research team.

Results

Socio-demographic characteristics of study participants

A total of 210 patients with clinically suspected wound infections were enrolled. The mean age was 20 years (SD ± 10 years), with 46.1% (83/210) aged between 1-17 years, 35.6% (64/210) aged 18-30 years and 18.6% (33/210) aged over 31 years. Males comprised 55.8% (115/210) of participants, while females accounted for 44.2% (91/210).

Surgical procedures were the leading cause of wounds,

reported in 77.7% (108/210) of cases. Other causes included bites (10.1%), burns (8.6%), and accidents (3.6%).

Etiological agents that cause wound infections among patients

Of the 210 wound swabs cultured, 88 (41.9%) yielded bacterial growth. Among the culture-positive samples, Gram-negative bacteria accounted for 61.4% (54/88) of isolates, while Gram-positive bacteria accounted for 38.6% (34/88). The most frequently isolated organisms were *Staphylococcus aureus* (20.5%, 18/88), coagulase-negative staphylococci (15.9%, 14/88), *Escherichia coli* (25.0%, 22/88), and *Klebsiella pneumoniae* (14.8%, 13/88). Less frequently isolated organisms included *Pseudomonas aeruginosa*, *Citrobacter* spp., *Proteus* spp., *Streptococcus pyogenes*, and *Acinetobacter baumannii* (Table 1).

Antimicrobial susceptibility across isolated bacterial pathogens

MRSA prevalence among *Staphylococcus aureus* isolates was 61.1% (11/18; 95% CI: 35.8-82.7%). Among Gram-positive organisms, resistance to

clindamycin and erythromycin was common among *S. aureus*, occurring in 58.8% and 50.0% of isolates, respectively. All tested Gram-positive isolates remained susceptible to vancomycin.

Among Gram-negative organisms, substantial resistance was observed to commonly prescribed antibiotics, particularly ampicillin, ceftriaxone, gentamicin, and ciprofloxacin. *Escherichia coli*, *Klebsiella pneumoniae*, and *Citrobacter freundii* exhibited the highest levels of resistance, with ciprofloxacin resistance reaching 77.3% among *E. coli* and 83.3% among *C. freundii*. In contrast, meropenem retained activity against all Gram-negative isolates except a single multidrug-resistant *Acinetobacter baumannii* isolate. For *Pseudomonas aeruginosa*, susceptibility was substantially higher to piperacillin-tazobactam (80.0%) than to piperacillin alone (20.0%).

Multi-drug resistance in isolated bacteria

Multidrug resistance (MDR), defined as resistance to three or more antimicrobial classes, was identified in 28.4% (25/88) of bacterial isolates as shown in table 3.

Table 1. Distribution of bacterial isolates recovered from infected wounds

Bacterial species	Frequency (n=88)	Percentage (%)
<i>Escherichia coli</i>	22	25.0
<i>Staphylococcus aureus</i>	18	20.5
Coagulase-negative staphylococci	14	15.9
<i>Klebsiella pneumoniae</i>	13	14.8
<i>Citrobacter freundii</i>	6	6.8
<i>Pseudomonas aeruginosa</i>	5	5.7
<i>Proteus vulgaris</i>	3	3.4
<i>Proteus mirabilis</i>	2	2.3
<i>Streptococcus pyogenes</i>	2	2.3
<i>Acinetobacter baumannii</i>	1	1.1
<i>Klebsiella aerogenes</i>	1	1.1
<i>Citrobacter kisanii</i>	1	1.1
Total	88	100.0

Table 2A. Antimicrobial susceptibility patterns of Gram-negative bacterial isolates

Organism	n	AMP R (%)	AMC R (%)	CEF R (%)	GEN R (%)	CIP R (%)	MEM R (%)
<i>Escherichia coli</i>	22	13 (59.1)	3 (13.6)	10 (45.5)	12 (54.6)	17 (77.3)	0 (0.0)
<i>Klebsiella pneumoniae</i>	13	4/6 (66.7)	1/6 (16.7)	9 (69.2)	7 (53.8)	7/12 (58.3)	0 (0.0)
<i>Citrobacter freundii</i>	6	4/4 (100.0)	4/4 (100.0)	4 (66.7)	3 (50.0)	5 (83.3)	0 (0.0)
<i>Proteus vulgaris</i>	3	2/2 (100.0)	1/2 (50.0)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)
<i>Proteus mirabilis</i>	2	NT	NT	0 (0.0)	1 (50.0)	2 (100.0)	0 (0.0)
<i>Pseudomonas aeruginosa</i>	5	NT	NT	2 (40.0)	1 (20.0)	1 (20.0)	0 (0.0)
<i>Acinetobacter baumannii</i>	1	0 (0.0)	0 (0.0)	1 (100.0)	1 (100.0)	1 (100.0)	1 (100.0)

AMP- Ampicillin; AMC-Amoxicillin-Clavulanic acid; CEF, Ceftriaxone; GEN, Gentamicin; CIP- Ciprofloxacin; MEM, Meropenem; TE, Tetracycline; CD, Clindamycin; ERY, Erythromycin; VAN, Vancomycin; PIP, Piperacillin; PTZ, Piperacillin-Tazobactam. Certain antimicrobial agents were tested only against organisms for which CLSI interpretive criteria were available.

Table 2B. Antimicrobial susceptibility patterns of Gram-positive bacterial isolates

Organism	n	FOX R (%)	CD R (%)	ERY R (%)	VAN R (%)
<i>Staphylococcus aureus</i>	18	11 (61.1)	10 (58.8)	9 (50.0)	0 (0.0)
Coagulase-negative staphylococci	14	NT	NT	NT	NT
<i>Streptococcus pyogenes</i>	2	NT	2 (100.0)	2 (100.0)	0 (0.0)

Table 3. Frequency distribution of multidrug-resistant bacterial isolates.

Bacterial species	Total isolates (n)	MDR isolates (n)	MDR (%)
<i>Staphylococcus aureus</i>	18	10	55.6
<i>Escherichia coli</i>	22	6	27.3
<i>Klebsiella pneumoniae</i>	13	3	23.1
<i>Pseudomonas aeruginosa</i>	5	1	20.0
<i>Proteus</i> spp.	5	1	20.0
<i>Citrobacter freundii</i>	6	4	66.7
<i>Streptococcus pyogenes</i>	2	0	0.0
Total	88	25	28.4

Discussion

This study characterized the bacterial etiology of wound infections at Mbale Regional Referral Hospital and demonstrated a predominance of Gram-negative organisms. *Escherichia coli* was the most frequently isolated pathogen, followed by *Staphylococcus aureus*, coagulase-negative staphylococci, and *Klebsiella pneumoniae*. Similar pathogen distributions have been reported in other Ugandan and African healthcare settings, where Enterobacteriaceae and *S. aureus* account for a substantial proportion of wound infections [9, 12, 23].

Surgical wounds accounted for more than three-quarters of all wounds sampled, highlighting the importance of postoperative wound care and infection prevention measures. Surgical site infections remain a major healthcare-associated infection in low-resource settings and may reflect challenges related to aseptic technique, wound care practices, patient overcrowding, and limited infection prevention resources (3,7).

The predominance of *E. coli* and *K. pneumoniae* is consistent with reports from other African referral settings [9, 10, 24]. These organisms are commonly associated with healthcare environments and previous antibiotic exposure and are increasingly recognized as important causes of wound and surgical site infections. Their persistence may be facilitated by prolonged hospitalization, overcrowding, and inadequate infection prevention and control measures.

High resistance to ampicillin among Enterobacteriaceae reflects patterns reported across Africa [22, 25]. The increased empirical use of this inexpensive antibiotic likely contributes to sustained selective pressure. Resistance to ceftriaxone and ciprofloxacin is more concerning, given their role as second-line agents in Uganda [26, 27]. Reduced susceptibility to these drugs limits available options

for serious wound infections. Similar trends reported in Ethiopia and other East African countries [20, 24, 28], suggest a wider regional antimicrobial resistance challenge.

Meropenem remained effective against most Gram-negative isolates. However, the single isolate of *Acinetobacter baumannii* was multidrug resistant, including resistance to meropenem. Although based on one isolate, this finding is concerning, as carbapenem-resistant non-fermenters are increasingly reported globally [20, 29, 30].

MRSA prevalence among *S. aureus* isolates was 61.1%, indicating a substantial burden of methicillin resistance within the hospital. Similar high MRSA rates have been reported in wound infection studies from Uganda and other African countries [11, 31, 32]. The presence of MRSA complicates empirical treatment, increases reliance on reserve antibiotics, and reinforces the need for strengthened infection prevention measures and antimicrobial stewardship programs.

Overall, 28.4% of bacterial isolates were multidrug resistant. The highest MDR proportions were observed among *Citrobacter freundii* and *Staphylococcus aureus*, while MDR was also detected among *E. coli*, *K. pneumoniae*, *P. aeruginosa*, and *Proteus* spp. Similar MDR patterns have been reported across Africa and reflect increasing selective pressure from widespread antibiotic use. [33]. The presence of MDR pathogens reduces treatment options and may contribute to prolonged hospitalization, increased healthcare costs, and poorer clinical outcomes.

Pseudomonas aeruginosa demonstrated greater susceptibility to piperacillin-tazobactam than to piperacillin alone, suggesting that β -lactamase inhibition may improve antimicrobial activity against some isolates. This finding supports the importance of susceptibility-guided therapy when managing infections caused by non-fermenting Gram-negative

organisms [34].

Given the resistance patterns observed, empirical therapy alone may be insufficient in some cases. The presence of MRSA and multidrug-resistant Gram-negative organisms may contribute to delayed wound healing, prolonged hospitalization, increased treatment costs, and poorer clinical outcomes. Routine culture and susceptibility testing, supported by regular hospital antibiograms, would improve prescribing practices. Broader surveillance and molecular studies could further clarify resistance mechanisms and guide future interventions.

Study limitations

This study did not include molecular testing; therefore, specific resistance genes were not identified. In addition, information on prior antibiotic use among participants was limited, which may have influenced the resistance patterns observed.

Conclusion

Wound infections at Mbale Regional Referral Hospital were predominantly associated with surgical wounds and were characterized by a substantial burden of antimicrobial resistance. The high prevalence of MRSA and multidrug-resistant Gram-negative pathogens raises concerns about the continued effectiveness of commonly used empirical therapies. These findings highlight the need to strengthen infection prevention practices within surgical care, promote routine microbiological diagnosis, and use local susceptibility data to guide antibiotic prescribing. Sustained surveillance will be critical to monitor emerging resistance and support antimicrobial stewardship efforts in the region.

Ethics approval and consent to participate

This study was approved by Mbarara University of Science and Technology Research Ethics Committee (MUST-2023-795). Administrative clearance was by MUST faculty research committee (FRC) and Mbale district Health Office. Written informed consent/assent were obtained from participants, enrolment was voluntary and participants could withdraw from the study at any time without consequences.

Consent for publication

Not applicable

Author contribution

HM contributed to conceptualization, methodology, investigation, data curation, formal analysis, and writing of the original draft. PPN contributed to data interpretation, manuscript drafting, visualization, and critical revision of the final manuscript. FB contributed to methodology, supervision, and manuscript review. JB contributed to supervision, project administration, and manuscript review. BT contributed to conceptualization, supervision, validation, and critical revision of the manuscript as the principal supervisor. All authors read and approved the final manuscript.

Availability of data and materials

The datasets generated and analysed during this study are available from the corresponding author upon reasonable request. A preprint of this manuscript is available online

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References

1. Xiques-Molina W, Pérez-Camacho K, Dávila CMG. Nursing and chronic wounds in global health: Addressing an unresolved burden in low- and middle-income countries. *J Holist Nurs Sci.* 2026;13(1):9-13.
2. World Health Organization. Sepsis: Key Facts. Geneva, Switzerland: World Health Organization; 2020.
3. Kotecha VR, Seni J. Issues in managing surgical infections in low-resource settings in Africa. In: *Global Infection Prevention and Management in Healthcare.* p. 448.
4. Zhu X, Olsson MM, Bajpai R, Järbrink K, Tang WE, Car J. Health-related quality of life and chronic wound characteristics among patients with chronic wounds treated in primary care: a cross-sectional study in Singapore. *Int Wound J.* 2022;19(5):1121-1132.
5. Houghton JS, Black I, Meffen A, Gray LJ, Payne TJ, Haunton VJ, et al. Relationship of the wound, ischaemia, and foot infection stage with frailty, disability, quality of life, and one-year outcomes in all-comers with chronic limb-threatening ischaemia: single-centre prospective cohort study. *Ann Vasc Surg.* 2025.
6. Tusiime M, Musoke D, Muneza F, Mutto M, Kobusingye O. Prevalence, risk factors and perceptions of caregivers on burns among children under 5 years in Kisenyi slum, Kampala, Uganda. *Inj Epidemiol.* 2022;9(1):18.
7. Costabella F, Patel KB, Adepoju AV, Singh P, Mahmoud HAH, Zafar A, et al. Healthcare cost and outcomes associated with surgical site infection and patient outcomes in low- and middle-income countries. *Cureus.* 2023;15(7).
8. Eriksson E, Liu PY, Schultz GS, Martins-Green MM, Tanaka R, Weir D, et al. Chronic wounds: Treatment consensus. *Wound Repair Regen.* 2022;30(2):156-171.
9. Monk EJ, Jones TP, Bongomin F, Kibone W, Nsubuga Y, Ssewante N, et al. Antimicrobial resistance in bacterial wound, skin, soft tissue and surgical site infections in Central, Eastern, Southern and Western Africa: a systematic review and meta-analysis. *PLOS Glob Public Health.* 2024;4(4):e0003077.
10. Bandy A, Wani FA, Mohammed AH, Dar UF, Dar MR, Tantry BA. Bacteriological profile of wound infections and antimicrobial resistance in selected gram-negative bacteria. *Afr Health Sci.* 2022;22(4):576-586.
11. Lwigale F, Kibombo D, Kasango SD, Tabajjwa D, Atuheire C, Kungu J, et al. Prevalence, resistance profiles and factors associated with skin and soft-tissue infections at Jinja Regional Referral Hospital: a retrospective study. *PLOS Glob Public Health.* 2024;4(8):e0003582.
12. Wangoye K, Mwesigye J, Tungotoy M, Twinomujuni Samba S. Chronic wound isolates and their minimum inhibitory concentrations against third-generation cephalosporins at a tertiary hospital in Uganda. *Sci Rep.* 2022;12(1):1195.
13. Jung L, Kiwanuka J, Mbabazi L, Nakate V, Musaazi J, Nabajja H, et al. A case for routine microbial diagnostics: results from antimicrobial susceptibility testing in post-traumatic wound infections at a Ugandan tertiary care hospital. *PLOS Glob Public Health.* 2023;3(8):e0001880.
14. Weinreich J, Namatovu C, Nsibirwa S, Mbabazi L, Kajumbula H, Dietze N, et al. Microbiological findings

- and clinical outcomes in Ugandan patients with infected burn wounds. *Eur Burn J*. 2023;4(1):69-79.
15. Nobel FA, Islam S, Babu G, Akter S, Jebin RA, Sarker TC, et al. Isolation of multidrug-resistant bacteria from patients with wound infection and their antibiotic susceptibility patterns: a cross-sectional study. *Ann Med Surg (Lond)*. 2022;84:104895.
 16. Hassan SA, Mohamed MA, Salad ZA, Mohamed ND, Ahmed FA, Dirie FA, et al. Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) and associated factors from surgical ward inpatients at Shaafi Hospital, Mogadishu, Somalia. *IJID Reg*. 2025;100717.
 17. AbdulAziz Z, Onaolapo JA, Ibrahim Y, Olayinka B, Abdulaziz MM. Prevalence and antimicrobial resistance profile of methicillin-resistant *Staphylococcus aureus* isolates from wound infections in Zaria, Nigeria. *J Curr Biomed Res*. 2022;2(5):475-489.
 18. Ehiaghe J, Okwara E, Usiosefe R. Prevalence of carbapenem-resistant bacteria associated with wound sepsis in Edo Specialist Hospital, Benin, Edo State, Nigeria. *Otuoke J Med Lab Sci*. 2024;1(2):33-40.
 19. Hamwi AM, Salem-Sokhn E. High frequency and molecular characterization of ESBL-producing Enterobacteriaceae isolated from wound infections in North Lebanon. *Expert Rev Anti Infect Ther*. 2023;21(8):901-909.
 20. Mbabazi L, Hahn S, Sserubiri L, Natukunda P, Wamawobe A, Kajumbula H, et al. Multi-drug resistant surgical site infections following caesarean delivery: a prospective observational study from urban Uganda. *BMC Womens Health*. 2025;25(1):526.
 21. Lubega A, Joel B, Justina Lucy N. Incidence and etiology of surgical site infections among emergency postoperative patients in Mbarara Regional Referral Hospital, southwestern Uganda. *Surg Res Pract*. 2017;2017(1):6365172.
 22. Onsando S, Masanta W, Nyerere A, Njire M, Moriasi G. Diversity and antibiotic susceptibility profiles of bacterial isolates from wound infections in patients at the surgical unit of Kisii Teaching and Referral Hospital, Kenya. *PLoS One*. 2025;20(6):e0326048.
 23. Rasmi AH, Ahmed EF, Darwish AMA, Gad GFM. Virulence genes distributed among *Staphylococcus aureus* causing wound infections and their correlation to antibiotic resistance. *BMC Infect Dis*. 2022;22(1):652.
 24. Justine BN, Mushi MF, Silago V, Igembe Z, Muyombe J, Kishengena PP, et al. Antimicrobial resistance surveillance of skin and soft tissue infections: hospital-wide bacterial species and antibiograms to inform management at a zonal tertiary hospital in Mwanza, Tanzania. *Infect Drug Resist*. 2025:791-802.
 25. Chelkeba L, Melaku T. Epidemiology of staphylococci species and their antimicrobial resistance among patients with wound infection in Ethiopia: a systematic review and meta-analysis. *J Glob Antimicrob Resist*. 2022;29:483-498..
 26. Kizito M, Owachi D, Lule F, Jung L, Bazanye V, Mugerwa I, et al. Antibiotic consumption and utilization at a large tertiary care level hospital in Uganda: a point prevalence survey. *PLoS One*. 2025;20(1):e0313587.
 27. Obakiro SB, Napyo A, Wilberforce MJ, Adongo P, Kiyimba K, Anthierens S, et al. Are antibiotic prescription practices in Eastern Uganda concordant with the national standard treatment guidelines? A cross-sectional retrospective study. *J Glob Antimicrob Resist*. 2022;29:513-519.
 28. Tesfaye S, Tafere W, Abebe W, Wondimeneh Y. Prevalence of extended-spectrum beta-lactamase-producing gram-negative rods and associated factors among patients with wound infection at University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. *Int J Microbiol*. 2024;2024(1):1478975.
 29. Vivo A, Fitzpatrick MA, Suda KJ, Jones MM, Perencevich EN, Rubin MA, et al. Epidemiology and outcomes associated with carbapenem-resistant *Acinetobacter baumannii* and carbapenem-resistant *Pseudomonas aeruginosa*: a retrospective cohort study. *BMC Infect Dis*. 2022;22(1):491.
 30. Emamgholitarab Malekshah F, Gholami M, Pahlavanian M, Goli HR. Investigating the prevalence of class 1, 2, and 3 integrons in carbapenem-resistant *Acinetobacter baumannii* isolated from burn wound infections. *Sci Rep*. 2025;15(1):31857.
 31. Mwanja H, Kiggundu R, Walwema R, Lwigale F, Waswa J, Hope M, et al. Epidemiology of bloodstream bacterial infections and missed opportunities to detect and respond to possible outbreaks due to drug-resistant bacteria in hospitals in Uganda: a review of retrospective national AMR surveillance data 2020 to 2023. *Wellcome Open Res*. 2025;10:665.
 32. Namusoosa R, Mugerwa I, Kasozi KI, Muruta A, Najjuka G, Atuhaire WD, et al. The epidemiology of antibiotic-resistant clinical pathogens in Uganda. *J Glob Health*. 2024;14:04184.
 33. Mayito J, Kibombo D, Olaro C, Nabadda S, Guma C, Nabukenya I, et al. Characterization of antibiotic resistance in select tertiary hospitals in Uganda: an evaluation of 2020 to 2023 routine surveillance data. *Trop Med Infect Dis*. 2024;9(4):77.
 34. Pacifici G. Clinical pharmacology of piperacillin/tazobactam. *J Clin Biomed Investig*. 2023;3:11-19.

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