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Prevalence, bacterial profile, antimicrobial resistance pattern, and predictors of blood culture positive sepsis among adults admitted at Jinja Regional Referral Hospital in Uganda

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Introduction: There is paucity of data on the prevalence, bacterial profile, antimicrobial resistance (AMR) pattern, and predictors of blood culture positive sepsis among adults admitted at Jinja Regional Referral Hospital (JRRH). The aim of the present study was to determine the prevalence, bacterial profile, AMR pattern, and predictors of blood culture positive sepsis among adults admitted at JRRH.

Methods: This was a cross-sectional study between June and August 2023 where patients were recruited using the quick Sepsis Related Organ Failure Assessment (qSOFA) criteria. Data (Sociodemographic and clinical), and blood was collected from eligible patients. Blood was incubated, sub-cultured, and their antimicrobial susceptibility was determined using the disc diffusion method. Data was analyzed on the statistical package for the social sciences (SPSS version 26) and summarized using descriptive statistics and logistic regression.

Results: Most patients were male (132/261, 50.6%), aged 18–36 (155/261, 71.6%), single (146/261, 55.9%), Christian (224/261, 85.8%), had secondary level of education (129/261, 49.4%), were students (93/261, 35.6%), and consumed alcohol (35/261, 13.4%). The prevalence of blood culture-positive sepsis was 53 out of 261 (20.32%), the most isolated pathogens were *Staphylococcus aureus* (20.8%, 11/53), *Streptococcus* spp. (18.9%, 10/53), and *Klebsiella pneumoniae* (13.2%, 7/53). *S. aureus* exhibited 100% resistance to gentamicin, tetracycline, and minocycline. *Streptococcus* spp was resistant to tetracycline, while *K. pneumoniae* was resistant to gentamicin. Blood culture positive sepsis was associated with the duration of symptoms for >5 days (aOR=2.010, CI=1.602–6.705, *p*=0.026), central nervous system (CNS) symptoms (aOR=3.058, CI=1.365–6.849, *p*=0.007), and low peripheral oxygen saturation (aOR=3.837, CI=1.733–8.496, *p*=0.001).

Conclusion: The findings suggest that blood culture positive sepsis occurred most frequently among male patients, with most patients aged 18–36 years, though further analysis is needed to establish strong demographic associations. The findings highlight notable antimicrobial resistance in *Staphylococcus aureus*, *Streptococcus* spp., and *Klebsiella pneumoniae*, which should prompt further investigation into antimicrobial stewardship programs. Furthermore, prolonged symptom manifestation, CNS involvement, and hypoxemia seem to be key predictors of blood culture positive sepsis in the study area. Public health interventions in the study area should focus on improving early detection and management of sepsis, with a particular emphasis on promoting awareness in high-risk groups.

KEYWORDS

antimicrobial resistance, blood culture, sepsis, antimicrobial susceptibility, Uganda

Background

Sepsis is a life-threatening condition resulting from the body's dysregulated response to infection (1–4). It is typically managed with source control, antimicrobial therapy, and supportive care for organ function (5, 6). A 2017 study by Rudd et al. reported that there were 11.0 million sepsis related fatalities, and 48.9 million sepsis cases globally with the highest burden recorded in sub-Saharan Africa, Oceania, and South Asia (7). Sepsis is a major cause of morbidity and mortality in sub-Saharan Africa, with limited data available on its bacterial etiology and resistance profiles (8, 9). Studies on the burden of sepsis in Uganda have reported values ranging from 11% to 14.7% (10, 11). Moreover, Krepiakovich and colleagues investigated the economic burden of sepsis in Uganda and reported that the mean out-of-pocket costs of managing sepsis was \$124.50 at private facilities and \$ 44.60 for post-discharge care, forcing many families to sell assets, particularly livestock, to cover hospital expenses (12). Moreover, pathogens which are responsible for sepsis in Uganda are increasingly developing resistance to commonly used antimicrobials (10, 13–15). A study at Mulago National Referral Hospital identified *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae* as predominant pathogens in neonatal sepsis (13). Furthermore, most of the clinical isolates showed resistance to ampicillin, gentamicin, and ceftriaxone (13). Similar observations have been made in other parts of Uganda (10, 14–18).

Jinja Regional Referral Hospital (JRRH) was established in the 1930's as a health unit for World War II combatants and prisoners of war from Kimaka (MoH, Uganda) (19). It then went on to become a district hospital and was upgraded to a regional referral for Eastern Uganda in 1995 (MoH, Uganda) (19). The hospital currently serves 4.5 million people across a vast catchment area comprising one city and eleven districts (MoH, Uganda) (19). Despite the growing burden of sepsis in Uganda, there is limited information on the prevalence, bacterial etiology, and antimicrobial

resistance patterns at Jinja Regional Referral Hospital. This study addresses these gaps and aims to provide valuable insights for better clinical management and public health interventions.

Materials and methods

Study setting

JRRH is a regional referral hospital In Eastern Uganda and is located 110km from Kampala. The hospital receives patients from several districts within Busoga, Central, Mbale, and some parts of Kenya. It is a 500-bed hospital with a bed occupancy of 42% (210/500) adults per daily. The hospital has a functional intensive care unit, an accidents and emergency department, and an internal medicine department. Patients with sepsis present at the accidents and emergency department and are initially evaluated and admitted to the medical or intensive care unit. Blood culture and antimicrobial sensitivity testing is carried out by a qualified microbiologist at the hospital laboratory and sepsis is managed by physicians and senior house officers.

Inclusion and exclusion criteria

All patients aged 18 years and above with at least 2 of the Quick Sepsis Related Organ Failure Assessment (qSOFA) criteria i.e. respiratory rate ≥ 22 , altered mental status, systolic blood pressure ≤ 100 and at the intensive care unit or medical, accident and emergency departments at JRRH during the study period were recruited. Patients who had used antibiotics in the previous 2 weeks, trauma and surgical patients, those who didn't consent, and those who could not understand English or Lusoga were excluded. Although the use of translators was considered, it was not feasible due to resource constraints.

Sample size

The Leslie Kish Formula was used to calculate sample size (20)

$$N = \frac{Z_{\alpha/2}^2 p(1-p)}{d^2}$$

Where, N= Estimated sample size required for the study

Z-alpha = 1.96, standard normal value corresponding to 95% confidence level

p= Estimated prevalence of Sepsis among adult patients = 21.7% (21)

d = Precision (0.05)

Substituting, $\frac{N=1.96^2 \times 0.217 \times (1-0.217)}{0.05^2} = 261$

The sample size required was 261.

Sampling technique

Consecutive sampling was conducted on all patients with suspected sepsis until the sample size of 261 participants was achieved. Patients who scored 2 or 3 based on the qSOFA criteria (Respiratory rate ≥ 22 , Altered mental status, Systolic blood pressure ≤ 100) were approached and the aims of the study was communicated to them. Informed consent was then administered for patients willing to participate.

Data collection

A study questionnaire was designed to collect sociodemographic and clinical characteristics from patients or their caregivers. Patient codes were used to maintain confidentiality and the validity and reliability of the questionnaire was tested through a pilot study at the Kampala International University Teaching and Referral Hospital (KIU-TH). Questionnaire validity was evaluated using content validation using two physicians who analyzed the domains and items in the questionnaire and assigned scores. The threshold for the content validity index was set at 0.80 (22). Questionnaire reliability was evaluated on 10 patients at KIU-TH based on a Cronbach's alpha of <0.70 .

Sample collection

Ten (10) ml of blood was collected aseptically into two separate blood culture bottles for aerobic and anaerobic blood culturing. Four milliliters of blood were collected into purple top ethylene diamine tetra acetic acid (EDTA) vacutainers for HIV and complete blood count (CBC) testing. Random blood sugar was also conducted at bedside.

Sample analysis

Laboratory analysis was carried out at the microbiology laboratory of JRRH. Blood culture bottle details were entered in

the Laboratory information system, and the culture bottles were onboarded onto the blood culture machine (BACTEC FX40). The blood culture bottles were incubated at 37°C for up to 7 days, with the BACTEC FX40 machine monitoring for bacterial growth. Once flagged as positive, subcultures were performed on blood agar, chocolate agar, and MacConkey agar. The cultures were incubated at 37°C and examined for bacterial growth after 24–48 hours. The Kirby-Bauer disc diffusion method was used to determine the susceptibility of the microorganisms to standard antibiotic discs (23, 24). Interpretation of the zones of inhibition was done based on the Clinical Laboratory Standard Institute (CLSI) criteria (25).

Data analysis

Data on sociodemographic variables were summarized using descriptive statistics on Statistical Package for the Social Sciences (SPSS Inc., Chicago, USA, version 26.0 for Windows). Cross tabulation was used to report the sensitivities of the different microorganisms to the tested antibiotics. Bivariable and multivariable analysis was conducted using binary logistic regression reporting both odds ratios and P values. Variables with p values ≤ 0.2 after bivariable analysis were reanalyzed multivariably using backward stepwise binary logistic regression. $p \leq 0.05$ was considered significant.

Results

Recruitment of study participants

Two hundred and eighty (280) adult patients who met the qSOFA criteria were managed at Jinja Regional Referral Hospital (JRRH) during the study period. Of these, 16 had taken antibiotics prior to presentation and were therefore excluded. Of the remaining 264, 3 did not consent to participate in the study. Therefore, 261 patients were recruited into the study but only 53 had blood culture positive sepsis.

Sociodemographic characteristics of the study participants

Table 1 describes the sociodemographic characteristics of study participants. Most of the study participants were male (132/261, 50.6%), had a mean age of 36.2 (SD=17.8), and were from the rural area (187/261, 71.6%). The mean duration of symptoms prior to presentation was 6.1(SD=3.5) days, thirty-two of the study participants were HIV positive with 31 on antiretroviral treatment. All participants had elevated temperature with leukocytosis but normal platelet count.

Baseline clinical characteristics of the study participants

Table 2 is a summary of the baseline clinical characteristics of the study participants. The mean duration of symptoms prior to

TABLE 1 Sociodemographic characteristics of study participants at the Jinja Regional Referral Hospital who were recruited into the study during the study period.

Variable (n=261)	Frequency (%)
Gender	
Male	132 (50.6)
Female	129 (49.4)
Age	
18-36	155 (59.4)
37+	106 (40.6)
Marital status	
Single	146 (56.0)
Married	102 (39.1)
Widow	13 (5.0)
Residence	
Rural	187 (71.7)
Urban	74 (28.3)
Religion	
Christian	224 (85.8)
Muslim	34 (13.0)
Other	3 (1.2)
Education level	
Primary	102 (39.1)
Secondary	129 (49.4)
Tertiary	30 (11.5)
Occupation	
Formally employed	08 (3.1)
Peasant	87 (33.3)
Business	61 (23.4)
Student	93 (35.6)
Other	12 (4.6)

presentation was 6.1 days (SD=3.5), with 126 participants (48.3%) experiencing symptoms for more than five days. The most common symptoms were respiratory issues, reported by 187 participants (71.7%), followed by gastrointestinal symptoms in 120 individuals (46.0%), and central nervous system symptoms in 118 participants (45.2%). All participants exhibited leukocytosis, with a white blood cell count exceeding $12 \times 10^9/L$. Furthermore, all patients presented with elevated body temperature, and the majority had normal platelet counts.

Table 3 is a summary of the history of chronic illnesses and medication use among the study participants. Of the 261 patients, 84 (32.2%) reported having a chronic illness. Thirty-two participants (12.3%) were HIV positive, of whom 31 were on antiretroviral treatment. Other chronic conditions included diabetes (11.9%), malignancy (3.4%), sickle cell disease (2.7%), and tuberculosis (2.7%). In terms of medication use, 77 participants (29.5%) were receiving treatment for chronic diseases.

TABLE 2 Baseline clinical characteristics of study participants who were recruited into the study during the study period.

Variable (n=261)	Frequency (%)
Duration of symptoms (in days)	
≤5	135 (51.7)
6+	126 (48.3)
Symptoms	
Central nervous system	118 (45.2)
Respiratory	187 (71.7)
Gastrointestinal tract	120 (46.0)
Cardiovascular system	44 (16.9)
Genitourinary	20 (7.7)
Musculoskeletal	65 (24.9)
Integumentary	30 (11.5)
Body Mass Index	
Normal	150 (57.5)
Underweight	09 (3.4)
Overweight	93 (35.6)
Obese	09 (3.4)
Systolic blood pressure	
<90	14 (5.4)
90-119	186 (71.3)
120-129	19 (7.3)
130+	42 (16.1)
Diastolic blood pressure	
<60	45 (17.3)
60-79	165 (63.2)
80+	51 (19.5)
White cell count	
> $12 \times 10^9/L$	261 (100)
Hemoglobin levels	
<8	9 (3.4)
8-10	123 (47.1)
10.1-11.9	48 (18.4)
12+	81 (31.0)
Temperature: 38+	261 (100)
Respiratory rate: >20	217 (83.2)
Pulse rate: >100	133 (50.9)
SPo2: <90	66 (25.3)
Glasgow Coma Scale: <15	66 (25.3)
12+	81 (30.1)
Platelets: >150	261 (100.0)

Profile of bacteria which were isolated from blood samples collected from study participants

Table 4 shows the profile of bacteria isolated from the blood samples collected from study participants at the Jinja Regional Referral Hospital. Bacterial growth was observed in 53/261 (20.31%) of the study participants with *Staphylococcus aureus* was

TABLE 3 Chronic illness and medication history of study participants who were recruited into the study during the period of study.

Variable (n=261)	Frequency (%)
History of chronic illness	
Yes	84 (32.2)
No	177 (67.8)
HIV	
Yes	32 (12.3)
No	229 (87.7)
Diabetes	
Yes	31 (11.9)
No	230 (88.1)
Malignancy	
Yes	09 (3.4%)
No	252 (96.6%)
Sickle Cell Disease	
Yes	07 (2.7)
No	254 (97.3)
Tuberculosis	
Yes	07 (2.7)
No	254 (97.3)
Medication for chronic diseases	
Yes	77 (29.5)
No	184 (70.5)
Use of antiretrovirals	
Yes	31 (11.9)
No	230 (88.1)
Use of antihypertensives	
Yes	31 (11.9)
No	230 (88.1)
Use of hypoglycemics	
Yes	31 (11.9)
No	230 (88.1)
Use of anti-inflammatory agents	
Yes	25 (9.6)
No	236 (90.4)

the most common microorganism isolated from patient blood samples (11/53, 20.8%), followed by *Streptococcus* spp (10/53, 18.9%), and *Klebsiella pneumoniae* (7/53, 13.2%).

Resistance patterns of bacteria isolated from the blood samples of study participants

Table 5 shows the resistance patterns of bacteria isolated from study participants at the Jinja Regional Referral Hospital during the

TABLE 4 Profile of the bacteria which were isolated from the blood samples of study participants at the Jinja Regional Referral Hospital during the study period.

Bacteria isolate	Frequency (%)
<i>Staphylococcus aureus</i>	11 (20.8)
<i>Streptococcus</i> spp	10 (18.9)
<i>Klebsiella pneumoniae</i>	7 (13.2)
<i>Bacillus</i> spp	4 (7.5)
<i>Coagulase negative Staph</i>	4 (7.5)
<i>Escherichia coli</i>	3 (5.7)
<i>Proteus vulgaris</i>	3 (5.7)
<i>Pasteurella</i> spp	3 (5.7)
<i>Serratia marcescens</i>	3 (5.7)
<i>Staph Epidermidis</i>	2 (3.8)
<i>Klebsiella oxytoca</i>	1 (1.9)
<i>Citrobacter freundii</i>	1 (1.9)
<i>Acinetobacter baumannii</i>	1 (1.9)
Total	53 (100)

study period. *Staphylococcus aureus* was 100% sensitive to Doxycycline, Penicillin, Azithromycin, Clindamycin and Cefoxitin but completely resistant to Gentamicin, Tetracycline and Minocycline. *Streptococcus Spp* was 100% sensitive to Levofloxacin, Cefepime, Clindamycin and Erythromycin but completely resistant to Tetracycline. *Klebsiella pneumoniae* was 100% sensitive to Ciprofloxacin, Imipenem, Cefalexin and Ceftazidime-Tazobactam but completely resistant to Gentamicin.

Bivariate and multivariate analysis of the factors associated with blood culture positive sepsis among study participants

Table 6 shows the results of the bivariate and multivariate analysis of the factors associated with blood culture positive sepsis among study participants. According to bivariate analysis, age ($p=0.189$), gender ($p=0.198$), marital status ($p=0.156$), education level ($p=0.179$, 0.140), occupation ($p=0.147$, 174), alcohol use ($p=0.169$), use of anti-inflammatory drugs ($p=0.064$), duration of symptoms ($p=0.024$), presence of central nervous system symptoms ($p=0.006$), body mass index category ($p=0.011$), peripheral oxygen saturation ($p<0.001$) and level of consciousness based on Glasgow coma scale ($p<0.001$) had p values less than 0.2. According to multivariate analysis, the duration of symptoms ($p=0.026$), the presence of central nervous system symptoms ($p=0.007$), and having low peripheral oxygen saturation ($p=0.001$) were significantly associated with blood culture positive sepsis. Moreover, patients who had the symptoms for more than 5 days were 2.010 times more likely to have blood culture positive sepsis

TABLE 5 Resistance patterns of bacteria isolated from study participants at the Jinja Regional Referral Hospital during the study period.

Drug	Bacterial pathogen													
	Categories	Staphylococcus aureus (n = 11)	Streptococcus spp (n = 10)	Klebsiella pneumoniae (n = 7)	Bacillus spp (n = 4)	Coagulase neg Staph (n = 4)	Escherichia coli (n = 3)	Proteus vulgaris (n = 3)	Pasteurella spp (n = 3)	Serratia marcescens (n = 3)	Staphylococcus epidermidis (n = 2)	Klebsiella oxytoca (n = 1)	Citrobacter freundii (n = 1)	Acinetobacter baumannii (n = 1)
Ciprofloxacin	S	71.4%	–	100%	–	50.0%	–	100%	100%	–	–	100%	100%	100%
	I	–	–	–	–	–	–	–	–	–	100%	–	–	–
	R	28.6%	–	–	–	50.0%	–	–	–	–	–	–	–	–
Levofloxacin	S	–	100%	–	–	–	–	–	100%	–	–	–	–	100%
Cefuroxime	S	–	–	–	–	–	–	–	100%	–	–	–	–	–
Doxycycline	S	100%	–	–	–	–	–	–	–	–	–	–	–	–
	I	–	–	–	–	–	–	–	33.3%	–	–	–	–	–
	R	–	–	–	–	100%	–	–	66.7%	–	–	–	–	–
Penicillin	S	100%	–	–	100%	–	–	–	–	–	–	–	–	–
	I	–	–	–	–	–	–	–	33.3%	–	–	–	–	–
	R	–	–	–	–	–	–	–	66.7%	–	100%	–	–	–
Imipenem	S	–	–	100%	–	50.0%	100%	100%	–	–	–	100%	–	–
	R	–	–	–	–	50.0%	–	–	–	–	–	–	100%	–
Chloramphenicol	S	–	–	–	–	100%	100%	100%	–	–	–	–	–	–
	I	–	–	100%	–	–	–	–	–	–	–	–	100%	–
Trimethoprim-sulfamethoxazole	S	–	–	–	–	100%	–	–	–	–	–	–	100%	–
	I	–	–	100%	–	–	–	–	–	–	–	–	–	–
	R	–	–	–	–	–	–	100%	–	–	–	–	–	–
Gentamycin	S	–	–	–	100%	–	–	–	–	–	–	–	–	–
	I	–	–	–	–	–	–	–	–	–	–	–	–	100%
	R	100%	–	100%	–	100%	100%	100%	–	–	–	100%	–	–
Ceftriaxone	S	85.7%	–	–	–	100%	66.7%	–	–	–	–	–	–	–
	I	–	–	–	–	–	33.3%	100%	–	–	–	100%	–	–
	R	14.3%	–	–	–	–	–	–	–	–	–	–	–	–
Meropenem	S	–	–	–	–	–	–	–	–	–	100%	–	–	–
Amikacin	S	–	–	–	–	–	–	–	–	–	100%	–	–	–
	I	100%	–	20.0%	–	–	–	–	–	–	–	–	–	–
	R	–	–	80.0%	–	–	100%	–	–	100%	–	–	–	–

(Continued)

TABLE 5 Continued

Drug	Bacterial pathogen													
	Categories	Staphylococcus aureus (n = 11)	Streptococcus spp (n = 10)	Klebsiella pneumoniae (n = 7)	Bacillus spp (n = 4)	Coagulase neg Staph (n = 4)	Escherichia coli (n = 3)	Proteus vulgaris (n = 3)	Pasteurella spp (n = 3)	Serratia marcescens (n = 3)	Staphylococcus epidermidis (n = 2)	Klebsiella oxytoca (n = 1)	Citrobacter freundii (n = 1)	Acinetobacter baumannii (n = 1)
Vancomycin	S	-	-	-	-	-	-	-	-	-	100%	-	-	-
	I	-	100%	-	-	-	-	-	-	-	-	-	-	-
Cefepime	S	-	100%	-	-	-	-	-	-	-	-	-	-	-
	R	-	-	-	-	-	-	-	-	-	100%	-	-	-
Nitrofurantoin	S	-	-	-	-	-	-	-	-	-	-	100%	-	-
	R	-	-	-	-	-	-	-	-	-	100%	-	-	-
Azithromycin	S	100%	-	-	-	-	-	-	-	-	-	-	100%	-
Clindamycin	S	100%	100%	-	-	-	-	-	-	-	-	-	-	-
	R	-	-	-	100%	-	-	-	-	-	-	-	-	-
Cefoxitin	S	100%	-	-	-	-	100%	-	-	-	-	-	-	-
Tetracycline	S	-	-	-	100%	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	100%	-	-	-	-	-	-	-	-
	R	100%	100%	-	-	-	-	-	-	-	-	-	-	-
Minocycline	R	100%	-	-	-	-	-	-	-	-	-	-	-	-
Oxacillin	I	100%	-	-	-	-	-	-	-	-	-	-	-	-
	R	-	-	-	-	-	-	-	-	-	100%	-	-	-
Cefalexin	S	-	-	100%	-	66.7%	100.0%	-	-	-	-	-	-	-
	R	-	-	-	-	33.3%	-	-	-	-	-	-	-	-
Ampicillin	I	-	-	80.0%	-	100%	100%	-	-	100%	-	-	-	-
	R	-	-	20.0%	-	-	-	-	-	-	-	-	-	100%
Ceftazidime-Tazobactam	S	-	-	100%	-	-	-	-	-	100%	-	-	-	100%
	R	-	-	-	-	-	100%	-	-	-	-	-	-	-
Amoxiclav	S	-	-	-	-	-	-	-	-	100%	-	-	-	-
Erythromycin	S	-	100%	-	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	100%	-	-	-	-	-	-	-	-	-
Piperacillin	S	-	-	-	-	-	-	-	-	100%	-	-	-	-

S, Sensitive; I, Intermediate; R, Resistant; -Antibiotics not tested.

TABLE 6 Output of bivariate and multivariate analysis of the factors associated with blood culture positive sepsis among study participants.

Variable	Bivariate Analysis Crude OR	95% CI (Bivariate)	p- value (Bivariate)	Multivariate Analysis Adjusted OR	95% CI (Multivariate)	p- value (Multivariate)
Age	1.272	0.692-2.336	0.189	1.574	0.271-9.134	0.613
Gender	1.493	0.811-2.748	0.198	1.921	0.830-4.446	0.127
Marital status	0.875 (Married)	0.463-1.654	0.681	3.163 (Married)	0.743-13.467	0.119
Education level	2.38	0.672-8.449	0.179	2.745	0.653-11.538	0.168
Occupation	0.320	0.068-1.493	0.147	1.323	0.127-13.787	0.815
Alcohol use	0.466	0.157-1.384	0.169	1.068	0.091-1.485	0.160
History of chronic illness	0.890	0.463-1.712	0.728	Ref	N/A	N/A
Duration of symptoms	2.040	1.099-3.789	0.024	2.010	1.602-6.705	0.026
CNS symptoms	2.388	1.284-4.440	0.006	3.058	1.365-6.849	0.007
BMI (Normal, Underweight, Overweight, Obese)	0.690	0.082-5.784	0.732	1.613	0.148-17.594	0.695
SPo2	3.637	1.921-6.886	<0.001	3.837	1.733-8.496	0.001
GCS	3.758	1.793-7.876	<0.001	2.347	0.957-5.760	0.062
Hemoglobin content	1.069 (Normal)	0.441-2.592	0.882	Ref	N/A	N/A

compared to patients who had the symptoms for 5 days or less (aOR=2.010, CI=1.602-6.705, $p=0.026$). Patients who displayed CNS symptoms were 3.058 times more likely to have blood culture positive sepsis than patients who had no CNS symptoms (aOR=3.058, CI=1.365-6.849, $p=0.007$). Furthermore, patients who had low oxygen saturation were 3.837 times more likely to have blood culture positive sepsis than patients whose oxygen saturation was normal (aOR=3.837, CI=1.733-8.496, $p=0.001$).

Discussion

This study sought to evaluate the bacterial profile, resistance patterns, and predictors of blood culture positive samples collected from patients who presented to the Jinja Regional Referral Hospital, a major hospital in Eastern Uganda. The study observed that most participants were from the rural areas which was expected, as most patients in the region are typically referred from rural regions, despite the hospital's urban location. Moreover, the time taken by patients to develop symptoms and when they presented to the hospital suggests a concerning trend of poor health-seeking behavior, as patients tended to present late. Moreover, 32 participants were HIV positive, with 31 receiving antiretroviral treatment, suggesting effective HIV care services. All participants exhibited elevated temperatures and leukocytosis, consistent with the study's aim to enroll patients suspected of having sepsis based on the qSOFA criteria.

Despite the suspicion of sepsis in all enrolled patients, only 53 out of 261 (20.3%) had culture-positive sepsis. This value was higher than the 14.7% prevalence rate reported by Nyesiga et al. at the Kirru National Referral Hospital in Uganda (10) and the

11.0% reported by a community-based study on sepsis by Kayom and colleagues (11). However, the value was lower than the 35% reported by Kiwanuka et al. among neonates at Mbarara Regional Hospital (17) and the 21.8% reported among neonates at Kidera Health Center in Eastern Uganda by John and co-workers (16).

The prevalence of *Staphylococcus aureus* (20.8%) in the study setting was consistent with the 20% observed at Kidera Health Center (17). The prevalence of *Streptococcus* spp. (18.9%) was much higher than the 2.6% reported by John and colleagues (16) and the 1.3% reported by Kiwanuka and co-workers (17). Moreover, the prevalence of *Klebsiella pneumoniae* (13.2%) was much lower than what was reported by John et al. (2.6%) and Kiwanuka et al. (2.5%) (16, 17). The resistance patterns observed in the present study do not make for good reading. *S. aureus* was 100% resistant to gentamicin and tetracycline while *Klebsiella pneumoniae* was 100% resistance to gentamicin. This is in contrast to the study by Tumuhameye et al. who observed 24.1%, and 44.8% resistance of *S. aureus* to gentamicin and tetracycline, and 40% resistance of *K. pneumoniae* to gentamicin (13).

S. aureus is an ESKAPE (*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter* spp) group pathogen which are important bacteria responsible for multidrug resistance (26). Resistance of *S. aureus* to aminoglycosides has been linked to the synthesis of transferases that modify the aminoglycoside molecule or the lack of enzymes to transport aminoglycosides into the bacterial cell (26–28). Ida and colleagues reported that resistance to gentamicin was specifically due to the two-domain acetyltransferase/phosphotransferase (AAC(6')-Ie/APH(2'')-Ia), encoded by the *aacA-aphD* gene (29). Resistance to tetracyclines

in *S. aureus* is mainly due to the Tet(M) protein but tetracycline resistance in *Staphylococcus* spp. conditioned by Tet (O), Tet(W) and Tet(44) proteins conditioning ribosomal protection has also been described (26, 30). *Klebsiella pneumoniae* was 100% resistance to gentamicin. This is in contrast to the study by Tumuhameye et al. who observed 40% resistance of *K. pneumoniae* to gentamicin (13). Resistance of *K. pneumoniae* to gentamicin has been reported to be due to the expression of 16 S rRNA methylase by the *armA* gene, the modification of cell permeability through changes in the AcrAB-TolC and KpnEF efflux pump system or the loss of the putative porin KpnO (31–34). All these lead to therapeutic failure.

This study observed that the duration of symptoms, presence of central nervous system symptoms, and low peripheral oxygen saturation (SpO₂) were independently associated with blood culture-positive sepsis. This is an important finding especially in the context of a resource-limited setting. From a clinical standpoint, central nervous system symptoms and low oxygen saturation suggest a severe infection likely to enter the bloodstream, as central nervous system infections often originate from other systems (35). It could be argued that low oxygen saturation may indicate reduced tissue perfusion due to septic shock or severe respiratory infections, which compromise the body's ability to fight off infections. Su and colleagues conducted a prospective cohort study at the emergency department of the National Taiwan University Hospital and reported that the predictors of bacteremia were fever $\geq 38.3^{\circ}\text{C}$, tachycardia $\geq 120/\text{minute}$, lymphopenia $< 0.5 \times 10^3/\text{L}$, aspartate transaminase $> 40 \text{ IU/L}$, C-reactive protein $> 10 \text{ mg/dL}$, and pro Calcitonin $> 0.5 \text{ ng/mL}$ and a presumptive diagnosis of respiratory tract infection (36). Another study by Chase and others identified respiratory failure, vasopressor use, neutrophilia, bandemia, abnormal temperature, suspected line or urinary infection and endocarditis to be associated with all-case bacteremia among patients at the emergency department at the Beth Israel Deaconess Medical Center in Boston, Massachusetts (37). No specific co-infections were reported in the study population. However, it is important to consider that bacterial co-infections could influence the clinical outcome of sepsis and complicate treatment strategies. Future studies should investigate the role of co-infections in sepsis cases to determine their impact on sepsis management and patient outcomes.

Previous authors have reported that HIV status is significantly associated with blood-culture positive sepsis (38, 39). However, this study presents contrary findings. It may be argued that because most of the HIV-positive participants in this study were on antiretroviral therapy (31 out of 32), these participants did not have advanced disease that is routinely associated with sepsis.

Limitations

The study adopted a cross-sectional design which measured data over a single point in time. Therefore, it was not possible to determine causal relationships between variables. Moreover, while a

control group was not included, future studies could benefit from incorporating healthy controls or comparing sepsis prevalence and resistance patterns between different populations to better understand the broader implications of these findings.

Conclusion

The findings suggest that blood culture positive sepsis occurred most frequently among male patients, with most patients aged 18–36 years, though further analysis is needed to establish strong demographic associations. The findings highlight notable antimicrobial resistance in *Staphylococcus aureus*, *Streptococcus* spp., and *Klebsiella pneumoniae*, which should prompt further investigation into antimicrobial stewardship programs. The findings further suggest that prolonged symptom manifestation, CNS involvement, and hypoxemia are key predictors of blood culture positive sepsis in the study area. Public health interventions should focus on improving early detection and management of sepsis, with a particular emphasis on promoting awareness in high-risk groups.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Makerere University School of Public Health REC (SPHREC) (REC No. SPH-2023-435). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

NK: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. AP: Investigation, Methodology, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. CA: Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. AM: Data curation, Investigation, Methodology, Resources, Software, Validation, Writing – original draft, Writing – review & editing. JM: Conceptualization, Investigation, Methodology, Resources, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. KA: Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. AA: Project administration, Resources, Writing – original draft, Writing – review & editing.

IN: Project administration, Resources, Software, Writing – original draft, Writing – review & editing, SV: Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing, MO: Data curation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft, Writing – review & editing, Visualization.

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