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A cross-sectional study on factors contributing to nosocomial infections in medical wards in Mengo Hospital.

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Abstract

Introduction
This study aimed to determine the factors contributing to Nosocomial infections (NIs), common isolates, and their susceptibility patterns associated with NIs in medical wards in Mengo Hospital.

Method
A cross-sectional study involving 84 patients attending medical wards in Mengo Hospital from August 2024 to November 2024 was carried out. Upon consenting, study subjects were enrolled in the study. Samples were collected from the study subjects who presented with NIs and taken to the laboratory for culture and susceptibility testing. The results obtained were recorded and analyzed using statistical packages SPSS version 25 and presented as tables and figures with clear narratives under them.

Results
Out of the 84 patients recruited and studied, the general prevalence of NIs was high at 52.4%. Factors associated with NIs among the study participants were catheterization (70.5%), over a month hospitalization of patients (65.9%), and prior intake of antibiotics (56.8%). Commonly isolated microorganisms associated with NIs were *Pseudomonas aeruginosa* 11.9% (10/84), *Candida albicans* 10.7% (9/84), and *Klebsiella pneumoniae* 7.1% (6/84). Resistance profile ranged from 14.3% to 84.6%. Most of the isolates showed resistance against Ceftriaxone (84.6%), Ceftazidime (68.4%), and Nitrofurantoin (64.7%). Meanwhile, better sensitivity patterns were recorded against Amphotericin B (85.7%), Imipenem (84.6%), and Tetracycline (80%).

Conclusions
Nosocomial infections among patients at medical wards in Mengo Hospital are high (52.4%) and present a significant public health problem.

Recommendations
Given the high prevalence of NIs and antimicrobial resistance (AR), there is a need for public awareness, strict hygiene practices in medical wards, and the implementation of antibiotic stewardship programs. Further research is essential to understand the epidemiology and resistance patterns of NIs to inform policy and guide effective interventions.

Keywords: *Nosocomial infections, Risk factors, Medical wards, Mengo hospital*
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Introduction

Nosocomial infections (NIs), also known as healthcare-associated infections (HAIs), are contracted infections while receiving medical care, which were neither present nor developing at the time of hospital admission (Anna & Farah, 2023) . For an infection to qualify as nosocomial, it must develop at least 48 hours after hospital admission. The worrying part of nosocomial infections is that they can lead to severe complications like sepsis and may potentially result in death (Cheung, 2021). Alarmingly, approximately 75% of the burden of

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these infections occurs in developing countries. Even asymptomatic patients may be considered infected if pathogens are isolated from sterile body sites such as blood or cerebrospinal fluid (Hassan et al., 2017).

Worldwide, nosocomial infections impact over 100 million patients each year (Zewdu et al., 2023). Additionally, hospital-acquired infections account for more than 25% of reported cases globally (Landelle & Pittet, 2016). In developed countries alone, more than four million patients acquire these infections every year, highlighting their status as a major public health problem (Zewdu et al., 2023). These infections disproportionately affect immunocompromised hospitalized patients, leading to prolonged hospital stays, increased treatment costs, and excessive healthcare burdens (Ahmad et al., 2023).

According to the World Health Organization (WHO), the prevalence of NIs among hospitalized patients is estimated at 7% in developed countries and 10% in developing countries. Studies from the United States, Europe, and Singapore report incidence rates ranging from 3.2% to 11.9%, depending on the region (Bagheri et al., 2021). A recent meta-analysis of 220 studies conducted in developing countries, of which only 14 originated from Africa, revealed an overall incidence rate of 7.4 infections per 100 patients (Samira et al., 2023).

In sub-Saharan Africa, the occurrence of nosocomial infections varies significantly, with reported rates ranging from 2% to 49% (Mbim et al., 2016). In Ethiopia, the incidence and prevalence have been reported at 35.8% (Zewdu et al., 2023) and 16.96% (Alemu et al., 2020), respectively, while Nigeria has shown a prevalence of 22.2% (Olawale et al., 2023). Similarly, studies conducted across North, South, East, and West Africa, including Tunisia and South Africa, revealed a pooled prevalence of 12.76% (Usman et al., 2022). However, regionally, cases of NIs ranged from 6.5% in Southern Africa to 19.7% in East Africa, with Central Africa reporting 10.3% cases, and 15.5% in West Africa. Furthermore, the mortality rate attributed to HAIs in sub-Saharan Africa is estimated at 22.2% (Melariri et al., 2024).

In Kenya, a study reported a point prevalence of culture-positive bacterial HAIs of 2.62% (95% CI: 3.8–6.7), with the most common infections being gastrointestinal (53%), bloodstream (21%), and lower respiratory tract infections (11%) (Patil et al., 2022). In Tanzania, 14.8% of hospitalized patients were found to have healthcare-associated infections (HAIs) (Kinyenje et al., 2020).

In Uganda, evidence from Lacor Hospital in northern Uganda indicated an overall HAI prevalence of 28%, with higher rates in surgical wards (47%) and lower rates in pediatric wards (21%) (Greco & Magombe, 2016). A systematic review and meta-analysis across Africa found the prevalence in Uganda to be 28.0%, surpassing figures reported in Tunisia (22.2%) and Morocco (25.2%) (Abubakar et al., 2022). Conversely, at Mulago National Referral Hospital, approximately 10% of patients undergoing surgical procedures developed sepsis attributed to NIs (Ssekitoleko et al., 2020).

The common cases of HAIs encountered in healthcare settings are urinary tract infections (UTIs), respiratory tract infections (RTIs), and surgical site infections (Ahmad et al., 2023). Bacteria are the leading causative agents, accounting for approximately 90% of cases, while protozoans, fungi, and viruses are less common contributors (10%). The predominant bacterial pathogens associated with HAIs include *Streptococcus* species, *Acinetobacter* species, *Enterococci*, coagulase-negative *Staphylococci* (CoNS), *Staphylococcus aureus*, *Proteus mirabilis*, *Klebsiella pneumoniae*, and *Escherichia coli* (Hassan et al., 2017).

In Uganda, hospitals emphasize infection prevention and control through adherence to the Ministry of Health's standard precaution guidelines. These include rigorous hand hygiene, appropriate use of protective gear, proper sterilization procedures, safe disposal of sharps, and effective waste management (Wasswa et al., 2017). Despite these measures, nosocomial infections remain a significant challenge among hospitalized patients. For example, a study from Lacor Hospital reported an HAI prevalence of 28.0% (Greco & Magombe, 2016), while in Northwest Ethiopia, the rate was 6.6 per 1,000 person-days of observation (Abebil et al., 2023). These results highlight the critical need to strengthen infection prevention and control (IPC) strategies within healthcare settings. It is against this background that the present study was undertaken to determine the factors contributing to nosocomial infections in the medical wards of Mengo Hospital, to generate current data to inform clinical decisions.

Materials and methods

Study design and site

The study was cross-sectional, conducted from August to November 2024 at Mengo Hospital, the oldest Hospital in Uganda, established by Sir Albert Cook in 1897. The Hospital is located on Namirembe hill in Rubaga division, northwest of Kampala, and it's approximately 2 kilometers (1.2 miles) from the city business centre. The hospital has four operating rooms, an intensive care unit, a maternity ward, a Laboratory department, a paediatric unit, an eye department, a dental department, an HIV counseling department, a radiology department, and training schools (Nursing and Midwifery, Laboratory and ultrasound), and a bed capacity of about 800 beds.

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The hospital primarily serves the residents of Rubaga division, Kampala Metropolitan area, other Ugandans, and the rest of the world. The study area is selected because it is familiar to the researcher.

Inclusion criteria

All patients who were admitted to medical wards in Mengo Hospital during the time of the study and presented with an infection that was not present during the time of admission.
In patients who signed an informed consent to take part in the study.

Exclusion criteria

All patients who were admitted to medical wards in Mengo Hospital during the time of the study and presented with an infection that was not present during the time of admission, but were too ill to take part in the study.

Sample size determination

The sample size was estimated using the formula by Fink and Kosecoff (1965),
N = (Z/e)2 (p) (1-p)
Where; N = sample size
Z = standard score corresponding to a given confidence level, usually a 95% confidence level (Z = 1.96).
e = the proportion of sampling error; an acceptable error level traditionally is up to ±0.5 or ±0.10 (5 or 10% point).
p = estimated proportion or incidence of cases, if not known, is usually taken at 50% (0.5).
N= (1.96/0.1)2*0.5*0.5
N= 96.04 approx. 97
Therefore, the sample size of 97 was considered. However, 13 participants were lost during the study, leaving 84 study participants.

Study tool design

The researcher designed a simple laboratory data entry form, which was used to collect data. Variables such as age, sex, factors associated with NIs, isolated organisms and their antimicrobial susceptibility test (AST) results were entered in a simple data entry form.

Sampling technique

The purposive (judgmental) sampling technique was used, and it targeted only patients admitted to medical wards in Mengo Hospital at the time of the study and presented with infections that occurred at least 48 hours after admission according to the Centers for Disease Control and Prevention (CDC) criteria.

Minimizing bias

Purposive sampling technique was used, and it targeted only patients who developed infections within 48 hours following admission. The pretesting of the research tool was done, research assistants were trained in data collection, the researcher gave ample time for data collection, clear inclusion and exclusion criteria were used, and adherence to standard operating procedures (SOPs) was ensured.

Study procedure

Sampling procedure

The researchers approached all patients admitted to the wards in Mengo Hospital presenting with nosocomial infection(s) and explained to them the purpose and the objectives of the study. The researcher invited the patients to enroll in the study willingly. Patients who accepted were invited to sign an informed consent, and thereafter, they were enrolled in the study.

Specimen collection

The in-patients were assessed for surgical site infections (SSIs), UTIs, respiratory infections, and others acquired 48 hours after admission with the help of medical officers and nurses. Clinical specimens such as clean-catch midstream urine, blood, throat swab, nasal swab, and other body fluids were collected using standard procedures from the respective sites of infections. The specimens were labelled by the patient's identification numbers, packed, and transported to the microbiology laboratory for further investigation.

Laboratory procedures

The samples collected were cultured by streaking onto Blood Agar, Chocolate Agar, MacConkey Agar, CLED, and Sabouraud (for yeast such as Candida species). Chocolate agars were incubated anaerobically and other plates aerobically, all at a temperature of 35-37 degrees Celsius for 24 hours, but Sabouraud up to 48 hours, then examined for growth and reported findings.
The Gram staining technique was performed on the discrete colonies of the pathogens from the overnight-incubated plate to differentiate Gram-positive and Gram-

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negative bacteria and yeast cells. A drop of oil immersion was added onto the dried smear and then examined under 100x objectives for the presence of Gram-negative bacteria, Gram-positive bacteria, and Yeast cells.

Biochemical tests were performed on the bacterial isolates from the cultured organisms on different plate media. Gram-positive organisms were identified by performing different biochemical tests, like the catalase test and coagulase test, and Gram-negative organisms were identified by performing tests such as urease, indole, citrate utilization, oxidase, and triple sugar iron test, and yeast were identified by performing the germ tube test. Therefore, the identification of the bacteria and fungi was based on their biomedical characteristics after an overnight incubation at 37 degrees Celsius.

An antimicrobial susceptibility test was performed on the discrete colonies of the isolated pathogens from the culture plates by preparing an inoculum and comparing it with a 0.5 McFarland turbidity standard. The inoculum was streaked onto a Muller-Hinton agar plate. Using sterile forceps, the filter paper disc impregnated with the antimicrobial agents was placed on the agar. Inoculated plates were incubated at 37 degrees Celsius for 18-24 hours. Plates were examined for areas of no growth following incubation. Zones of inhibition were measured to determine the sensitivity, intermediate, or resistance to the antibiotics.

Data analysis and presentation

Data obtained was analyzed using descriptive statistics, manual analysis, and or using statistical packages such as SPSS version 25. The data analyzed were presented inform of charts, figures, and tables with narratives made under them.

Ethics

Ethical permission to carry out the research study was obtained from the Mengo Hospital Research Ethics Committee (MHREC) and was approved on 17th October 2024 under ethical number MH/REC/108/09-2024. Permission to carry out the study at the study was obtained from all the authorities at the study site. Informed consent was obtained from all the respondents. Confidentiality of all data collected was maintained using laboratory-generated numbers. No unauthorized access was allowed to the data. No harm was done to the subjects in this study. Only those who were directly linked to the study had access to the data. Soft copy data was saved using strong passwords, and hard copy data was locked in a cupboard, and the keys were safely kept. Respondents' names never appeared on the data-capturing forms of study subjects. Any respondent who decided to pull out of the study was free to do so without any penalty, and their health care seeking services were not affected. The patients never paid any money for participating in the study.

Results

Figure 1: Participants recruited

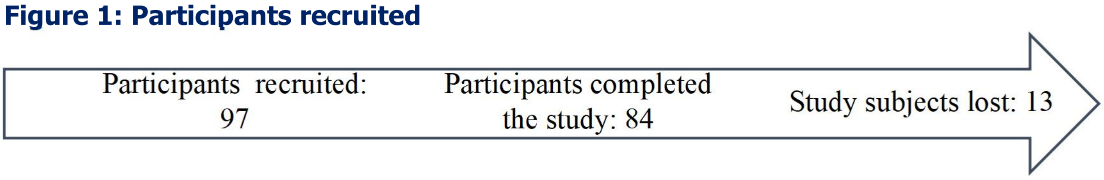

Figure 1 shows the number of participants recruited. In this study, 97 participants were recruited, 84 completed the study, while 13 were lost. The participants who were lost were because the relatives were not willing to allow them to continue with the study

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Table 1: The distribution of patients by age group and gender in the study sample

Variables	Category	Frequency	Percent (%)
Gender	Female	49	58.3
	Male	35	41.7
	Total	84	100
Age group (years)	0-9	12	14.3
	10-19	3	3.6
	20-29	11	13.1
	30-39	20	23.8
	40-49	9	10.7
	50-59	5	6.0
	60-69	8	9.5
	70-79	15	17.9
	80-89	1	1.2
	Total	84	100

Table 1 shows the distribution of patients by gender and age group in the study sample. Findings revealed that the majority (58.3%; n=84) of the patients were females. Moreover, most of the respondents were aged between 30-39 years (23.8%), followed by 70-79 years (17.9%), and 0-9 years (14.3%). The least presented age group was 80-89 years, 1.2%. The average age of the respondents was 41 years (SD:23.7).

Figure 2: The general prevalence of nosocomial infection (NIs) among study patients attending medical wards in Mengo Hospital

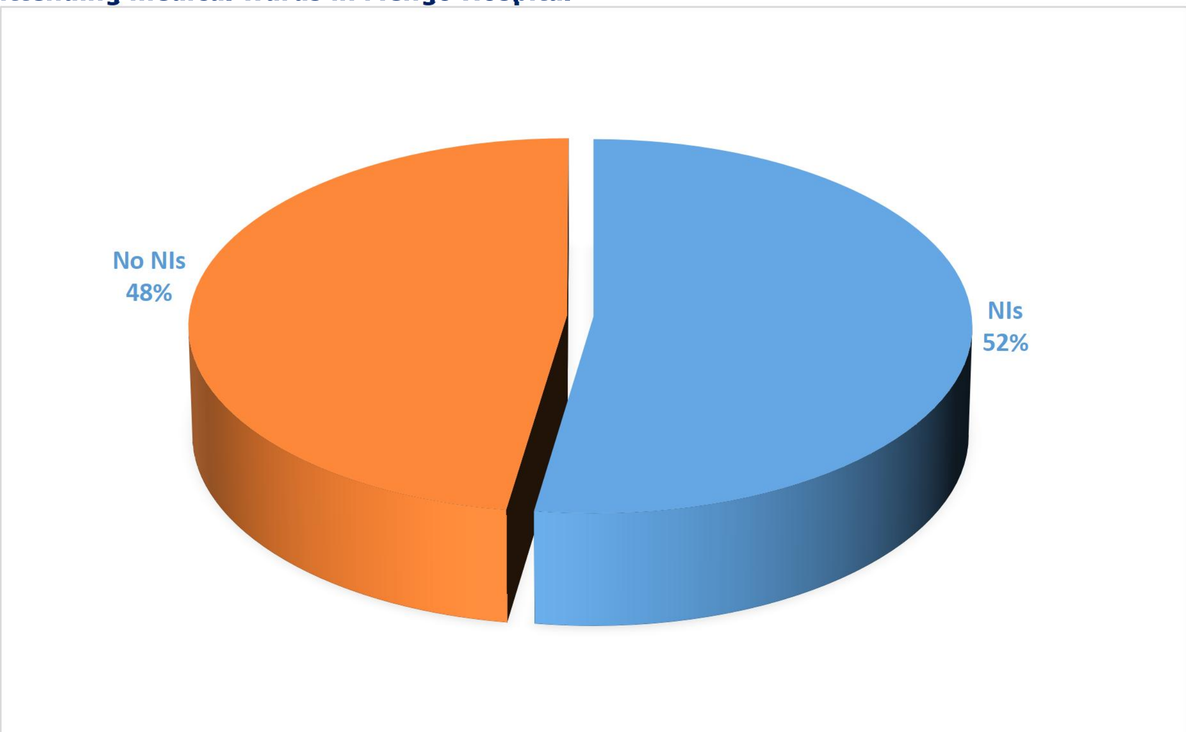

Figure 2 shows the general prevalence of nosocomial infection (NIs) among the study patients attending medical wards in Mengo Hospital. Findings revealed that 52.4% (44/84) of the study participants had nosocomial infections.

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Table 2: The factors to nosocomial infection (NIs) among study patients at medical wards in Mengo hospital

Variables	Category	NIs (n=44)	No NIs (n=40)	Percentage NIs (%)
Duration of stay in the hospital	1 week	4	10	9.1
	2 weeks	11	22	25
	A month	29	8	65.9
	Total	44	40	100
Prior intake of antibiotics	Yes	25	31	56.8
	No	19	9	43.2
	Total	44	40	100
Patients on a catheter	Yes	31	12	70.5
	No	13	28	29.5
	Total	44	40	100
Patients of surgery	Yes	9	16	20.5
	No	35	24	79.5
	Total	44	40	100

Table 2 illustrates the factors contributing to nosocomial infections among study patients attending medical wards in Mengo Hospital. Findings revealed that many patients who were catheterized contracted nosocomial infection (70.5%), followed by patients who had overstayed more than a month of hospitalization (65.9%) and patients who had previously taken antibiotics (56.8%). Very low cases of nosocomial infection were associated with patients who had prior cases of surgery (20.5%).

Table 3: The common microorganisms causing NIs in medical wards in Mengo Hospital

Variables		Frequency	Percent (%)
Isolated micro-organism	*Staphylococcus epidermidis*	2	2.4
	Staphylococcus aureus	5	6.0
	Staphylococcus species	1	1.2
	Pseudomonas aeroginosa	10	11.9
	Candida albicans	9	10.7
	Citrobacter freundii	2	2.4
	Rothia kristinae	2	2.4
	Providensia stuartii	1	1.2
	Klebsiella pneumoniae	6	7.1
	Escherichia coli	3	3.6
	Ralstonia mannitolilytica	1	1.2
	Ralstonia pickettii	1	1.2
	Pseudomonas putida	1	1.2
	Total NIs cases	44	52.4
	No growth after 48 hours	40	47.6

Table 3 illustrates the common microorganisms associated with nosocomial infections in medical wards in Mengo Hospital. Findings demonstrated that *Pseudomonas aeruginosa* was the commonest cause of

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NIs, accounting for 11.9% (10/84), followed by *Candida albicans* 10.7% (9/84) and *Klebsiella pneumoniae* 7.1% (6/84). Other microorganisms that caused NIs were *Staphylococcus epidermidis* 2.4% (2/84), *Staphylococcus aureus* 6% (5/84), *Staphylococcus species* 1.2% (1/84), *Citrobacter freundii* 2.4% (2/84), *Rothia kristinae* 2.4% (2/84), *Providensia stuartii* 1.2% (1/84), *Escherichia coli* 3.6% (3/84), *Ralstonia mannitolilytica* 1.2% (1/84), *Ralstonia pickettii* 1.2% (1/84), *Pseudomonas putida* 1.2% (1/84).

Table 4a: The antibiotic susceptibility patterns of the common isolates associated with nosocomial infections in medical wards in Mengo hospital

Variables		Isolated microorganism													Total	%
		1	2	3	4	5	6	7	8	9	10	11	12	13		
Tetracycline	Sensitive	2	2	0	0	0	0	0	0	0	0	0	0	0	4	80
	Resistant	0	1	0	0	0	0	0	0	0	0	0	0	0	1	20
	Total	2	3	0	0	0	0	0	0	0	0	0	0	0	5	100
Clindamycin	Sensitive	2	1	1	0	0	0	0	0	0	0	0	0	0	4	57.1
	Intermediate	0	2	0	0	0	0	0	0	0	0	0	0	0	2	28.6
	Resistant	0	0	0	0	0	0	1	0	0	0	0	0	0	1	14.3
	Total	2	3	1	0	0	0	1	0	0	0	0	0	0	7	100
Gentamycin	Sensitive	0	1	0	2	0	0	0	0	1	1	0	0	0	5	33.3
	Intermediate	0	0	0	0	0	0	0	0	0	0	0	1	0	1	6.7
	Resistant	2	2	0	0	0	2	1	0	2	0	0	0	0	9	60
	Total	2	3	0	2	0	2	1	0	3	1	0	1	0	10	100
Nitrofurantoin	Sensitive	2	1	0	0	0	0	0	0	0	1	0	0	0	4	23.5
	Intermediate	0	2	0	0	0	0	0	0	0	0	0	0	0	2	11.8
	Resistant	0	0	0	0	0	2	1	1	4	2	1	0	0	11	64.7
	Total	2	3	0	0	0	2	1	1	4	3	1	0	0	13	100
Vancomycin	Sensitive	2	1	1	0	0	0	1	0	0	0	0	0	0	5	71.4
	Resistant	0	2	0	0	0	0	0	0	0	0	0	0	0	2	28.6
	Total	2	3	1	0	0	0	1	0	0	0	0	0	0	7	100
Teicoplanin	Sensitive	1	3	0	0	0	0	0	0	0	0	0	0	0	4	80
	Resistant	1	0	0	0	0	0	0	0	0	0	0	0	0	1	20
	Total	2	3	0	0	0	0	0	0	0	0	0	0	0	5	100
Moxifloxacin	Sensitive	2	1	0	0	0	0	0	0	0	0	0	0	0	3	50
	Resistant	0	2	1	0	0	0	0	0	0	0	0	0	0	3	50
	Total	2	3	1	0	0	0	0	0	0	0	0	0	0	6	100
Linezolid	Sensitive	2	1	0	0	0	0	0	0	0	0	0	0	0	3	100
	Resistant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	2	1	0	0	0	0	0	0	0	0	0	0	0	0	100

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Table 4b: The antibiotic susceptibility patterns of the common isolates associated with nosocomial infections in medical wards in Mengo hospital (b)

Variables		Isolated microorganism													Total	%
		1	2	3	4	5	6	7	8	9	10	11	12	13		
Tigecycline	Sensitive	2	1	0	0	0	0	0	0	0	0	0	0	0	3	100
	Resistant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	2	1	0	0	0	0	0	0	0	0	0	0	0	3	100
Ciprofloxacin	Sensitive	0	0	0	8	0	0	1	0	1	1	0	1	0	12	54.5
	Resistant	0	0	0	1	0	2	0	0	4	2	0	0	1	10	45.5
	Total	0	0	0	9	0	2	1	0	5	3	0	1	1	22	100
Rifampicin	Sensitive	1	3	0	0	0	0	0	0	0	0	0	0	0	4	100
	Resistant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1	3	0	0	0	0	0	0	0	0	0	0	0	4	100
Amikacin	Sensitive	0	0	0	4	0	0	0	0	1	1	0	0	0	6	50
	Intermediate	0	0	0	1	0	0	0	0	0	0	0	0	1	2	16.7
	Resistant	0	0	0	0	0	2	1	0	1	0	0	0	0	4	33.3
	Total	0	0	0	5	0	2	1	0	2	1	0	0	1	12	100
Piperacillin	Sensitive	0	0	0	4	0	0	0	0	0	2	0	0	0	6	50
	Resistant	0	0	0	1	0	2	0	0	0	1	0	1	1	6	50
	Total	0	0	0	5	0	2	0	0	0	3	0	1	1	12	100
Meropenem	Sensitive	0	0	0	8	0	0	0	0	3	3	0	1	0	15	71.4
	Resistant	0	0	0	1	0	2	1	0	1	0	0	0	1	6	28.6
	Total	0	0	0	9	0	2	1	0	4	3	0	1	1	21	100
Fluconazole	Sensitive	0	0	0	0	7	0	0	0	0	0	0	0	0	7	70
	Resistant	0	0	0	0	3	0	0	0	0	0	0	0	0	3	30
	Total	0	0	0	0	10	0	0	0	0	0	0	0	0	10	100
Amphotericin B	Sensitive	0	0	0	0	6	0	0	0	0	0	0	0	0	6	85.7
	Resistant	0	0	0	0	1	0	0	0	0	0	0	0	0	1	14.3
	Total	0	0	0	0	7	0	0	0	0	0	0	0	0	7	100
Ceftazidime	Sensitive	0	0	0	4	0	0	0	0	1	0	0	1	0	6	31.6
	Resistant	0	0	0	3	0	2	0	0	4	3	0	0	1	13	68.4
	Total	0	0	0	7	0	2	0	0	5	3	0	1	1	19	100
Imipenem	Sensitive	0	0	0	6	0	1	0	0	2	2	0	0	0	11	84.6
	Resistant	0	0	0	0	0	0	0	0	2	0	0	0	0	2	15.4
	Total	0	0	0	6	0	1	0	0	4	2	0	0	0	13	100
Ceftriaxone	Sensitive	0	0	0	0	0	0	0	0	1	0	0	1	0	2	15.4
	Resistant	0	0	0	1	0	0	1	1	4	3	0	0	1	11	84.6
	Total	0	0	0	1	0	0	1	1	5	3	0	1	1	13	100
Micafungin	Sensitive	0	0	0	0	10	0	0	0	0	0	0	0	0	10	100
	Resistant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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	Total	0	0	0	0	10	0	0	0	0	0	0	0	0	10	100

Key for tables 4a and 4b:

1 *Staphylococcus epidermidis*
2 *Staphylococcus aureus*
3 *Staphylococcus species*
4 *Pseudomonas aeruginosa*
5 *Candida albicans*
6 *Citrobacter freundii*
7 *Rothia kristinae*
8 *Providensia stuartii*
9 *Klebsiella pneumoniae*
10 *Escherichia coli*
11 *Ralstonia mannitolilytica*
12 *Ralstonia pickettii*
13 *Pseudomonas putida*

Tables 4a and 4b show the antibiotic susceptibility patterns of the common isolates associated with nosocomial infections in medical wards in Mengo Hospital. Findings revealed that resistance was recorded for every antimicrobial except Linezolid, Tigecycline, Rifampicin, and Micafungin, which showed 100% sensitivity. Resistance profile ranged from 14.3% to 84.6%. The highest cases of resistance were recorded against Ceftriaxone at 84.6%, Ceftazidime 68.4%, Nitrofurantoin 64.7%, Gentamycin 60%, Piperacillin and Moxifloxacin at 50%.

Findings also showed that antimicrobials with better sensitivity patterns were Amphotericin B 85.7%, Imipenem 84.6%, Tetracycline 80%, Teicoplanin 80%, Meropenem 71.4% and Fluconazole 70%.

Pseudomonas aeruginosa showed high sensitivity to Imipenem (100%, 6/6), Meropenem (88.9%, 8/9), Ciprofloxacin (88.9%, 8/9), Piperacillin, and amikacin (80%, 4/5).

Candida albicans showed high sensitivity to Micafungin (100%, 10/10), Amphotericin B (85.7%, 6/7), and Fluconazole (70%, 7/10).

Citrobacter freundii showed high cases of resistance to numerous numbers of antibiotics, namely, Gentamycin (100%, 2/2), Nitrofurantoin (100%, 2/2), Ciprofloxacin (100%, 2/2), Amikacin (100%, 2/2), and Piperacillin (100%, 2/2).

Klebsiella pneumoniae showed resistance to a wide range of antibiotics, namely Nitrofurantoin (100%, 4/4), Ciprofloxacin (80%, 4/5), Ceftriaxone (80%, 4/5), and Gentamicin (66.7%, 2/3).

Staphylococcus aureus also showed high cases of resistance to Gentamycin, Vancomycin, and Moxifloxacin, all at (66.7%, 2/3).

Discussion

Out of 84 patients studied, 58.3% were females. Findings also demonstrated that the majority were aged between 30-39 years, accounting for 23.8%, followed by 70-79 years, 17.9%, 0-9 years, 14.3%, and 80-89 years, 1.2%. One of the factors associated with NIs in this study was catheterization, as many patients who were catheterized contracted nosocomial infection (70.5%). This is probably because of an open pathway through which bacteria can invade following insertion of a catheter. Other associated factors to NIs were over a month hospitalization of patients (65.9%) - which increase the risk of exposure to hospital acquired pathogens, and prior intake of antibiotics (56.8%) - probably because these antibiotics especially the broad spectrum end up killing both healthy and unhealthy bacteria in the body - which increases the chances of NIs. Very low cases of NIs were associated with patients who had prior cases of surgery (20.5%). This is possibly because of modern emerging aseptic surgical practices.

These findings support previous reports. For example, Isigi et al. (2023) in a similar study found that longer hospital stays, prior intake of antibiotics, urinary catheters, and older age were risk factors for nosocomial infections among patients. In a comparable 10-year retrospective case–control study in the Chinese tertiary care hospital, findings indicated surgery, any device placement (including central venous catheter, mechanical ventilation, urinary catheter, and tracheotomy), prior use of triple or more antibiotics combinations, carbapenem, and β-Lactamase inhibitors were significantly associated with NIs (Wanga et al., 2024) . Findings from these studies agreed with the findings, which showed that using mechanical ventilation, being on urinary catheter, being on intravenous catheter, and length of hospital stay >20 days were significantly associated with nosocomial infections. Healthcare services providers need to give emphasis on infection prevention and control of nosocomial infections (Zewdu et al., 2023).

However, some previous reports revealed other risk factors for nosocomial infections, which were different from what we report in this study. For instance, a study from a Palestinian hospital revealed that factors to NIs were advanced age, immunosuppression, and the presence of other treatment-related factors such as duration of preoperative hospitalization, type of surgery, among others (Aiesh et al., 2023).

The study findings further revealed that *Pseudomonas aeruginosa* (11.9%; 10/84) was the commonest cause of NIs, followed by *Candida albicans* (10.7%; 9/84) and *Klebsiella pneumoniae* (7.1%; 6/84), *Staphylococcus aureus* (6.0%; 5/84), among others. These findings support the previous report. For example, a study

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conducted in China demonstrated that *Pseudomonas aeruginosa, Klebsiella pneumoniae* as the dominant microorganisms isolated among the Gram-negative bacteria, *Staphylococcus aureus* was the most common Gram-positive bacterial species, while *Candida albicans* and *Candida glabrata* were the leading fungal isolates (Li et al., 2019) . Moreover, a related study in China demonstrated that *Staphylococcus aureus, Klebsiella pneumoniae,* and *Pseudomonas aeruginosa,* in order of magnitude, were the most frequently isolated pathogens (Wang et al., 2019).

The current study findings were consistent with the Ugandan study, which demonstrated that *Klebsiella pneumoniae*, *Acinetobacter species,* and *Staphylococcus aureus,* in order of magnitude, were the most frequently isolated bacteria. In our study, *Acinetobacter species* was never an isolate recovered from our samples (Agaba et al., 2017) . These study findings, together with other previous reports, strongly agree that microorganisms, for example, *Pseudomonas aeruginosa, Klebsiella pneumoniae, Candida albicans, and Staphylococcus aureus,* among others, are common and are associated with NIs among patients. This signifies that there is an urgent need to tackle the impact of NIs among patients to ensure improved quality of health care provision, and will undoubtedly reduce the cost of hospitalization and improve quality of life.

In the present study, *Pseudomonas aeruginosa* exhibited high sensitivity to Imipenem (100%, 6 out of 6), Meropenem and Ciprofloxacin (each at 88.9%, 8 out of 9), as well as Piperacillin and Amikacin (both at 80%, 4 out of 5). However, *Candida albicans* showed high sensitivity to Micafungin (100%, 10/10), Amphotericin B (85.7%, 6/7), and Fluconazole (70%, 7/10). *Klebsiella pneumoniae* showed resistance to a wide range of antibiotics, namely Nitrofurantoin (100%, 4/4), Ciprofloxacin (80%, 4/5), Ceftriaxone (80%, 4/5), and Gentamicin (66.7%, 2/3). *Staphylococcus aureus* also showed high cases of resistance to Gentamycin, Vancomycin, and Moxifloxacin, all at (66.7%, 2/3). Most of the isolates showed resistance against Ceftriaxone at 84.6%, Ceftazidime 68.4%, Nitrofurantoin 64.7%, Gentamycin 60%, Piperacillin, and Moxifloxacin at 50%.

The current study findings align with previous studies conducted in various settings. For instance, a study at Hiwot Fana Specialized University Hospital in Eastern Ethiopia revealed that *Staphylococcus aureus* exhibited high resistance rates (80%) to both vancomycin and erythromycin, and 70% to cephalexin and gentamicin. Similarly, *Pseudomonas aeruginosa* showed 83.7% resistance to both ceftazidime and cephalexin (Tolera et al., 2018) . In a related study conducted in Uganda, the most commonly isolated organisms were *Klebsiella pneumoniae*, *Acinetobacter* species, and *Staphylococcus aureus*, in that order (Agaba et al., 2017) . The same study (Agaba et al., 2017) also showed that the prevalence of multidrug-resistant bacterial species was 58%, and imipenem was the most effective antibiotic across most isolates. Furthermore, our findings are consistent with a study conducted in Niger that assessed the antibiotic susceptibility of bacteria isolated from patients with nosocomial infections. Most isolates demonstrated high resistance rates, with up to 96.2% resistant to ceftriaxone, while showing high susceptibility (92.83%) to meropenem. *Klebsiella* species, in particular, exhibited 90% resistance to piperacillin but remained highly susceptible (95.66%) to meropenem (Boubou et al., 2024).

However, the findings of the current study differ from those of a previous study conducted at Ruhengeri Referral Hospital in Rwanda (Munyeshyaka et al., 2021). The study reported that clindamycin and erythromycin were the only effective antibiotics against all bacterial isolates. Moreover, *Staphylococcus aureus* was susceptible to vancomycin, ciprofloxacin, and cefuroxime. However, it showed resistance to nitrofurantoin. Furthermore, *Escherichia coli* showed sensitivity to cefuroxime, ciprofloxacin, and vancomycin, but resistance to nitrofurantoin. *Pseudomonas* and *Proteus* species showed sensitivity to vancomycin (100%), and other antibiotics tested, except for nitrofurantoin, which was resistant. The findings further indicated that *Enterobacter* isolates exhibited complete sensitivity to erythromycin, nitrofurantoin, and clindamycin, while demonstrating total resistance to ciprofloxacin, vancomycin, and cefuroxime.

External validity of the study findings

The hospital primarily serves residents of Rubaga Division within the Kampala Metropolitan area, as well as patients from other parts of Uganda and beyond. As a result, the patient population reflects a broad geographical and demographic spread, enhancing the generalizability of the study findings. The study site was chosen due to the researcher's familiarity with the facility, which facilitated effective study implementation. All patients, irrespective of age or sex, who were admitted to the medical wards of Mengo Hospital and diagnosed with nosocomial infection(s) were enrolled in the study. This inclusive approach promoted participant variability and improved the representativeness of the sample, thereby strengthening the external validity of the findings. Clinical specimens were collected from

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relevant infection sites following standard procedures, and laboratory analyses adhered to established protocols. Ethical approval for the study was obtained from the Mengo Hospital Research Ethics Committee (MHREC) on 17th October 2024 under ethical number MH/REC/108/09-2024.

Conclusions

Nosocomial infections (52.4%) and antimicrobial resistance (ranging from 14.3% to 84.6% for different antibiotics) among patients at medical wards in Mengo Hospital are high and present serious public health problems. Factors associated with NIs among the study participants were catheterization (70.5%), over a month hospitalization of patients (65.9%), and prior intake of antibiotics (56.8%). Commonly isolated microorganisms associated with NIs among the study participants were *Pseudomonas aeruginosa,* accounting for 11.9% (10/84), followed by *Candida albicans,* 10.7% (9/84), and *Klebsiella pneumoniae,* 7.1% (6/84). Most of the isolates showed resistance against Ceftriaxone at 84.6%, Ceftazidime 68.4%, Nitrofurantoin 64.7%, Gentamycin 60%, Piperacillin, and Moxifloxacin at 50%. Meanwhile, better sensitivity patterns were recorded against Amphotericin B 85.7%, Imipenem 84.6%, Tetracycline 80%, Teicoplanin 80%, Meropenem 71.4% and Fluconazole at 70%.

Study limitations

In some instances, manual culture and sensitivity were done instead of the automatic technique using Vitek 2 compact due to machine breakdown.

Recommendations

Given the high prevalence of NIs and the seriousness of antimicrobial resistance, there is a need to create awareness among the public about NIs, the importance of appropriate antibiotic use, and reducing the emergence of antimicrobial resistance. An infection control protocol should be developed and used in all medical wards. The healthcare service providers should develop and implement antibiotic stewardship programs to promote appropriate antibiotic use and prevent the emergence of resistance. Further research is needed to understand the epidemiology and antimicrobial resistance patterns of NIs in different settings.

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List of abbreviations

HAI -Healthcare-associated infection
IPC -Infection Prevention and Control
MHREC-Mengo Hospital Research Ethics Committee
MoH -Ministry of Health
NIs -Nosocomial Infections
RTI -Respiratory Tract Infection
UAHEB -Uganda Allied Health Examinations Board
US -United States
UTI -Urinary Tract Infection
WHO - World Health Organization

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Conflict of interest

There was no conflict of interest declared.

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Author contribution

Nalwoga Patricia – Conceptualization, data collection, methodology.
Nyiramahoro Salome – Supervision, investigation.
Oromcan, Benjamin Wathum – Supervision, Investigation, Formal analysis, Writing original draft - review & editing.

Data availability

Data was readily available and accessible.

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