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Antimicrobial Resistance Profiles of Bacterial Contaminants at a Tertiary Hospital in Kenya Reveal Critical Infection Risks and Urgent Need for Enhanced IPC Measures

Kolek Chester[1]*, Briton M. Kavulavu[2], Faith Okalebo[3], Benson Singa[4], Mary Masheti[5], Ian Omuom[1] Ochieng Odhoch[1], Chris Oduol[5], Robert Musyimi[6] and Caroline Tigoi[6]

[1]*Migori County Referral Hospital, P.O. Box 202-40400, Migori, Kenya.*

[2]*Department of Medical Microbiology, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya.*

[3]*School of Pharmacy, University of Nairobi, P.O. Box 19676-00202, Nairobi, Kenya.*

[4]*Kenya Medical Research Institute (KEMRI), Centre for Clinical Research, P.O. Box 54840-00200, Nairobi, Kenya.*

[5]*KEMRI-University of Washington, CHAIN Team, P.O. Box 54840-00200, Nairobi, Kenya.*

[6]*KEMRI Wellcome Trust, P.O. Box 230, Kilifi, Kenya.*

***Correspondence:**

Kolek Chester, Migori County Referral Hospital, P.O. Box 202-40400, Migori, Kenya.

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ABSTRACT

Hospital-acquired infections (HAIs) remain one of the most prevalent adverse events among hospitalized patients, significantly impacting patient outcomes and healthcare systems. A major contributing factor to HAIs is the high contamination rate of hospital environments with pathogenic bacteria. The risk of HAIs is exacerbated when surface contaminants are antimicrobial-resistant (AMR) pathogens, which complicates treatment strategies and increases patient morbidity. The need to characterize the AMR profiles of bacterial contaminants in hospital settings is critical for the effective implementation of Infection Prevention and Control (IPC) measures. This study aimed to determine the AMR patterns of bacterial contaminants isolated from high-frequency surfaces in a tertiary hospital in Kenya. A total of 62 surface swabs were collected in April 2020 from various hospital departments, including gynecology, pediatric, newborn, and renal units, and cultured using standard microbiological techniques. The bacterial isolates were further screened for AMR using laboratory-based assays. Of the 62 swabs, 61.3% (n=38) yielded bacterial growth, from which 46 isolates were identified. Gram-negative bacteria accounted for 86.96% (n=40) of the isolates, with Acinetobacter spp. being the most prevalent (41.3%). Resistance markers were detected in 36.96% (n=17) of the isolates, with Acinetobacter spp. exhibiting the highest resistance rate (36.84%). These findings underscore the urgent need for stringent adherence to IPC protocols and continuous surveillance, along with genomic studies to trace the transmission dynamics of AMR pathogens within hospital environments.

Keywords

Hospital-acquired infections (HAIs), Antimicrobial resistance (AMR), Bacterial contamination, Infection prevention and control (IPC), Environmental pathogens, *Acinetobacter spp*.

Abbreviations

AMR: Antimicrobial Resistance, CRO: Carbapenem-Resistant Organisms, ESBL: Extended-Spectrum Beta-Lactamases, HAI: Hospital-acquired Infection, MRSA: Methicillin-

Resistant Staphylococcus aureus, CONS: Coagulase-Negative Staphylococci, NBU: New Born Unit, HCWs: Healthcare Workers.

Introduction

Hospital-acquired infections (HAIs) continue to threaten the treatment outcomes of many patients worldwide. According to the World Health Organization (WHO), HAIs represent the most prevalent adverse event among patients in hospital settings [1]. Significant morbidity and mortality, in addition to other impacts such as high costs of care and reduced quality of life, are among the detrimental effects of HAIs [2-4]. According to studies that have attempted to quantify the prevalence of HAIs, above 2.5 million cases of HAIs are reported annually in Europe [2]. These cases often result in deaths, and about 90,000 deaths are approximated to be attributable to the six most common types of HAIs - healthcare-associated pneumonia, healthcare-associated urinary tract infection (HA-UTI), surgical site infection (SSI), healthcare-associated Clostridium difficile, healthcare-associated neonatal sepsis, and healthcare-associated bloodstream infection [2]. Whereas the average global prevalence of HAIs has been reported to be only about 0.14% [3], the prevalence is even higher in Africa and the developing world. According to a meta-analysis by Abubakar et al. [3], the pooled prevalence of HAIs in Africa was 12.76% [4].

The continued isolation of multidrug-resistant pathogens among HAI cases is an alarming finding. In one study that assessed the antimicrobial susceptibility (AST) patterns among HAI cases in China, Zhang et al. [5]. observed an HAI prevalence of 1.24%, of which 0.18% were multidrug-resistant (MDR) pathogens. The most common resistant pathogens were *Acinetobacter spp* (53.86%) and *Pseudomonas spp*. (21.6%) [5]. In a global study by Murray et al. [6], it was overt that amidst the highest prevalence of HAIs in Africa, the reporting of resistant pathogens was also high. Of these resistant pathogens, *Escherichia coli*, *Coagulase-negative staphylococci (CONS)*, *Staphylococcus spp*, and *Pseudomonas spp* were most prevalent [6]. The ward in which a patient is a possible determinant of the HAI status. According to Despotovic et al. [7], up to 32.7% of patients in an intensive care unit were observed to bear HAIs, with above 50% resistance being noted for common antibiotics. Local data appears to point to a similar picture. Kagia et al. [7] observed a carriage rate of 10% for Extended-spectrum beta-lactamase (ESBL) producing pathogens among neonates in a hospital in Kilifi. Among the positive ESBL cases, 55% had acquired ESBL pathogens in the hospital [8]. Among surface contaminants, the prevalence of MDR pathogens is not far different. According to a study that assessed surface contamination in multiple hospitals in Kenya, Odoyo et al. [9] reported that up to 12.6% of the sampled high-touch surfaces were contaminated with MDR pathogens, the most common of which was *Acinetobacter boumanii* at 3.7%. Others were *K. pneumonia* (3.6%), *Enterobacter species* (3.1%), methicillin-resistant *S. aureus* (MRSA) (0.8%), E. coli (0.8%, *P. aeruginosa* (0.3%), and *E. faecalis and faecium* (0.3%). It is to be noted that these bacteria are members of the highly stubborn ESKAPE group.

An analysis of recent studies on contamination of hospital environment reveals particularly concerning trends. Contamination rates range from 12.6% [9] to 86% [10]. S. aureus is the most common pathogen, with CoNS and E. coli frequently isolated. High resistance is observed across multiple studies, including S. aureus (96.6% resistance to Ampicillin) [11] and A. baumannii (95.6% resistance to Meropenem) [9] (Table 1).

The snapshot review of the literature revealed that much of the literature available on the AMR patterns of HAIs considered patient isolates mainly. However, as Odoyo et al. [8] reported, surface contamination with resistant pathogens increases the risk for difficult-to-treat HAIs among hospitalized patients. Thus, any hospital intending to implement accurate and effective Infection Prevention and Control (IPC) strategies must understand the prevalence and AMR patterns of surface contaminants in the highly-frequented surfaces such as sinks, door handles, staff hands, and commonly used and shared equipment [9]. These surfaces have been reported as significant agents in infection spread in the hospital setting and are hence the focus of hospital IPC guidelines [16-18]. The present study aimed to determine the antimicrobial susceptibility patterns of surface contaminants at the Migori County Referral Hospital.

Materials and Methods

Study Design, Site, and Sampling

The study was undertaken as a descriptive cross-sectional study at Migori County Referral Hospital (MCRH) pediatric and gynecology wards and the Renal and Newborn Units. MCRH is a 150 bet capacity hospital in Migori County at the Kenya-Tanzania border. MCRH is the highest referral hospital in Migori County, southwest of Kenya (1.06412^0S,34.47573^0E). Purposive sampling was used to select highly frequented sites that would pose an increased threat for infection spread, including door handles, sinks, and shared equipment. Whereas the sampling approach targeted a minimum sample size of 50 (20 from equipment, 20 from hospital surfaces, and ten from staff), 62 samples were collected, as detailed in Table 2.

Specimen Collection and Transport

Surfaces were swabbed with moistened (sterile 8.5% normal saline) COPAN floq swab. The swab was rolled over the intended surfaces to cover about 30cm^2 touches. After collection, the swabs were transported in Cary-Blair medium tube at 2-8^{0}C in a cool box packed with ice cubes.

Culture, Identification and Antimicrobial Susceptibility Testing

Upon arrival in the laboratory, tubes were vortexed at 300 RPM for 20 seconds and opened inside Class II biosafety cabinets to control exposure to aerosols. 20 µl broth was inoculated and streaked on horse blood agar and CLED agar plates. Horse blood agar and CLED agar plates were incubated at 37^{0}C in 5% CO_2 and aerobic incubator for 24 hours. Any emerging colonial growth was sub-cultured on respective plates and set as mentioned

Table 1: Snapshot review of recent studies on hospital environment contamination with resistant bacteria.

Study	Hospital Level	Departments Studied	Bacteria Isolated	Testing Methods	Contamination Rate	Predominant Species	Resistance Patterns
Amulioto et al., 2021 [11]	No mention found	Wards and operating room	*S. aureus, Bacillus spp., Citrobacter spp., Enterobacter spp., P. aeruginosa, Acinetobacter spp., E. coli, CoNS*	Culture, biochemical tests, Kirby Bauer disc diffusion	64.7% (44/68)	S. aureus (55.9%)	High resistance to Ampicillin/ Cloxacillin (96.6%)
Kimani et al., 2023 [12]	Level V	No mention found	*CoNS, S. aureus, E. coli, K. pneumoniae, K. oxytoca, P. mirabilis, S. enterica, E. cloacae, A. baumannii, E. faecalis, B. cepacia, S. maltophilia*	VITEK 2, disc diffusion	66.2% (202/305)	CoNS (17.5%), S. aureus (15.6%)	High resistance to third-generation cephalosporins, monobactams, nalidixic acid, tetracyclines, penicillins (75-87%)
Magori et al., 2021 [13]	No mention found	Surgical and new-born units	*S. aureus, E. coli, Acinetobacter spp., Pseudomonas spp., CoNS*	Standard laboratory methods, Vitek 2 system	63% (442/700)	CoNS (13.0%), S. aureus (3%)	High resistance to trimethoprim/ sulfamethoxazole, benzylpenicillin
Muthoni, 2021[14]	Public (KNH) & Private (KMH)	Various hospital areas including surfaces, drainages, and waste	*Providentia spp., S. aureus, E. coli, Pseudomonas spp., CoNS, Serratia spp., Klebsiella spp., Proteus spp., Enterobacter spp.*	Swab collection, API 20E, disk diffusion method	471 bacterial isolates	E. coli (most sensitive), S. aureus, CoNS	High resistance to ampicillin, cefotaxime, levofloxacin, tetracycline
Odoyo et al., 2023[9]	Level 6, 5, and 4	Surgical, general, maternity, newborn, outpatient, pediatric	*A. baumannii, K. pneumoniae, Enterobacter spp., MRSA, E. coli, P. aeruginosa, E. faecalis/faecium*	Standard bacteriological culture methods	12.6% (78/617)	A. baumannii (3.7%), K. pneumoniae (3.6%)	High resistance to Meropenem (95.6%)
Sebre et al., 2020[10]	Specialized Teaching	Intensive care units, operation theaters	*S. aureus, A. baumannii, CoNS, P. aeruginosa, E. coli, Bacillus spp., Klebsiella spp.*	Routine bacterial culture, biochemical tests, Kirby Bauer disk diffusion	86% (141/164)	S. aureus (34.4%), A. baumannii (21.3%)	High resistance to Penicillin, Cefoxitin (92.8%, 83.5%)
Sserwadda et al., 2018[15]	General	Post-operative ward	*S. aureus, K. pneumoniae, P. vulgaris, Enterobacter spp., S. merscescans*	Culture, Kirby Bauer disc diffusion method	44.2% (61/138)	S. aureus (75.4%), K. pneumoniae (11.5%)	High resistance to Penicillin (93%)

Table 2: Distribution of swabs based on sampled surfaces and departments.

Surfaces	NBU	Pediatric Ward	Gynecology Ward	Renal Ward
Sink	2	2	2	1
Wall	0	1	1	0
Door Knob	1	2	0	0
Bed	1	2	1	0
Bp Machine	1	1	1	0
Resuscitating Pump	1	0	0	0
Weighing Scale	1	1	0	1
Stethoscope	1	1	1	0
Phone	1	0	1	1
Thermometer	1	2	0	0
Fetal Scope	0	0	1	0
Trolley	0	1	1	1
Dialysis Machine	0	0	0	1
Tripod Stand	1	0	0	1
Pox	0	1	0	0
Nebulizer	1	0	0	0
Dop	0	0	1	0
SPO_2	0	0	0	1
Total (n (%))	16 (25.8)	21 (33.9)	14 (22.6)	11 (17.7)

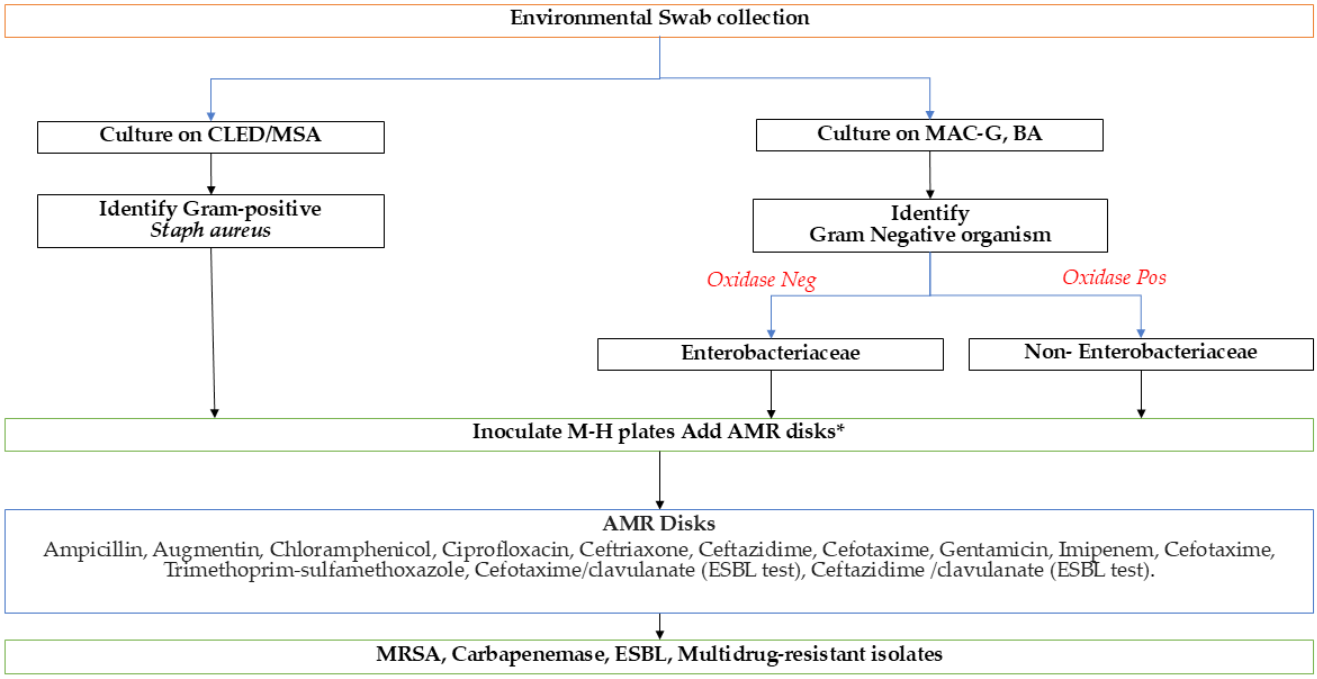

Figure 1: Flow chart summarizing the procedure followed for isolation, identification, and antibiotic susceptibility characterization of the specimen collected from MCRH.

above. Identification of bacterial genus and species were done by MALDI-TOF, and antibiotic susceptibility testing was done on all pathogens by disc diffusion (Kirby Bauer) as described in CLSI guidelines to identify antibiotic-associated resistant markers. The disks used were: Ampicillin, Augmentin, Chloramphenicol, Ciprofloxacin, Ceftriaxone, Ceftazidime, Cefotaxime, Gentamicin, Imipenem, Cefotaxime, and Trimethoprim-sulfamethoxazole. ESBL production was screened phenotypically using the double-disk synergy method. Cefotaxime (30 mcg) and ceftazidime (30 mcg) were used alone for screening before double confirmation using cefotaxime/ clavulanate (30/10 mcg) and ceftazidime/ clavulanate (30/10 mcg) combination as per the recommendation of CLSI (Figure 1).

Results

Bacteria Isolates

Out of the 62 swabs collected as per Table 2 above, 61.3%(n=38) showed positive growth, as summarized in Table 3 below.

The positivity rates varied across the departments as follows: Gynecology wards (78.6%), NBU (56.2%), Pediatric ward (61.9%), and Renal Unit (45.5%). A total of 46 isolates were obtained.

Table 3: Summary of growth patterns observed per department.

Department	Growth				Total
	No		Yes		
	n	%	n	%	
Gynecology	3	21.4	11	78.6	14
New Born Unit	7	43.8	9	56.2	16
Pediatric	8	38.1	13	61.9	21
Renal Unit	6	54.5	5	45.5	11
Total	24	38.7	38	61.3	62

Of the 46 isolates obtained, a majority were *Acinetobacter spp.,* which comprised 41.3% (n=19), followed by *Staphylococcus spp* at 13.04% (n=6), *Enterobacter spp* at 10.9% (n=5), and *Klebsiella spp* at 8.7% (n=4). Others reported were *Waustersiella spp* and *Pantoea spp*. at 4.3% (n=2), and *Citrobacter spp*, *Escherichia spp, Pantoea spp, Pseudomonas spp, Empedobacter spp, Enterococcus spp, Ledercia spp, Providencia spp,* and *Stenethophomonas spp* at 2.2% (n=1). Regarding AMR patterns, 36.96% (n=17) were positive for the resistance markers screened. Important to note as the fact that among the *Acinetobacter spp* which were most reported, resistance rate was 36.84% (7/19). Gram negative species comprised 86.96% (n=40) while Gram positive species comprised 13.04% (n=6). Table 4 below summarizes these findings by genus whereas Table 5 summarizes the findings by species isolated.

Table 4: Summary of the resistance patterns of the isolates obtained (by Genus).

Genus	Resistance				Total	%
	No	%	Yes	%		
Acinetobacter	12	63.16	7	36.84	19	41.3
Citrobacter	0	0.00	1	100.00	1	2.2
Empedobacter	1	100.00	0	0.00	1	2.2
Enterobacter	1	20.00	4	80.00	5	10.9
Enterococcus	1	100.00	0	0.00	1	2.2
Escherichia	0	0.00	1	100.00	1	2.2
Klebsiella	3	75.00	1	25.00	4	8.7
Ledercia	0	0.00	1	100.00	1	2.2
Pantoea	0	0.00	2	100.00	2	4.3
Providencia	1	100.00	0	0.00	1	2.2
Pseudomonas	1	100.00	0	0.00	1	2.2
Staphyloccoccus	6	100.00	0	0.00	6	13.04
Stenethophomonas	1	100.00	0	0.00	1	2.2
Waustersiella	2	100.00	0	0.00	2	4.3
Total	29	63.04	17	36.96	46	100

Table 5: Summary of the resistance patterns of the isolates obtained (by species).

ISOLATE	Gram reaction	Resistance		Total
		No	Yes	
Acinetobacter baumanii	Negative	0	2	2 (4.35)
Acinetobacter haemolyticus	Negative	4	1	5 (10.87)
Acinetobacter junii	Negative	2	0	2 (4.35)
Acinetobacter lwoffi	Negative	3	0	3 (6.52)
Acinetobacter sps*	Negative	3	3	6 (13.04)
Acinetobacter variabilis	Negative	0	1	1 (2.17)
Citrobacter freudii	Negative	0	1	1 (2.17)
Empedobacter brevis	Negative	1	0	1 (2.17)
Enterobacter cloacae	Negative	1	4	5 (10.87)
Enterococcus faecium	Negative	1	0	1 (2.17)
Eschericia coli	Negative	0	1	1 (2.17)
Klebsiella oxytoca	Negative	1	0	1 (2.17)
Klebsiella pneumoniae	Negative	1	1	2 (4.35)
Ledercia adecarboxylata	Negative	0	1	1 (2.17)
Pantoea calida	Negative	0	1	1 (2.17)
Pantoea dispersa	Negative	0	1	1 (2.17)
Pseudomonas stutzeri	Negative	1	0	1 (2.17)
Staphyloccoccus aureus	Positive	6	0	6 (13.04)
Stenethophomonas maltophilia	Negative	1	0	1 (2.17)
Klebsiella varicola	Negative	1	0	1 (2.17)
Providencia rettgeri	Negative	1	0	1 (2.17)
Waustersiella falseniia	Negative	2	0	2 (4.35)
Total (%)	Negative-86.96% Positive-13.04%	29 (63.04)	17 (36.96)	46 (100)
****This organism was only identified to genus level***				

Table 6: Summary of resistance makers per department.

Department	Resistance					Total
	CRO and ESBL Pos	ESBL Pos	ESBL Neg	Methicillin sensitive	VAC Sensitive	
Gynecology	2	2	6	2	0	12
New Born Unit	2	3	5	1	1	12
Pediatric	2	6	6	3	0	17
Renal Unit	0	0	5	0	0	5
Total (%)	5 (10.9)	11 (23.9)	22 (47.8)	6 (13.0)	1 (2.2)	46 (100)

Resistance Markers

The resistance markers tested included ESBL, carbapenem resistance, methicillin sensitivity for *Staphylococcus aureus*, and vancomycin sensitivity. Of all the 46 isolates obtained, significant resistance was observed. 10.9% (n=5) showed both ESBL and CRO resistance, whole 23.9% (n=11) were positive for ESBL production. All the rest were non-resistant strains as shown by negative ESBL at 47.8% (n=22), methicillin sensitive at 13% (n=6) and vancomycin sensitivity at 2.2% (n=1). The distribution

of the resistant strains by department showed no significant trends. However, it is to be observed that the NBU and Pediatric wards bore the bulk of the isolates as well as the resistant strains as summarized in Table 6 below.

Discussion

A swab positivity rate of 61.3% among the surfaces swabbed was considered high and indicative of a high level of contamination across the departments. Previous studies have found varying contamination rates among frequented surfaces, equipment, and HCWs' hands. In one such study, a contamination rate of 85.8% was reported on stethoscopes used at a tertiary hospital [19]. In a similar setting in Tanzania, a contamination rate of 26.4% was noted among HCWs' hands [16]. In similar hospitals in Kenya, diverse but close contamination rates have also been reported, including 55% by Nyaruaba et al. [20] and 95.9% by Odoyo et al. [21]. In the study by Odoyo et al. [21], potential factors that could lower this high contamination rate were also studied. The study hence recommended that cleaning such as daily washing of patient bedding, provision, and education on the use of handwashing stations, supply of running water for handwashing, and soap for handwashing lowered the bacterial load of the considered surfaces significantly [21]. Hence, based on these recommendations, it would be possible to deduce that the high contamination rate reported at the present hospital could be explained by failure to adhere strictly to IPC guidelines that demand thorough and regular cleaning of frequented surfaces. Since Kenya introduced IPC guidelines in 2019 [22] to reduce HAIs, numerous challenges have limited their effective implementation, including resource limitations such as lack of personal protective equipment for HCWs, lack of running water, and general poor adherence to hygiene regulations [23].

The contaminants reported were mainly Gram Negative bacteria, with Staphylococcus spp being the only Gram-Positive. This was similar to the isolates reported in similar studies in Kenya [20,21] and Tanzania [16]. In the study by Chaoui et al. [17] in Morocco, the primary isolates obtained on the surfaces swabbed were *Enterobacteria* (31.6%), *Staphylococcus aureus* (24%), *Pseudomonas aeruginosa* (9.2%) and *Acinetobacter spp*. (3.3%). It is worth noting that contrary to the Kenyan studies, where *Acinetobacter* or *Escherichia* [8,9,11,20,21] are the most commonly observed bacterial contaminants, the North African study had *Acinetobacter* as the least prevalent and *Enterobacteria* as the most common [17]. Overall, researched data supports the hypothesis that the most common contaminants in hospital environments are Gram-negative bacteria and Staphylococcus spp. [3,4,17]. Is it probable that a country's development status would influence the prevalence and types of contaminants reported in the hospital environment? This remains to be answered. Raoofi et al. [24], in a meta-analysis that pooled the global prevalence of HAIs, reported that HAI rates were higher in Africa and the developing world and generally lower in America, Europe, and developed countries. Unfortunately, the differences in the types of bacteria causing HAIs in these regions are yet to be extensively studied and summarized. This may be attributed to resource availability, well-designed healthcare systems, and adherence to IPC guidelines in the developed countries [24]. In a systematic review that pooled data mainly from developed countries in Europe and America, Saleem et al. [25] concluded that *Klebsiella pneumonia*, *Pseudomonas aeruginosa* and *E. coli* were the most reported pathogens. Still, gram negative pathogens were most common causes of HAIs, similar to data reported in Africa [16,26] and even Kenya [8,20,21]. Since evidence has been presented that high rate of contamination translates to high HAI rates [27], the need to invest more in hospital environment decontamination has never been more urgent [28].

The reporting of resistant pathogens among environmental contaminants in a hospital setting is perhaps the most critical finding in this study as well as similar ones. The progressively increasing burden of resistant infections has warranted the declaration of AMR as a silent pandemic [29]. Current statistics reveal that about 1.3 million deaths annually are attributable to AMR, more than HIV/AIDs and Malaria [29]. It is further predicted that AMR might consume up to 10 million lives by 2050, making AMR an essential focus in modern-day microbiology research [30,31]. In a discussion of the central role of hospital environmental contamination in favoring the spread of multi-drug resistant Gram Negative pathogens, Chia et al. [18] posit that there is increasing evidence to support the hypothesis that hospital contamination with resistant pathogens may directly translate to higher prevalence of highly resistant HAIs. The fact that the most common contaminants reported across the board are members of the stubborn ESKAPE group supports this belief [9]. For instance, in a similar study among five Kenyan hospitals, Odoyo et al. [9] observed that all the hospital departments sampled were contaminated with MDR ESKAPE organisms. 95.6% of the isolates of *A. baumannii*, *Enterobacter species*, and *K. pneumoniae* were resistant to common antibiotics like piperacillin, ceftriaxone, and cefepime. More alarming was that all the *K. pneumoniae* isolates were resistant to all antibiotics tested except colistin [9]. These findings, which have been confirmed in our study, were similar to those reported in other studies [11,20,21].

Significant swab positivity was observed in all the departments sampled, with the gynecology, pediatric, and newborn unit having more special positivity rates similar to the findings of Odoyo et al. [9]. Among developing countries, surgical site infections have been reported as the most common HAIs [32]. Thus, with caesarian sections being the most common surgeries in Kenya [33], the risk to the mother and the neonate is always more elevated. The high contamination rate reported in this study, because the hospital environment poses a transmission risk to patients, may partly explain the high rate of HAIs reported in developing countries [9,34]. The fact that resistant pathogens were reported across all the departments is also worth considering in this interpretation. MDR pathogens, especially those of the ESKAPE family, initiate more severe HAIs, which may badly affect patients in these departments [35]. Since resistant pathogens were isolated in the NBU and pediatric wards as well, the risk they pose to

the immune-naïve populations in these departments is worth contemplating. Newborns would generally be more affected by HAIs since their immune system is underdeveloped [36]. The fact that resistant pathogens are surface contaminants in departments with some of the most vulnerable patients in the hospital should point to an urgent need to adhere strictly to IPC guidelines to mitigate the situation [7,36,37]. Whereas the present study did not determine the statistical association between the department from which a specimen was obtained and the occurrence of resistance phenotypes, the data showed that the pediatric and NBU units were most affected by these. This aspect of association has also yet to be considered by any other studies, hence a need to statistically quantify this association through inferential statistics.

Generally, some bacterial species have a documented higher rate of AMR than others. The members of the ESKAPE family are a case in point [6]. In the present study, *Acinetobacter spp* were the most reported contaminants and doubled up as the genus with the highest resistance rate. A similar finding had also been reported in an analysis that considered five different hospitals in Kenya [9]. The increased contamination rate with *Acinetobacter spp* is noteworthy owing to the bacteria's unique characteristics that give it the ability to cause HAIs. First is its ability to form biofilms which has been confirmed by Espinal and Vila [38]. Additionally, its ability to survive through long periods of desiccation [39]. These properties make *Acinetobacter spp* an important clinical pathogen implicated in many HAIs, including ventilator-associated pneumonia, skin and soft tissue infections, urinary tract infections, secondary meningitis, and bloodstream infections in Kenya as other parts of the globe [9,40,41]. The pathogen has been implicated in several HAI reports in Kenya [42] and one case, as a cause of a hospital outbreak [43]. The fact that A. boumanii is intrinsically resistant to many of the commonly used antibiotics makes it a time bomb that is waiting to explode, hence the need to give it immediate attention [9,21,44]. Thus, there is a pressing need to direct more effort toward hospital environmental hygiene to reduce contaminants and prevent the possibility of HAI outbreaks, especially those caused by resistant pathogens.

Other gram negative pathogens observed in this study, in addition to the gram positive Staphylococcus aureus are not to be given a blind eye in the implementation of hospital IPC strategies. According to Chia et al. [18], MDR gram negative organisms are associated with high mortality rate and continue to present a challenge to healthcare systems globally. Since there is a growing body of knowledge to associate hospital environmental contamination and occurrence of HAIs [27], hospital IPC guidelines should be made as comprehensive as possible. In support of this, Chaoui et al. [17] detailed that the idea of environmental bacterial reservoir is a reality that poses a public health risk hence needing strict current recommendations for hand hygiene, cleaning, and disinfection of surfaces in hospitals. In a study by Darge et al. [26] 68.4% gram positive and 31.5% gram negative isolates were identified as contaminants in a hospital in Ethiopia, with both category showing significance AMR. Moremi et al. [45] argued that room occupancy by a patient shedding nosocomial pathogens may the primary source of surface contaminants, thus drawing attention to special patient considerations as part of IPC guidelines. This finding also agreed with conclusions from a meta-analysis by Mitchel et al. [46]. It is also possible that general surface contamination may also be a source of these pathogens. As explained by Hajar et al. [47], dispersion of gram negative contaminants from colonized sinks to hands of staff may also happen when these sinks are not thoroughly cleaned. Sinks are among the frequented surfaces in the hospital setting, together with others like shared equipment and door handles. To combat the high contamination rate, there is a need to improve overall adherence to IPC guidelines, with more emphasis being placed on cleaning surface contamination.

Conclusions

A high contamination rate with pathogenic bacterial species was noted among the departments sampled. Among the isolates obtained, also, a significant rate of antibiotic resistance was observed. *Acinetobacter spp* was the most common pathogen isolated and doubled up as the one with the highest resistance to common antibiotics. We recommend thorough adherence to IPC guidelines and regular surveillance as the best approaches to mitigate the problem. Genomic-level studies also need to map the transmission of resistant pathogens between the environment and patients.

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