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Prevalence and Types of Bacterial Contaminants in a Tertiary Hospital in Kenya

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ABSTRACT

Background: Hospitals pose a risk of bacterial infections to patients, the environment, and staff. To design Infection Prevention and Control (IPC) programs, facilities need to know the patterns and types of contaminants in various parts of a hospital. The present study aimed to evaluate the prevalence and types of contaminants on hospital surfaces, equipment and healthcare providers' palms with the aim of informing development and implementation of IPC guidelines at the hospital level.

Methods: This cross-sectional study was done in Migori County Referral Hospital. A total of 62 swabs were collected from selected surfaces, equipment, and health workers palms in April, 2020. They were cultured and bacterial contaminants were identified using standard microbiological procedures.

Results: Of the 62 swabs assessed, 61.3% yielded bacterial growth, from which 46 pathogenic bacteria were identified. The most prevalent isolates in all wards were Acinetobacter species at 41.3% (n=19 of 46 isolates) followed by Enterobacter at 13.0% (n=6/46) and Staphylococcus species at 13.0% (n=6/46).

Conclusion: Contamination of surfaces, equipment, and staff's hands was high, hence pointing to an elevated risk of Hospital-Acquired

Infections (HAIs). Thus, there is a need to leverage IPC guidelines to limit contamination and curtail the spread of HAIs.

Keywords: Hospital acquired infections; Infection prevention and control; Bacteria; Contaminated surfaces; COVID-19

INTRODUCTION

Hospital Acquired Infections (HAIs) are increasingly becoming a global burden with severe consequences ranging from a variety of morbidities to mortalities [1]. Daily, out of every 31 patients, 1 develops a HAI during their stay in hospital. This statistic is much higher in the Sub-Saharan Africa (SSA) [2]. In Kenya, the prevalence of HAI is estimated at 4.4 percent owing to poor adherence to Infection Prevention Control (IPC) measures [3-6]. These infections are potentially acquired from hospital surfaces, equipment and healthcare workers during hospitalization. Bacteria account for 90% of HAIs. Amidst the COVID-19 pandemic and the fact that it could spread through surface contamination, the need to monitor surface contaminants in hospital settings became even more necessary. Published studies have continued to mention that coinfection with members of the ESKAPE category in hospital settings was a particular concern for patients suffering COVID-19. In one study, coinfection of COVID-19 and bacterial contaminants was as high as 50%.

Whereas insufficient data has limited estimation of the health impact of these HAIs, increased lengths of hospital stay and higher mortality rates are certainly expected. There is insufficient data in the African setting, and particularly in Kenya, about the type of bacterial agents that colonize selected surfaces and health care providers in the hospital and their correlation with invasive disease-causing strains. Clear knowledge of the prevalence and types of these bacterial contaminants will inform efforts to reduce such and lower occurrence rates of HAIs.

METHODOLOGY

This was a descriptive cross-sectional pilot study conducted in April 2020 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. Whereas the purposive sampling approach targeted minimum sample size of 50 (20 from equipment, 20 from hospital surfaces, 10 from staff), a total of 62 samples were collected as detailed in Table 1.

Surfaces were swabbed with moisten (sterile 8.5% normal saline) COPAN floq swab. The swab was rolled-over the intended surfaces to cover about 30cm touch. After collection, the swabs were transported in Cary-Blair medium tube at 2°C-8°C in a cool box. Upon arrival in the laboratory, tubes were vortexes at 300 RPM for 20 seconds and open in BSC class II to control exposure to aerosols. 20 µl broths was inoculated and streaked on horse blood agar and CLED agar plates. Horse blood agar and CLED agar plates were incubated at 37°C in 5% CO_2 and aerobic incubator respectively for 24 hours. Any emerging colonial growth was sub-cultured on respective plates and incubated as mention above. Identification of bacterial genus and species were done by MALDI-TOF.

Table 1: Sample collection in the units selected.

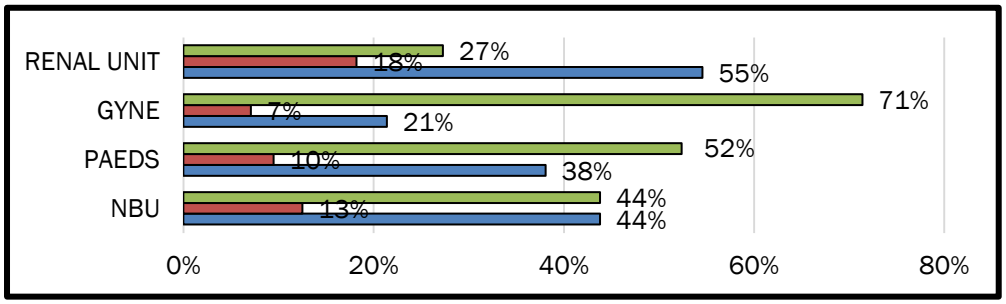
Equipment and surfaces	NBU	PAEDS	GYNE	Renal unit	Total
Sink	2(28.6)	2(28.6)	2 (28.6)	1 (14.3)	7 (11.3)
Wall	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	2 (3.2)
Door knob	1 (33.3)	2 (66.7)	0 (0.0)	0 (0.0)	3 (4.8)
Bed	1 (25.0)	2 (50.0)	1 (25.0)	0 (0.0)	4 (6.5)
Bp machine	1 (33.3)	1 (33.3)	1 (33.3)	0 (0.0)	3 (4.8)
Resuscitating pump	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.6)
Weighing scale	1 (33.3)	1 (33.3)	0 (0.0)	1 (33.3)	3 (4.8)
Stethoscope	1 (33.3)	1 (33.3)	1 (33.3)	0 (0.0)	39 (62.9)
Phone	1 (33.3)	0 (0.0)	1 (33.3)	1 (33.3)	39 (62.9)
Thermometer	1 (33.3)	2 (66.7)	0 (0.0)	0 (0.0)	3 (4.8)
Fetal scope	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	1 (1.6)
Trolley	0 (0.0)	1 (33.3)	1 (33.3)	1 (33.3)	3 (4.8)
Dialysis machine	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	1 (1.6)
Tripod stand	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	2 (3.2)
Pox	0	1 (100.0)	0 (0.0)	0 (0.0)	1 (1.6)
Nebulizer	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.6)
Dop	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	1 (1.6)
Spo2	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	1 (1.6)
Total	16 (25.8)	21 (33.9)	14 (22.6)	11 (17.7)	62 (100)

Note: NBU=New born unit; PAEDS=Pediatric ward; GYNE=Gynecology ward; SPO_2=Pulse oximeters; DOP=Drip stand; POX=Portable oxygen concentrator.

RESULTS

Out of all the 62 swabs from all the areas, 61.3% (n=38) yielded bacterial growth, 46 different known pathogenic bacteria were identified. A total of 46 bacterial isolates were cultured from all swabs [8]. The pediatric ward had the highest diversity of bacteria on the swabs with 73.9% (n=17/23) different bacterial isolates. The renal unit yielded the lowest diversity of organisms at 21.7% (n=5/23) from 11 swabs. The prevalence of contamination is presented in Figure 1.

Figure 1. Prevalence of Bacterial contamination and gram positive and gram-negative strains in samples obtained from selected departments. **Note:** Positive (Gram +ve); Negative (Gram -ve); No Growth.



The most prevalent genus in the facility was Acinetobacter at 41.3% (n=19) in all wards followed by Enterobacter at 13.0% (n=6) and Staphylococcus at 13.0% (n=6). The most pathogenic Acinetobacter isolate was Acinetobacter baumanii found in NBU and gynecology units. Unexpectedly, prevalence of Pseudomonas at 2.2% (n=1) was low. Out of 12 isolates obtained from gynecology ward, 6 belonged to *Acinetobacter species* and one belonged to *Empedobacter brevis*, two *Enterobacter cloacae*, and 2 were Staphylococcus aureus and one was *Stenethophomonas maltophilia*. Isolates obtained from the Pediatric unit belonged mainly to the Acinetobacter genus. From the Renal unit, only 5 pathogenic isolates were obtained. These included the following: *Acinetobacter haemolyticus, Acinetobacter junii, Klebsiella pneumoniae*, *Pseudomonas stutzeri* and *Wantersiella falsenii*. Table 2 below summarizes the species and the wards in which they were isolated [9].

Table 2. Known pathogenic bacterial species from selected departments.

Isolate	NBU	PAEDS	GYNE	Renal unit	Total
Acinetobacter Baumanii	1 (8.3%)	0 (0)	1 (8.3%)	0 (0)	2 (4.4%)
Acinetobacter Haemolyticus	2 (16.7%)	2 (11.8)	0 (0)	1 (20)	5 (10.9%)
Acinetobacter junii	0 (0)	0 (0%)	1 (8.3%)	1 (20)	2 (4.4%)
Acinetobacter lwoffi	1 (8.3%)	1 (5.9)	1 (8.3%)	0 (0)	3 (6.5%)
*Acinetobacter sps**	1 (8.3%)	2 (11.8%)	3 (25%)	0 (0)	6 (13.0%)
Acinetobacter variabilis	0(0)	1 (5.9%)	0 (0)	0 (0)	1 (2.2%)
Citrobacter freudii	0 (0)	1 (5.9%)	0 (0)	0 (0)	1 (2.2%)
Empedobacter brevis	0 (0)	0 (0)	1 (8.3%)	0 (0)	1 (2.2%)
Enterobacter cloacae	1 (8.3%)	2 (11.7%)	2 (16.7%)	0 (0)	5 (10.8%)
Enterococcus faecium	1 (8.3%)	0 (0)	0 (0)	0 (0)	1 (2.2%)
Escherichia coli	1 (8.3 %)	0 (0)	0 (0)	0 (0)	1 (2.2 %)
Klebsiella oxytoca	0 (0)	1 (5.8%)	0 (0)	0 (0)	1 (2.17 %)
Klebsiella pneumoniae	1 (8.3 %)	0 (0)	0 (0)	1 (20%)	2 (4.4 %)
Klebsiella variicola	0 (0)	1 (5.9%)	0 (0)	0 (0)	1 (2.2 %)
Leclercia Adecarboxylata	0 (0)	1 (5.9%)	0 (0)	0 (0)	1 (2.2 %)
Pantoea calida	0 (0)	1 (5.9%)	0 (0)	0 (0)	1 (2.2 %)
Pantoea dispersa	0 (0)	1 (5.9%)	0 (0)	0 (0)	1 (2.2 %)
Providencia rettgeri	1 (8.3 %)	0 (0)	0 (0)	0 (0)	1 (2.2 %)
Pseudomonas stutzeri	0 (0)	0 (0)	0 (0)	1 (20%)	1 (2.2 %)
Staphylococcus aureus	1 (8.3 %)	3 (17.6%)	2 (16.7%)	0 (0)	6 (13.0 %)
Stenethophomonas maltophilia	0 (0)	0 (0)	1 (8.3 %)	0 (0)	1 (2.2 %)
Wantersiella falsenii	0 (0)	0 (0)	0 (0)	1 (20%)	1 (2.2 %)
Waustersiella falseniia	1 (8.3 %)	0 (0)	0 (0)	0 (0)	1 (2.2 %)
Total	12 (100)	17 (100)	12 (100)	5 (100)	46 (100)

Note: *=The organism was only identified up to genus level; NBU=New born unit, PAEDS: Pediatric ward, GYNE: Gynecology ward

Surfaces had the highest number of isolates at 58.7% (n=27) and showed the greatest diversity (17 species) in the type of species isolated. This was followed by equipment at 28.3% (n=13) from the equipment which yielded 10 different species and 13% (n=6) from humans with only 3 species isolated. *Acinetobacter species*, Enterobacter cloacae had the highest prevalence on surfaces and equipment. *Escherichia coli* and *Klebsiella oxytoca* were only found on equipment. *Staphylococcus aureus* was most prevalent on humans at 50% (n=3) though it was also found on all areas sampled. Other isolates found in humans were *Acinetobacter lwoffi* and *Wantersiella falsenii*. The distribution of the isolates based on the type of sample is as summarized in Table 3 below.

Table 3. Prevalence and type of bacterial contamination on humans, surfaces and equipment from selected department.

Isolate	Surface N (%)	Equipment N (%)	Humans N (%)	Total N (%)
Acinetobacter baumanii	2 (7.41)	0	0	2 (4.35)
Acinetobacter haemolyticus	4 (14.81)	1 (7.69)	0	5 (10.87)
Acinetobacter junii	1 (3.7)	1 (7.69)	0	2 (4.35)
Acinetobacter lwoffi	0	1 (7.69)	2 (33.33)	3 (6.52)
*Acinetobacter sps**	2 (7.41)	4 (30.77)	0	6 (13.04)
Acinetobacter variabilis	1 (3.7)	0	0	1 (2.17)
Citrobacter freudii	1 (3.7)	0	0	1 (2.17)
Empedobacter brevis	0	1 (7.69)	0	1 (2.17)
Enterobacter cloacae	4 (14.81)	1 (7.69)	0	5 (10.87)
Enterococcus faecium	1 (3.7)	0	0	1 (2.17)
Escherichia coli	0	1 (7.69)	0	1 (2.17)
Klebsiella oxytoca	0	1 (7.69)	0	1 (2.17)
Klebsiella pneumoniae	2 (7.41)	0	0	2 (4.35)
Klebsiella varicola	0	1 (7.69)	0	1 (2.17)
Ledercia adecarboxylata	1 (3.7)	0	0	1 (2.17)
Pantoea calida	1 (3.7)	0	0	1 (2.17)
Pantoea dispersa	1 (3.7)	0	0	1 (2.17)
Providencia rettgeri	1 (3.7)	0	0	1 (2.17)
Pseudomonas stutzeri	1 (3.7)	0	0	1 (2.17)
Staphyloccoccus aureus	2 (7.41)	1 (7.69)	3 (50)	6 (13.04)
Stenethophomonas maltophilia	1 (3.7)	0	0	1 (2.17)
Wantersiella falsenii	0	0	1 (16.67)	1 (2.17)
Waustersiella falseniia	1 (3.7)	0	0	1 (2.17)
Total	27 (58.7)	13 (28.3)	6 (13%)	46

Note: *=The organism was only identified up to genus level.

DISCUSSION

The overall prevalence of bacterial growth was reported at 61.3% (n=38/62) indicating a high level of contamination of hospital surfaces, and equipment. The reporting of contamination on the sampled surfaces was higher than average reported contamination rates in literature. A possible reason for the prevalence high contamination could be to poor adherence to hospital IPC guidelines for infection control. Published data has shown that adherence to IPC can significantly lower prevalence of HAIs. This is also possibly suggestive of the low effectiveness of the detergents for cleaning [11-16]. Hence, our data point to a variety of possible causative factors that may need to be addressed at the study site as well as similar settings. These may include redesign and observation of IPC guidelines, and use of proper high quality detergents and disinfectants. Use of modern technologies such as antimicrobial surfaces may also be considered. Bacterial resistance to commonly used disinfectants is also a possibility. For instance, there is established bacterial resistance chlorhexidine is due to the qac gene which confers resistance to quaternary antiseptics. Considerations on changes of type of disinfectant used on surfaces need to be made as well as increasing frequency of cleaning. The targeted surfaces include door handles, tabletops, and sinks.

The pattern of contamination differed by department. Pediatric unit yielded 81% contamination; gynecology unit yielded 78.6%, while the renal unit yielded 45.5%. Whereas very few studies have attempted to compare hospital surface contamination by wards or departments, these data are still central in decision making and may be explained in diverse ways. In one study, bacterial contamination in the gynecology units was reported at 48.3% . Published data shows that occurrence of antibiotic resistance gram-negative contaminants in the gynecology unit is lately necessitating use of copper's biocidal activity to control contamination. In the NBU, high carriage rates have been uniformly reported across literature. Business if the wards may impact the contamination rate. The gynecology and NBU units are generally busier. Implementation of restricted entry, PPE use, and strict decontamination schedules may be essential in reducing these rates. Amidst the COVID-19 pandemic, it has been reported that strict hand washing, use of PPEs, and restricted patient flow are effective IPC approaches. The statistics deduced here are reflective of how staff adheres to IPC guidelines.

Surfaces table tops, door handles, hands of healthcare staff, among others act as catchment for contaminants in the hospital setting. Thus, most HAIs are acquired from touching hospital surfaces or interaction with contaminated equipment. The wards surfaces had the highest number of isolates at 58.7% (n=27) and showed the greatest diversity in the type of species isolated. Contamination rate for equipment was also significant at 28.3% (n=13) which had 10 different species. Observably, the rate was least among humans at 13% (n=6). The pattern observed suggests that whereas staff was keen on decontamination as evidenced by minimal contamination, disinfection of surfaces and equipment was less observed or less effective. On this note, it is possible to control the HAIs pandemic only through observation of IPC guidelines and use of high quality supplies [17-23].

Reporting members of the ESKAPE gang among the contaminants noted in this study is a particularly alarming finding. The most prevalent genus in terms of frequency levels in the facility was as follows: Acinetobacter 19 (41.3%) followed by Enterobacteria 6(13.0%) which were predominantly surface contaminants and also gram-positive Staphylococcus 6(13.0%) mainly found on humans [24-25]. Studies in Morocco and Rwanda had similar findings on the isolates though had a variable frequency of distribution. Whereas the high contamination level with Acinetobacter species may be justified by the community being mainly agricultural wince Acinetobacter is a soil inhabitant the main concern is the fact that *Acinetobacter baumanii* is notorious in causing hospital associated pneumonia, septicemia, meningitis, UTIs and other infections, similar to Kleibsiella [26-31]. This finding was

consistent with a study in Nigeria that found *Acinetobacter baumanii* to be a prevalent surface contaminant. *Staphylococcus aureus* was the leading in prevalence among the rest of the species. This may be expected due to the fact that the bacterium is a normal flora of the human skin. *Staphylococcus aureus* found on equipment and surfaces were possibly as a result of possible contamination from staff, caregivers and patients. It is well documented that S. aureus it is also a common causative agent for HAI [32-37].

CONCLUSION

The study observed a high level of contamination of surfaces, equipment and healthcare workers' hands at the facility. Since these have been shown to be the most common agents in the spread of HAIs, it may be deduced that high contamination may directly translate to high prevalence of HAIs at the facility. Consequently, we recommend that the hospital's management needs to invest more efforts in ensuring complete adherence to IPC guidelines and frequent monitoring of contamination levels with the aim of lowering occurrence of HAIs. Other hospitals of similar standards need to also learn from this data and implement the necessary prevention guidelines.

DECLARATION

In this study, an institutional based single population proportion cross-sectional study design was used that limits the relevance of the risk factor analysis to the entire population of HIV positive mothers on ART.

FUNDING

Not applicable

AVAILABILITY OF DATA AND MATERIAL

Not applicable

ETHICAL APPROVAL

The study was approved by the KEMRI Scientific Ethics Review Unit and assigned approval number SERU/CGMR-C/054/3318. Further approval before data collection was also obtained from the facility management. Staff whose hands were swabbed gave consent for the procedure.

COMPETING INTERESTS

The authors declare no competing interests.

CONSENT FOR PUBLICATION

Not applicable

AUTHORS CONTRIBUTIONS

The study was conceptualized by Kolek Chester and compiled by Kavulavu Briton. It was then reviewed by Faith Okalebo, Benson Singa and Kirkby D Tickell who compiled the proposal and sought approval. Actual data collection was completed by Mary Masheti and Chris Oduol. Ian Omuom, Ochieng Odhoch, being part of the hospital leadership, reviewed the study and assisted in data collection. Actual laboratory work was done by Caroline Tigoi and Robert Musyimi. Data analysis was completed by Kolek Chester and Faith Okalebo who also produced the tables and figures. The manuscript was developed by Kolek Chester and Kavulavu Briton and reviewed by all co-autors before submission.

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