Journal of Advances in Medicine and Medical Research

27(10): 1-13, 2018; Article no.JAMMR.44101
ISSN: 2456-8899
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

The Role of Hospital Surfaces and Theatre Environment in Transmission of Nosocomial Infections in a Rural District Hospital in Eastern Uganda

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Authors' contributions

This work was carried out in collaboration between all authors. Authors WCK, KE, LJ, NE, OE, TA, and IG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RN managed and coordinated the whole Community Based Education program and conducted critical reviews of the manuscript and author IJS participated in the planning of the study, drafting and critical review of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2018/44101
Editor(s):
(1) Dr. Thomas I. Nathaniel, University of South Carolina, School of Medicine-Greenville, Greenville, USA.
Reviewers:
(1) B. O. Amechi, Nigeria.
(2) Angel J. Vaillant, The University of the West Indies - St. Augustine Campus, Trinidad and Tobago.
(3) Maria Antonietta Toscano, University of Studies of Catania, Italy.
Complete Peer review History: http://www.sciencedomain.org/review-history/26805

Original Research Article

Received 18 July 2018
Accepted 04 October 2018
Published 24 October 2018

ABSTRACT

Background: Healthcare-associated infections (HAIs) are the "most frequent adverse events" in the delivery of healthcare worldwide. Most of these infections are linked to resistant pathogens harboured by hospital fomites and could persist for a long period of time thereby predisposing

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patients to HAI. Therefore the aim of this study was to determine the role of hospital surfaces (HS) and theatre environment (TE) in the transmission of drug-resistant pathogens.
Materials and Methods: A descriptive cross-sectional study design was employed using a sample of 42 swabs collected from indoor hospital surfaces and settle plate method for the theatre environment. Isolates were cultured under favourable growth conditions and identified using colonal morphology, microscopic appearance on gram stain and biochemical methods. Anti-microbial susceptibility testing was performed using the Kerby-Bour disc diffusion method. Results were analysed using SPSS version 16.0 software package and findings presented in tables, charts and graphs.
Results: All plates contained growth either bacterial or fungal (bacteria 66% and fungi 34%), majority isolates included Klebsiella (35%) and aspergillus spp. (26.19%) among bacteria and fungi respectively. Other pathogens isolated included Bacillus, Staphylococcus and Pseudomonas among bacteria and Rodothorula and Cladosporium among fungi. All isolates on settle plates displayed varying numbers of colony forming units ranging from $1.6*10^2$ to $4.2*10^4$ CFU/m^3. Enterococcus showed the highest resistance to anti-microbial agents, though the general trend of pathogens tested showed the existence of resistance to the commonly used antibiotics. There was rising resistance to the beta-lactam class of antibiotics whereas vancomycin, linezolid, refampin and cefoxitin showed high susceptibility to the antibiotics. There was a 60% MDR and 2.38% ESBL specifically with pseudomonas.
Conclusion and Recommendations: There was a high level of bacterial and fungal colonisation on hospital surfaces and theatre environment with a correspondingly high level of resistance to antimicrobial agents in Ngora Freda Carr Hospital.

Keywords: Bacteria; fungi; theatre; colonization; anti-microbial resistance; susceptibility profile.

1. INTRODUCTION

1.1 Background

Healthcare-associated infections (HAIs) are the “most frequent adverse events" in the delivery of healthcare worldwide. It is estimated that hundreds of millions of patients are affected by HAIs every year and are linked to significant numbers of deaths and high health care costs [1]. Though much progress has been made in tackling HAIs, a lot is still to be desired.

The clinical and financial burden on patients and healthcare providers for multi-drug resistant organisms (MDROs) really remains a challenge. Antibacterial resistance-associated infections are known to increase morbidity and mortality and cost of treatment as well as potentially putting others in the community at a higher risk of infections [1]. Patients who are infected with MDROs often have an increased risk of prolonged illness and mortality [2]. The cost of care for these patients can be more than double as compared to those without MDRO infection”. Conversely, in high-income countries where the burden of infectious diseases is relatively modest, resistance to first-line antibacterial agents is usually overcome by use of second- and third-line agents. However, in developing countries where the burden of infectious diseases is high, patients with antibacterial-resistant infections may be unable to obtain or afford effective second-line treatments and such drugs may not readily be available in some settings despite the high costs [3].

In sub-Saharan Africa (SSA), the situation is aggravated by poor hygiene, unreliable water supplies, civil conflicts, and increasing numbers of immunocompromised people, such as those with HIV, which facilitate both the evolution of resistant pathogens and their rapid spread in the community [3].

In Uganda, hospital fomites harbour resistant pathogens that could persist for a long period of time thereby predisposing patients to HAI, methicillin-resistant *Staphylococcus aureus* (MRSA) is the most prevalent resistant pathogen in most parts of Uganda [4,5]. Several studies have reported high levels of antibiotic drug resistance in hospital settings in Uganda [6-9]. Moreover, the health care seeking behaviours in the community may vary depending on the socioeconomic status of individuals involved [8]. Information on resistance surveillance particularly for isolates from community settings is scarce as surveillance mainly focuses on the susceptibility of isolates collected from clinical specimens in hospitals. Hospital surfaces and theatre environments may be neglected sanctuaries for both bacteria and fungi which may be resistant to antimicrobials. We aimed to

determine the role of hospital surfaces (HS) and theatre environment (TE) in transmission of drug-resistant pathogens.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This was a cross-sectional study employing quantitative methods that was conducted between April and May 2017. Ngora Freda Carr Hospital is located in Ngora sub-county, Ngora district in Eastern Uganda. It's a Private Not For Profit (PNFP) health facility under the Uganda Protestant Medical Bureau (UPMB). It serves an approximate population of 157,400. Attached to the hospital is Ngora School of nursing and midwifery. According to the Uganda health system framework, NFCH comprises of all the departments of a general public hospital [10]. Among the key service departments in the hospital including but not limited to; OPD, male, female, maternity and children's wards, a basic functional laboratory, a major Operation theatre, dispensary, ART clinic, administration unit and staff quarters.

2.2 Data Collection Methods and Tools

Samples were obtained from hospital surfaces and theatre environment which were believed to be potential sources for acquiring the contaminant pathogens. Representativeness was ensured by collecting samples from each department.

Study samples included swabs taken from hospital sources that include but not limited to items and surfaces in theatre, surgical, medical, paediatric and maternity wards as well as Out Patient Department of Ngora Freda Carr Hospital. Disinfection was always done at the start of each day of data collected and samples were collected during scheduled work periods. Fomites included but not limited to thermometers, sphygmo-manometer, stethoscopes, visitors' chairs, intravenous stands, beds, bedside tables, hand towels, kidney dishes, patients' crepe

Map 1. Map of Uganda showing Ngora district

bandages, curtains, telephones, dressing trolleys, light switches, door handles, record books, recording pens, examination bed area, pediatric weighing scale, pulsometer control panels, cupboard shelves, drug locks, screens, cardiotocograph control panels, counter tops (Nurses and doctors' stations) and water sinks (identified as Patients' sinks, Doctors' sinks, Nurses' sinks) were swabbed.

2.3 Laboratory Procedures

(a) Specimen Collection and Pathogen Identification

Specimen collection involved using a sterile cotton swab stick moistened with 0.9% sterile physiological saline. Thereafter the swab was then pressed and rolled several times over the entire surface of a selected item. With utmost care to avoid touching the swab, it was then immediately placed into an appropriate bijou bottle containing Brain heart infusion broth and aerobically incubated overnight at 37°C [11].

On suspected growth exhibited by turbidity in the broth, specimens were subcultured on Blood agar and MacConkey agar (oxoid) using aseptic streaking techniques followed by 24 hours of incubation at 37°C aerobically. Plates were then read for bacterial growth, and organisms examined for their characteristic colonial appearance, hemolysis, swarming, and/or pigmentation on the different media, before subsequent follow-up for identification and confirmation through gram-staining, sugar fermentation, and biochemical reactions. On failure to grow within 24 hours, plates were further re-incubated for the same time under similar conditions before discarding them and recording their results as negative.

Members of the family Enterobacteriaceae were identified by indole production, Hydrogen Sulphide (H_2S) production, citrate utilization, gas production, motility tests, urease test, oxidase, and carbohydrate utilisation. For gram-positive bacteria identification and confirmation was done using coagulase, DNase, catalase, mannitol fermentation, CAMP (Christie, Atkins, and Munch Peterson) test, bile esculin test, bacitracin, optochin and novobiocin susceptibility tests were used.

(b) Settle Plate Method

The evaluation of bacterial and fungal contamination in the operating theatre was performed by using settle plate method. The sterile Blood agar plates were transported to the operating theatre in sealed plastic bags. The plates were labelled with sample numbers, a site within the operation theatre, date of sample collection and control plates were kept to monitor any prior contamination of plates. During air sampling, sterile gloves, mouth mask and protective gowns were worn to prevent self-contamination of the culture media. The index of microbial air contamination was based on the count of the microbial fallout on to Petri-dishes left open to the air according to the 1/1/1 scheme; that is 1 hour, 1 meter above the floor and at least 1 metre away from walls or any obstacle [12]. After this exposure, the plates were covered with their lids and taken to the microbiology laboratory in sealed plastic bags and incubated for 24 hours at 37^{o}C. The culture plates that showed discrete macroscopic colonies were counted. The colonies were assessed for the growth of potentially pathogenic bacteria initially by colony characteristics, haemolysis pattern and microscopic examination of Gram stained smears. Final identification was done following standard bacteriological techniques. The concentration of airborne bacteria was expressed as colony forming units per cubic meter (CFU/m^3). Settle plate showing fungus was also noted. Lactophenol cotton blue (LCB) mount of fungi was done to identify fungal colonies [13].

(c) Reporting of Settle Plates

1. Single CFU of Staphylococcus spp., Pseudomonas spp., any fungi.
2. >50 CFU of Gram negative bacteria other than Pseudomonas spp.

A formula to determine the number of Colony Count (on settle plate) per m^3 was adopted [14].

$$CFU/m^3 = \frac{a \times 1000}{p \times t \times 0.2}$$

a = the number of colonies on Settle plate.
p = the surface measurement of plate used.
t = time of exposure of settle plate.

2.4 Isolation and Identification of Fungi

Fungal organisms were mainly recovered using the settle plate method. Fungi that grew on any exposed plates were sub-cultured on potato dextrose agar and incubated at 27^{0}C for three

weeks. The fungi were then stained using Lactophenol cotton blue and observed under X40 objective for phenotypic characterisation of the filamentous fungi.

2.5 Antimicrobial Susceptibility Testing

Antimicrobial susceptibilities were done using the modified Kirby-Bauer's disc diffusion methods and the Clinical and Laboratory Standards Institute (2014) guidelines were used to interpret the results [11,15].

The drug categories used for this study included; aminoglycoside (Gentamycin, 10 µg), Fluoroquinolones (Ciprofloxacin, 10 µg), Chloramphenicol (Chloramphenicol, 30 µg), Folic acid inhibitor (Sulphamethazole-Trimethoprim, 1.25 µg), or Tetracyclines (Tetracycline, 30 µg). An ESBL producer that showed resistance to at least one agent in three or more antimicrobial categories for which it did not have known intrinsic resistance was defined as a co-resistant pathogen.

A multidrug resistant (MDR) phenotype of isolates was identified as an expression of resistance to at least one agent in three or more different antimicrobial categories to which these isolates did not have known intrinsic resistances. These MDR defining categories included: cephalosporins, aminoglycosides, macrolides, lincosamides, fluoroquinolones, folate pathway inhibitors (sulfamethazole-trimethoprim), antipseudomonal Penicillin-β-lactamase inhibitors (piptazocin), tetracycline, and chloramphenicol. All MRSA was defined as MDR by virtue of their inherent nature of being MRSA as this predicted resistance to cephamycin (Cefoxitin, a surrogate marker for Methicillin), ciprofloxacin, and all β lactam antibiotics [16].

2.6 Data Analysis and Presentation

Data were entered in Microsoft Excel, cleaned and imported to SPSS Version 16.0 statistical package for analysis. Associations were tested using Pearson's Chi-square on bivariate cross-tabulated tables. Following data analysis results were presented in Statistical frequency distribution tables, graphs and charts were used for data presentation in terms of proportions, absolute values, percentages, and confidence intervals calculated by Poisson's test for point estimates at 95% level of confidence with a *P-value* of 0.05 considered as statistically significant.

2.7 Quality Control

Reference strains used as controls included: *E. coli* (ATCC 25922), *E. faecalis* (ATCC 29212), *S. aureus* (ATCC 25923), Methicillin Resistant *S. aureus* (ATCC 43300), *Escherichia coli* ATCC 35218 (ESBL producer), *K. pneumoniae* ATCC 700603 (ESBL producer), and *P. aeruginosa* (ATCC 27853).

2.8 Ethical Consideration

Permission to carry out the study was obtained from Busitema University Faculty of Health Sciences Research and Ethics committee. The purpose of the study was explained to each of focal person(s) from the departments where samples were collected and consent was obtained prior the actual data collection exercise. Access to collected data was restricted to only persons directly involved in the study.

3. RESULTS

3.1 Prevalence of Pathogens on Surfaces and Theatre Environment at Ngora Freda Carr Hospital

During the study period, 42 samples were collected from clinical items and surfaces from across all wards as well as theatre environment. Results revealed that all samples collected harboured bacterial and or fungal pathogens as indicated in Fig. 1.

3.2 Prevalence of Bacterial and Fungal Pathogens in Ngora Freda Carr Hospital

The pathogens isolated were further analysed to identify the various genera and species of bacteria and fungi in the culture media as shown in Figs. 2 and 3.

The highest bacterial isolates were *Klebsiella spp*. (38%) and the lowest prevalence was Enterobacter and *Proteus spp.* all belonging to the family of Enterobacteriaceae (Fig. 2).

In addition, among the isolates, were mycotic (fungal) colonization solely isolated on settle plate growths from the theatre environment and they included *Aspergillus spp*. mainly *A. fumigatus* accounting for the highest isolate 35.48% (11/31) and the rest were *Rodothorula* and *Cladosporium spp*. as shown in Fig. 3.

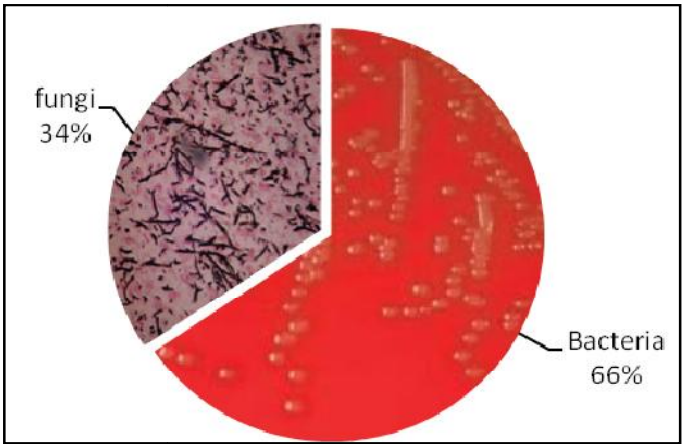

Fig. 1. Overall prevalence of pathogens in Ngora Freda Carr Hospital

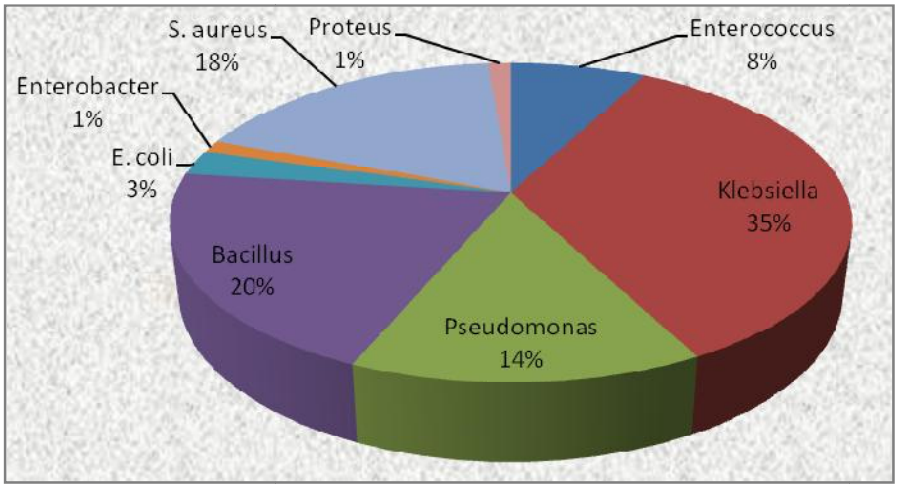

Fig. 2. Prevalence of bacterial pathogens in Ngora Freda Carr Hospital

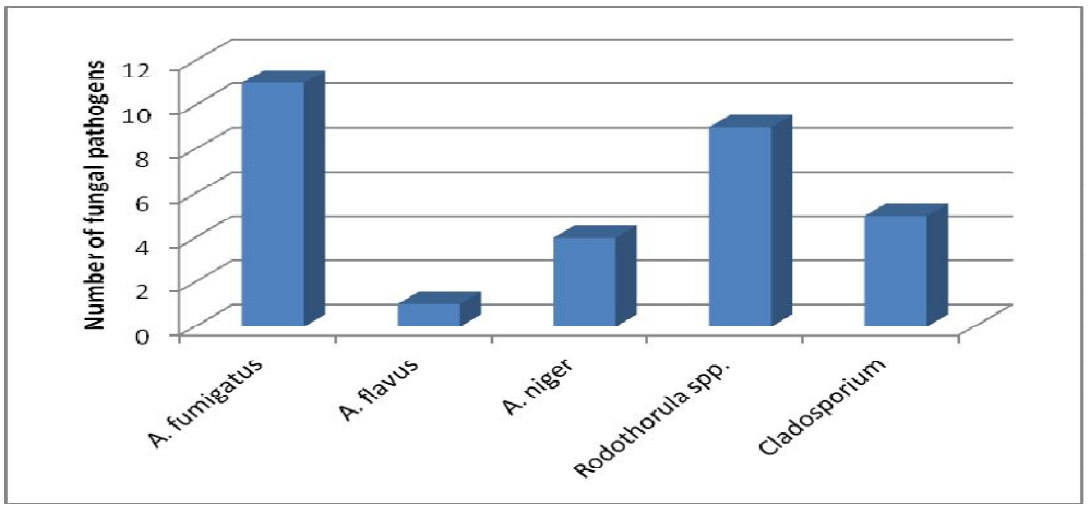

Fig. 3. Prevalence of fungal pathogens in NFCH

3.2.1 Estimation of level of colonisation

The number of colony-forming units was established for each settle-plate to estimate the level of colonisation in the theatre environment to determine the risk of infectivity related to the pathogen dose. Findings as shown in Table 1, revealed that; *Staphylococcus aureus* was the highest bacterial contaminant in the theatre environment ($3.2*10^3$CFU/m^3 or $4.2*10^4$CFU/m^2) whereas *aspergillus spp.* with a colonization level of $26*10^3$CFU/m^3 or $25.1*10^3$ CFU/m^2 accounted for the highest fungal contaminant among fungi.

3.3 Resistance Profile for Bacterial Pathogens

A variety of anti-microbial agents from different classes were used to test the sensitivity of bacterial pathogens. Tests based on the presumed bacterial susceptibility ensued by inherent physiological and structural characteristics visa vee the different mechanisms of action of the antimicrobial agents used and findings presented in Fig. 4.

Resistance was highest among *Enterobacter* whereby all drugs used in the test were shown to be ineffective in causing marked zones of inhibition of bacterial proliferation around them as based on the Clinical and Laboratory Standards Institute guidelines (2014). On the other hand, *enterococcus* showed the highest sensitivity, and the rest of the pathogens (*Klebsiella, E. coli,* and *Pseudomonas*) showed 100% resistance to at least three of the anti-microbial agents used.

Table 1. Frequency of bacterial and fungal colonies isolated from theatre

Pathogen	Number of plates	Total number of CFU	Number of CFU/plate	CFU/m^3	CFU/m^2
Bacteria					
Pseudomonas	7	40	5.71	9.0E+02	6.3E+03
Bacillus	12	158	13.17	2.1E+03	2.5E+04
S. aureus	13	268	20.62	3.2E+03	4.2E+04
Proteus	1	1	1.00	1.6E+02	1.6E+02
Fungi					
A. fumigates	8	58	7.25	1.1E+03	9.1E+03
Other Aspergillus spp.	11	102	9.27	1.5E+03	1.6E+04
Rodothorula spp.	6	10	1.67	2.6E+02	1.6E+03
Cladosporium	4	1	0.25	3.9E+01	1.6E+02

Note: CFU/m^3 = (a x 1000) / (p × t × 0.2), where a =number of colonies per plate, p = 53.54cm^2 (surface area of plate), t = 0.5 hr (time of exposure)

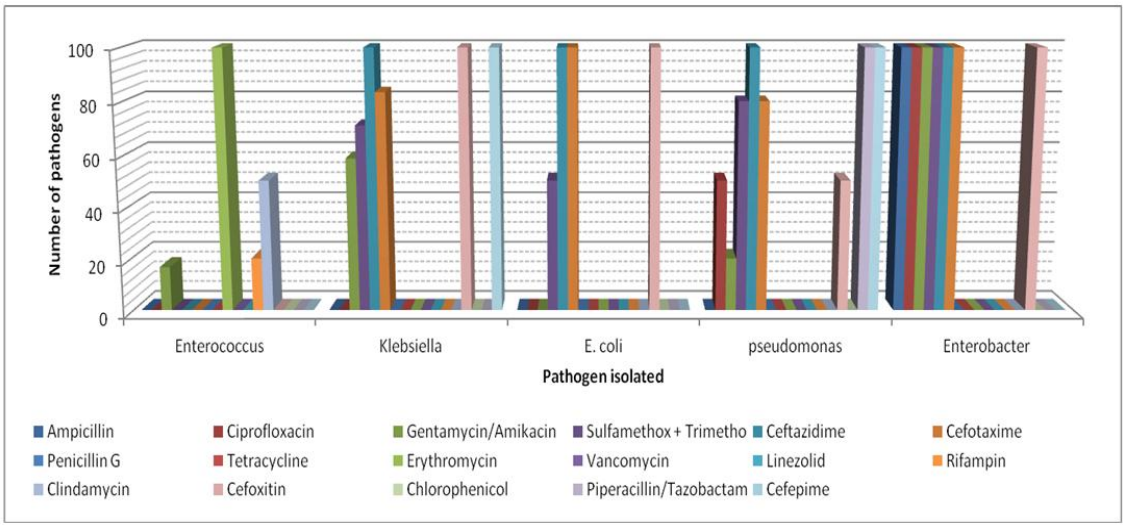

Fig. 4. Resistance profile of isolated bacterial pathogens from Ngora Freda Carr hospital

3.4 A Comparison of Sensitivity among Antimicrobial Agents Used

Findings presented in Fig. 5. Revealed that, anti-microbial agents which showed the highest level of bacterial clearance included: Vancomycin, and ciprofloxacin, whereas ceftazidime, ampicillin, cefipime piperacillin/tazobactam, cefotaxime, cefoxtine and cefepime were the most resisted anti-bacterial agents. Acceptable levels of clearance were also observed among genatmycin/ amikacin, linezolid and chlorophenicol where over 50% of the isolates were cleared. Sulfamethoxazole + trimethoprim, a drug routinely used for prevention of opportunistic infections in HIV/AIDS had a resistance profile of over 70%.

3.5 Assessment of MDR among Different Classes of Antimicrobial Agents

Multidrug resistance (MDR) was defined as resistance to one or more anti-bacterial agents from three (3) or more classes of drugs. This was achieved by first grouping the drugs into their pharmacological classification based on their similarity in mechanisms of action and the sensitivity pattern across the different classes established as shown in Table 2.

Findings revealed that 60.00% (3/5) of bacterial pathogens were resistant to one or more drugs from three or more classes of drugs hence were taken to be MDRs.

Among the isolates, only 2.38% (1 in 42) of the Pseudomonas species tested positive for Extended Spectrum β Lactamase (ESBL) and therefore exhibited extended multi-drug resistance.

Vancomycin was used to detect VRE, however, there was no VRE detected.

Sensitivity tests were not performed on *bacillus* due to its high-risk infectivity potential in case of *B. anthracis* which requires high level of protective techniques for safe handling. Conversely, the fungal isolates were not tested for sensitivity because the sole target for this study was bacterial colonisation.

4. DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

4.1 Discussion

4.1.1 Prevalence of microbial pathogens

All samples for this study harboured pathogens which were cultured on appropriate growth media and isolated and identified using colonal morphology and biochemical techniques.

The observed 100% contamination of hospital surfaces and theatre environment was uniquely overwhelming compared to a similar study in a rural setting in Uganda where the contamination was found to account for only 57.59% of the samples collected close to half in this study [4]. Though Segujja et al was silent about isolation of fungi, this study isolated a number of fungi from settle plate method in the theatre environment. Presence of fungi in the theatre poses a high risk of contaminating the patient's wound and internal viscera especially for those undergoing long

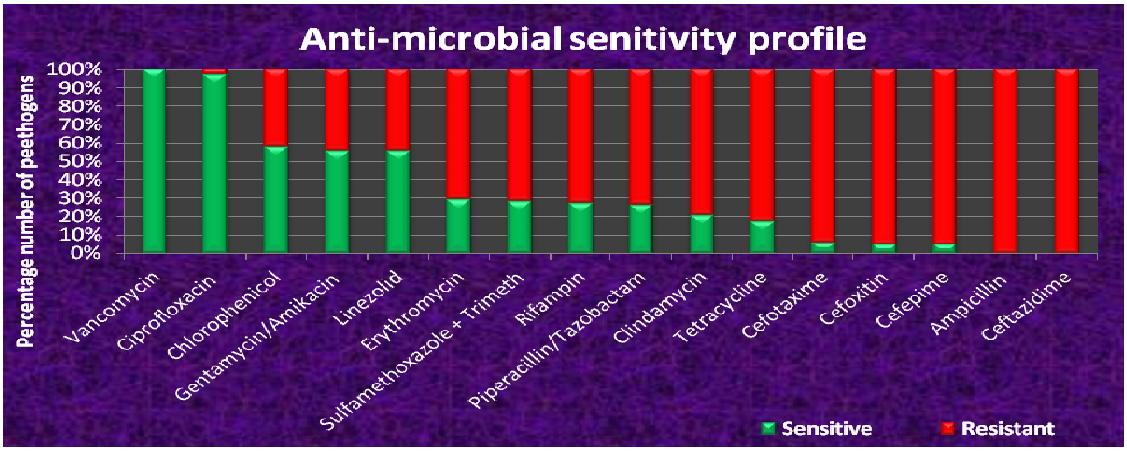

Fig. 5. Sensitivity profile among the different antimicrobial agents

Table 2. Assessment of multi-drug resistance

Class of drugs		*Enterococcus*		*Klebsiella*		*E. coli*		*Pseudomonas*		*Enterobacter*	
		S	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**
Penicillins	AMP /AMC	*	*	23	0	2	0	4	4	0	1
	TPZ	*	*	*	*	*	*	0	2	*	*
Quinolones	CIP	1	0	24	0	2	0	5	0	0	1
Aminoglycosides	CN / AMX	5	1	10	14	2	0	4	1	0	1
	VA	4	0	*	*	*	*	*	*	*	*
	DA	1	1	*	*	*	*	*	*	*	*
	RA	4	1	*	*	*	*	*	*	*	*
Sulfonamides	SXT	*	*	7	17	1	1	1	4	0	1
Cephalosporins	CAZ	*	*	0	24	0	2	0	5	0	1
	CTX	1	0	4	20	0	2	1	4	0	1
	FOX	*	*	0	17	0	1	1	1	0	1
	FEP	*	*	0	7	0	0	0	1	*	*
Tetrcyclines	TE	5	0	*	*	*	*	*	*	*	*
Macrolides	E	0	5	*	*	*	*	*	*	*	*
	LNZ	6	0	*	*	*	*	*	*	*	*
Chlorophenicol	C	5	0	*	*	*	*	1	0	*	*
Number of drug classes resisted			Two		Three		Two		Four		Five
Multi-drug resistance			No		MDR		No		MDR		MDR

*Footnote: S = Sensitive; R = Resistant; MDR = Multi-drug resistant; *sensitivity not done*

standing open surgery due to the increased exposure time hence causing systemic fungal infection such as aspergilosis among others [17,18]. While stringent measures have been employed by high income countries to bring down the infection rates due to nosocomial infections, implementation of the same has not been possible in the low income countries probably due to poor implementation strategies and less interest of these countries in this particular area [19]. A robust infection and prevention program, properly trained and well-motivated team of medical personnel may be important to bring down the prevalence of contamination in hospital surfaces and theatre environment in low income countries. While resources seem to be the most important component in prevention of HAIs, commitment from management and stringent measures to manage the resources are crucial in lowering the prevalence of the infections.

Klebsiella spp which belongs to the enterobacteriacea family was the most frequently isolated bacteria probably due to the poor hygiene. On the contrary, most studies report *Staphylococcus aureus* as the most commonly isolated [20]. On the other hand, Bacillus spp which we did not fully characterize was isolated in considerably large numbers which poses eminent danger to patients especially if it was *Bacillus anthracis*. Pathogenicity is often directly correlated to the level of environmental contamination which on the other hand determines the infective dose. In this study, theatre environment samples collected using settle plate method revealed that *S. aureus* and *Aspergillus spp.* were the most prevalent bacterial and fungal organisms isolated per unit volume or surface area respectively. Both pathogens can easily be released into the atmosphere from the skin (for *S. aureus*, a normal flora of the skin) and from the exhaled air for Aspergillus. For this matter, therefore, aerosolised pathogens in theatre pose a high risk of infection to the patient due to the likelihood of contaminating the open site predisposing the patient to the surgical site and intra-cavity infections [21]. Issues related to poor organizational work culture, attitudes and practices may contribute to poor infection prevention and control practices which will eventually drive faster the epidemic of hospital acquired infections [18]. Noncompliance of standard guidelines for infection control in the operating theatres and the prevailing practices of entering operating theatre without changing or without slipper or sterile shoe covers by the theatre users may also account for high levels of contamination in this setting.

4.1.2 Microbial resistance/sensitivity profile

Anti-microbial resistance was mainly observed among the class of Enterobacteriaceae especially enterobacter spp where there was 100% resistance to several of the antibiotics used. This correlates to the frequency of occurrence of the bacterial infections and hence the probable colony-gene transfer for the resistant strains. Our findings agree with other studies that resistance has widely been observed towards commonly used antibiotics agents [22]. Most of the resistance was observed among beta lactam antibiotics mainly penicillins and cephalosporins [3,8]. This class of drugs is the most commonly prescribed antibiotics for bacterial and non-bacterial infections which could explain the likelihood for development of resistance against its member anti-microbial agents [23]. Conversely, resistance against ciprofloxacin which is a flouroquinolone was surprisingly very low at only 3% compared to 72% and 38% in studies elsewhere [24], yet it's one of the drugs commonly used. In the advent of high treatment costs with other high line treatment options, the rural communities may less likely be in position to afford expensive medicines resulting in poor infection containment.

Whereas some pathogens showed high sensitivity to certain groups of anti-microbial agent, there was undisputable concern of 60% MDR pathogens where the pathogen(s) was resistant to one or more antimicrobial agents from at least three classes of drugs. This was considered to be too high compared to an average of 16.17% in studies elsewhere [4]. The highest MDR occurred among enterobacters followed by pseudomonas spp. and so agreed with Segujja and colleagues' findings.

The principle of synergism among therapy is seen as one of the most effective strategies to clear anti-microbial resistant pathogens. This employs using antimicrobial agents which have different mechanisms of drug action against a pathogen. It was revealed that 2.38% organisms (predominantly pseudomonas) exhibited co-resistance against gentamycin and ciprofloxacin hence taken to be ESBL or Extended MDR. Nevertheless this flicker chance still indicates the existence of ESBL producers in this hospital that

would surely present with quite a great patient management problem especially unresponsiveness to what could be used as ESBL treatment alternatives [4].

Although in this study no or low resistance was observed against commonly available anti-microbial agents like tetracycline, and chlorophenicol among others, preference of these medicines among prescribers is significantly low or erratically used as over the counter by the patients. Other medicines which were 100% effective like vancomycin and linezolid are unfortunately very expensive and only reserved for severe non-responsive infections. On the other hand, the use of these medicines especially Vancomycin is limited due to the severe renal impairment associated with its prolonged administration [25]. Resistance against sulfamethoxazole + trimethoprim at 74.19%, a trend raises eyebrows due to it high utilisation among people living with HIV/AIDS (PLWHA) to protect against opportunistic infections.

5. CONCLUSION

The highest contaminating pathogens belonged to the enterobacteriaceae family, of which the most prevalent was Klebsiella spp., there was also a high colonisation with Bacillus spp. which poses a high risk of causing fatal conditions due to its high-risk contiguity. Whereas none of surface isolates contained Staphylococci, this bacterial genera was the highest isolate on settle-plate growths. Recovery of Staphylococcus from surfaces may imply a high likelihood of Staphylococcal contamination of surgical sites leading to surgical site infections (SSIs) and supurative skin infections among others.

The highest fungal isolate was *Aspergillus* spp. especially A. fumigates which are among the commonest opportunistic systemic fungal pathogens among immune compromised patients. Comparatively, with bacterial isolates, none of the hospital surface samples yielded vegetated fungal growths which may explain the saprophytic characteristics of fungi.

Bacterial sensitivity analysis revealed a general increase of antibiotic resistance to the commonly used antibiotics with more organisms becoming multi-drug resistant. Resistance was highest against beta-lactam group/class of drugs.

6. RECOMMENDATION

The hospital management should establish an infection prevention and control (IPC) committee which should conduct periodic assessment of the set indicators for maintaining the standards of infection prevention and control. Refresher trainings should be organised and conducted to build the capacity of staff on IPC including prevention of the risk to promote development of anti-microbial resistance.

CONSENT

The purpose of the study was explained to each of focal person(s) from the departments where samples were collected and consent was obtained prior the actual data collection exercise.

ETHICAL APPROVAL

Permission to carry out the study was obtained from Busitema University Faculty of Health Sciences Research and Ethics committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sydnor ER, Perl TM. Hospital epidemiology and infection control in acute-care settings. Clin Microbiol Rev. 2011;24(1): 141-73.
2. Basak S, Singh P, Rajurkar M. Multidrug resistant and extensively drug resistant bacteria: A study. J Pathog. 2016; 4065603.
3. Kariuki S, Dougan G. Antibacterial resistance in sub-Saharan Africa: An underestimated emergency. Ann N Y Acad Sci. 2014;1323:43-55.
4. Segujja F, Mwambi B, Drago C, Lubowa N, Mugambwa J, Wabuyi P. Characterization and antimicrobial susceptibility patterns of isolates from ward fomites. British Biotechnology Journal. 2016;14(4):1-16.
5. Nalwoga J, Tirwomwe M, Nyanchoka OA, Nyabayo JM, Mose NC, Ondieki CM. Drug resistant *Staphylococcus aureus* in clinical samples at Kampala International University-teaching Hospital, Bushenyi

District, Uganda. American Journal of Biomedical Research. 2016;4(4):94-8.

6. Seni J, Najjuka CF, Kateete DP, Makobore P, Joloba ML, Kajumbula H, et al. Anti-microbial resistance in hospitalized surgical patients: A silently emerging public health concern in Uganda. BMC Res Notes. 2013;6:298.
7. Iramiot J. Stanley FB, Herbert Itabangi, Martha Nakaye, Mwambi Bashir, Joel Bazira. Prevalence and antibiotic susceptibility patterns of clinical isolates of methicillin-resistant *Staphylococcus aureus* in a Tertiary Care Hospital in Western Uganda. British Microbiology Research Journal. 2014;4(10).
8. Najjuka CF, Kateete DP, Kajumbula HM, Joloba ML, Essack SY. Antimicrobial susceptibility profiles of *Escherichia coli* and *Klebsiella pneumoniae* isolated from outpatients in urban and rural districts of Uganda. BMC Res Notes. 2016;9:235.
9. Stanley IJ, Kajumbula H, Bazira J, Kansiime C, Rwego IB, Asiimwe BB. Multidrug resistance among *Escherichia coli* and *Klebsiella pneumoniae* carried in the gut of out-patients from pastoralist communities of Kasese district, Uganda. PLoS One. 2018;13(7):e0200093.
10. Health TUMo. Guidelines for governance and management structure; 2013.
11. Bauer AW, Kirby WMM, Sherris JC, Turk M. Antibiotic susceptibility testing by a standardized single disk method. American Journal of Clinical Pathology. 1966;45: 493–6.
12. Napoli C, Marcotrigiano V, Montagna MT. Air sampling procedures to evaluate microbial contamination: A comparison between active and passive methods in operating theatres. BMC Public Health. 2012;12:594.
13. Kasdekar MM, Duthade MM, Damle AS, Khapurkuntikar MN, Iravane JA, Bhakre JB, et al. Air quality monitoring of operation theaters in Government Medical College and Hospital, Aurangabad, India. Inter-national Journal of Current Microbiology and Applied Sciences. 2016;5(6):42-9.
14. Prathab AGCL. Microbiological surveillance of air quality in operation theatres - comparison of the conventional settle plate techniques vs use of an air sampling device. Journal of Evolution of Medical and Dental Sciences. 2012;1(4): 371-81.
15. Institute CaLSs. Performance standards for antimicrobial susceptibility testing. 27 ed; 2014.
16. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012; 18(3):268-81.
17. Haider SSB. Study of fungal load in wards, departments and doctors' equipments in a tertiary care hospital and evaluation of 3 new mounting solutions for fungal micromorphological study. International Journal of Medical and Health Research. 2017;3(9):49-51.
18. Sudhir Chandra Joshi VD, Rita Joshi, Megha Sharma, Ashish Pathak , Harshada Shah, Ashok J. Tamhankar, Cecilia Stålsby Lundborg. How can the patients remain safe, if we are not safe and protected from the infections? A Qualitative Exploration among Health-Care Workers about Challenges of Maintaining Hospital Cleanliness in a Resource Limited Tertiary Setting in Rural India. International Journal of Environmental Research and Public Health. 2018;15(1942).
19. Brewster LTC, Dixon-Woods M. Qualitative study of views and experiences of performance management for healthcare-associated infections. J Hosp Infect. 2016; 94:41–7.
20. DiGiulio DB, Romero R, Kusanovic JP, Gomez R, Kim CJ, Seok KS, et al. Prevalence and diversity of microbes in the amniotic fluid, the fetal inflammatory response, and pregnancy outcome in women with preterm pre-labor rupture of membranes. Am J Reprod Immunol. 2010; 64(1):38-57.
21. Singh KDFAAKK. Bacterial contamination in operating theatres of district hospital budgam in kashmir division. Innovative Journal of Medical and Health Science. 2013;62(63).
22. Iredell JBJ, Tagg K. Antibiotic resistance in Enterobacteriaceae: Mechanisms and clinical implications. BMJ; 2016.
23. Weber DJ, Rutala WA, Miller MB, Huslage K, Sickbert-Bennett E. Role of hospital

surfaces in the transmission of emerging health care-associated pathogens: Norovirus, Clostridium difficile and *Acinetobacter* species. Am J Infect Control. 2010;38(5 Suppl 1):S25-33.

24. Fasugba O, Gardner A, Mitchell BG, Mnatzaganian G. Ciprofloxacin resistance in community- and hospital-acquired *Escherichia coli* urinary tract infections: A systematic review and meta-analysis of observational studies. BMC Infect Dis. 2015;15:545.

25. Elyasi S. KH, Dashti-Khavidaki S, Mohammadpour A. Vancomycin-induced nephrotoxicity: Mechanism, incidence, risk factors and special populations: A literature review. European Journal of Clinical Pharmacology. 2012;68(9):1243-55.

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