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Full length Research Paper

Presence of pathogen bacteria in the environment of Kenyatta National Hospital, Kenya

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Nosocomial infections have impacted great burden in healthcare system and has led to deteriorating health condition and deaths. This study characterizes medically important bacterial diversity, isolated from staff hands, hospital surfaces and wastes in healthcare settings in Kenya during a one year period. Descriptive cross sectional hospital based study design and simple random sampling method was used to collect 246 samples from 10 sections in each hospital, using sterile cotton swabs and processed in the laboratory. Colony morphology and biochemical characterization was also recorded and confirmation of Enterobactericeae using API-20E test for later study of ESBL resistant genes was done. Statistical analysis was done using Microsoft Excel and ANOVA. The study highlighted the presence of *Providentia rettgeri* (21.01%), *Staphylococcus aureus* (18.47%), *Escherichia coli* (13%), other Gram negatives (9.55%), *Pseudomonas aeuriginosa* (9.3%), coagulase negative *Staphylococcus* (CONS) (9.12%), *Serratia marcescens (6.58%), Klebsiella pneumonia* (6.36%), *Proteus vulgaris* (4.03%) and *Enterobacter cloaca* (3%). Most nosocomial infections especially urinary tract infections are caused by these bacteria. It is necessary for hospitals to implement most of the recommended measures in this study to reduce the risk of transmission of pathogens via contaminated hospital surfaces and sites.

Key words: Hospital surfaces, hospital waste, environment, isolation, bacteria, nosocomial infections.

INTRODUCTION

Hospital is the place, which is frequently accessed by the people irrespective of age, sex, race, religion, region and even nationality. The waste generated during entire healthcare activities has higher potential to produce health and environmental hazards than the wastes of other places (Boyce et al., 1997). Hospital acquired infection also called nosocomial infection is an infection acquired in hospital by a patient who was admitted for a reason other than that infection. Nosocomial pathogens are organisms causing diseases that are acquired from the hospital and healthcare environment within few days of admission and are responsible for nosocomial infections (Medubi et al., 2006). The hospital exists as a closed community; it is therefore not surprising that certain microorganisms become predominant and cause diseases (Boyce et al., 1997). The pathogens can be expelled from an infected or colonized patient either through direct contact, aerosols droplets or faeces to the

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environmental surfaces. These pathogens can be contracted by the healthcare workers and even by the patients. Therefore, environmental surfaces in healthcare centers act as reservoir for bacteria and can as well serve as vectors of the bacterial pathogens (Boyce et al., 1997). The risk for nosocomial infections poses a potential patient safety threat (WHO, 2002). These infections are often caused by breaches of infection control practices and procedures, unclean and non-sterile environmental surfaces, and/or ill employees. Kenya like many developing countries experience the problem of getting sufficient medical supply and even worse is the disposal of medical waste. This is due to lack of enforcement of legislation for handling, treatment and disposal. Healthcare surfaces and wastes act as the store house of harmful infectious pathogens. Potential health risk includes spreading of diseases by these pathogens and wide dissemination of antimicrobial resistance genes. Antimicrobial resistance in both pathogenic and commensal bacteria is increasing steadily. Failure of antibiotic resistant bacteria containment is responsible for this expansion. The incidence of infections caused by beta lactam resistant organisms due to the production of various enzymes has increased in recent years. Hospital waste can be hazardous to public health and ecological balance since it can contain various kinds of pollutants such as radioactive, chemical and pharmaceutical wastes and also pathogenic microorganisms (WHO, 2002). In Kenya like many developing countries, data is limited to the number of cases registered in health facilities, like Ibn Sina hospital in Rabat (Bakkali et al., 2015) which highlighted the presence of pathogens in distinct areas of the hospital environment like *Pseudomonas aeuriginosa*, *Staphylococcus aureus*, *Klebsiella* species and various gram negative bacilli. Therefore, the present study was done to evaluate the presence of pathogen bacteria in the environment of Kenyatta National Hospital (KNH) and Kikuyu Mission Hospital (KMH) in Kenya and to characterize them for better management of the hospital environment quality.

MATERIALS AND METHODS

This constitutes bacteriological analysis and it included cultivation of collected samples from various sites or departments in the hospitals, colony morphology study under different selective media, biochemical tests and confirmatory test using API-20E strips. The study site chosen for this study are KNH and KMH situated in Nairobi County (www.knh.or.ke and www.pceakikuyuhospital.org) in which samples were collected from various sites or departments in the hospitals. The study design used in this research was descriptive cross sectional hospital based study with a sample size of 246. Simple random sampling method was used to collect samples from ten departments in each hospital. Sampling was performed during the morning after the regular daily cleaning. Different surfaces and locations were included (door handles, toilet, bathroom knobs, bed rails, cabinet locks and handles, water dispensers taps, tables including operating tables, scrubber surfaces, sink surfaces, theatre equipment surfaces (for example breathing tubes, infusion pump, aspirators), waste bin surfaces, dump site, door handles and knobs and floor surfaces, etc. Basically, 23 to 24 samples were used, at least, for each sampling site, giving a total of 246 samples in each hospital. Samples collected using sterile polyester fibre tipped applicator swabs (Becton Dickson, Basel, Switzerland) were moistened in 2 ml sterile saline solution and rolled several times over a surface area of around 25 cm. They were then put into sterile tubes, tightly capped and labeled appropriately; similarly, sterile swabs were dipped into drainages and treated as earlier stated. They were transported in ice cooler box to the laboratory for processing. Samples were inoculated on various selective and differential media such as MacConkey, Mannitol salt agar (MSA), Eosin methylene blue (EMB), and *Salmonella shigella* agar (SS), using the streaking method. Samples were incubated at 36°C (+/- 1°C) in an incubator for 18 to 24 h (overnight). Visible colonies were further sub cultured and incubated for 24 h at 37°C. Isolation and identification of microorganisms were done according to standard procedures. Bacteria were identified by examination of colonial morphology, on appropriate agar media. Samples from MacConkey media were classified as either lactose fermenters or non-lactose fermenters. Gram staining rapid tests (catalase, oxidase, and coagulase) was done to classify the isolates. Various biochemical tests (indole test, methyl red-Voges Proskauer test, citrate utilization and triple sugar iron test, were performed on the isolates to confirm their identities and aid in bacterial species identification as per the protocol by Tolaro (2005). Results of Enterobactericeae were confirmed using API-20E test (Biomeriux, France) (Baron and Finglod, 1996). Confirmation was necessary for future study in antibiotic sensitivity test (Kirby et al., 1966) and detection of Beta lactamase genes from Enterobactericeae. Data analysis was done using SPSS and ANOVA. Scientific approval of the study was obtained from Kenyatta National Hospital Ethics and Review Committee, while ethical clearance to carry out the study was obtained from KNH and KMH hospitals administration. All procedures were carried out in accordance to the standard biosafety guidelines and waste disposal.

RESULTS

Isolation of pathogen strains from hospitals surfaces and hands

Results from this study revealed that a total of 592 sampling were made from various hospital surfaces and hands of health staffs. KNH had the highest number of positive plates which indicated the presence of bacterial with a total of 197 (80.08%), while KMH had 163 (66.26%). There was no statistical significant increase in the prevalence of contamination in private as compared to public hospitals ($p = 0.38$). Out of those 246 samples, majority of positive plates for the presence of bacterial in both hospitals were from site A (waste from hospital main drainage) with 25 (100%) and site I (orthopedic unit) for KNH with 25 (100%) level of positive growth plates. The least was site C (operation theatre) for both hospitals; KNH had only 6 plates with positive growth out of 25 (24%), while KMH had 9/25 (36%) as indicated in Table 1. Among the 360 positive samples, 471 pathogens strains were isolated, comprising of Gram negative bacteria which were more in most departments, (341, 72.3%) than the Gram positive bacteria (130, 27.7%).

Table 1. Distribution of samples taken from different hospital environments and waste in KNH and KMH.

Sample site	Name of Hospital	Total samples N (%)	Samples positive N (%)	Samples average N (%)
A (waste hospital main drainage)	KNH	25 (100)	25 (100)	25 (100)
	KMH	25 (100)	25 (100)	
B (ICU)	KNH	25 (100)	16 (64)	15.5 (62)
	KMH	25 (100)	15 (60)	
C (Operation theatre)	KNH	25 (100)	6 (24)	7.5 (30)
	KMH	25 (100)	9 (36)	
D (Sterilization area)	KNH	25 (100)	20 (80)	15 (60)
	KMH	25 (100)	10 (40)	
E (Pediatrics ward)	KNH	24 (100)	22 (92)	22.5 (90)
	KMH	24 (100)	21 (84)	
F (Gynecology/obstetric)	KNH	24 (100)	16 (67)	17.5 (70)
	KMH	24 (100)	19 (79)	
G (Internal medicine)	KNH	24 (100)	22 (92)	16 (64)
	KMH	24 (100)	10 (42)	
H (General ward)	KNH	24 (100)	23 (96)	18.5 (74)
	KMH	24 (100)	14 (58)	
I (Orthopedic/surgical unit)	KNH	25 (100)	25 (100)	23 (92)
	KMH	25 (100)	21 (84)	
J (Hospital dump	KNH	25 (100)	22 (88)	20.5 (80)
	KMH	25 (100)	19 (76)	
site) Total	KNH	246	197 (80.08)	73.17
	KMH	246	163 (66.26)	

The distribution of strains according to samples origin

The distribution of strains isolated from surfaces and hands of health personnel and their detection rates were reported in figures and it shows that 471 were isolated from surfaces of various locations in different surfaces and personnel hands. Characterization of strains isolated showed clearly a high prevalence of Gram negative bacteria. Results clearly demonstrate the presence of both Gram positive and Gram negative bacteria with the predominance of *Providentia* species (21.01%), *S. aureus* (18.47%), *Escherichia coli* (12.95%), other Gram negatives such as *Roultella ornithylitica, Ochrobactrum anthropic, Pantoea* species (9.55%), *Pseudomonas* species (9.34%), coagulase negative *Staphylococcus* (CONS) (9.12%), *Serratia* species (6.58%), *Klebsiella* species (6.36%), *Proteus* species (4.03%), and *Enterobacter* species (2.54%) as shown in Table 2. Most of the frequently isolated bacterial included *E. coli* in waste water main drainages (A) while *Providentia*, *Pseudomonas*, *Serratia* and *Klebsiella* species were the most abundant in ICU, while *S. aureus* and other coagulase negative Gram positives were abundant in ICU (B), general ward (H). Moreover, the percentage of detection of Gram positive and Gram negative bacteria isolated at different locations is summarized in Figure 1. For both Gram negative and Gram positive bacteria, the main infected surfaces were the door handles and nurses hands surfaces representing the major reservoirs of pathogens. Moreover, Gram negative bacteria were predominant in sinks and waste waters, whereas Gram positive bacteria prevail in samples taken from door handles and nurses hands surface as reported in Table 2.

Pseudomonas species was most abundant in sinks (20.4%) followed by operation table (18.18%) (Table 2). In operation table (26.66%), *Klebsiella pneumoniae* was most abundant followed by door handles (20%). *E. coli* was found mostly in nurses' hands surface (NHS) (22.9%), followed by nurses' staff table (NST) (19.6%). *Proteus vulgaris* was found in stretchers and elevator

Table 2. The occurrence of bacterial isolates according to samples origins.

Sample source	Sample size	*Pseudomonas* spp.	*Klebsiella* spp.	*E. coli*	*Proteus* spp.	*Enterobacter cloaca*	*Providentia* spp.	*Serratia* spp.	Other Gram negatives	*S. aureus*	Other coagulase negative staphs	Total number of bacteria in each location
NHS	38	0	0	14	0	6	5	0	2	19	4	50
NST	37	0	5	12	2	1	7	0	6	12	1	46
DH	38	0	6	10	0	2	14	0	1	15	11	59
TS	38	7	0	0	1	1	11	4	3	11	2	40
OT	37	8	8	8	2	0	8	1	2	6	1	44
Sink	38	9	2	0	3	0	11	5	6	0	0	36
Stretcher	38	0	0	9	5	1	13	1	3	3	2	37
Floor surf	38	7	1	0	1	0	11	3	1	3	1	28
EB	38	4	0	5	5	1	2	0	1	3	17	40
WW	38	6	4	0	4	0	7	7	9	0	0	35
DS	38	2	2	0	0	0	5	7	8	0	2	26
BR	38	0	3	1	1	1	2	2	1	6	1	18
CB	38	0	0	2	0	0	3	1	2	7	1	16
Total	492	44	30	61	19	12	99	31	45	87	43	471

buttons while *Enterobacter cloaca* was abundant in nurses' hands surfaces. Species of *Providentia* were mostly found in door handles at 14.14%, *Serratia* species were most abundant in waste water samples and door surfaces at 22.58% in both cases. Other Gram negative isolates were found in waste water and door surfaces. *S. aureus* was abundantly found in nurses' hands surface in about 21.83%, while other coagulase negative *Staphylococcus* was most abundant in elevator buttons (39.53%) and door handles in 25.58% occurrence (Table 2).

DISCUSSION

In this study, it was clearly demonstrated that the hospital with the most positive plates indicated higher contamination. More contaminated plates were observed in this study from the public hospital, which is slightly more but not significant in the private hospital. This is a reflection of the practices in these establishments and may be attributed to improper or insufficient treatment of the wastes before disposal (Sridhar and Olajumoke, 2003). It can be explained by the fact that majority of people are low income earners in this part of the country and ordinary working citizens who tend to patronize the public hospital because of lesser medical charges as compared to the private hospital where charges are higher (Sridhar and Olajumoke, 2003). Moreover, the public hospital pre-treats their wastes before disposal. Occurrence of bacterial isolates generated from different departments, wards and waste effluent sites at both hospitals is revealed in the study. The department with the highest level of contamination was A (main drainage waste water) in both hospitals (100%) with all the plates indicating positive. The department, with the least contamination was site C (operation room) probably because of the level of efficiency in use of disinfectants and sterilization in the operation room as confirmed by research done by Moges et al. (2014) in Ethiopia, who found the operation room with lesser bacterial contamination as compared to other hospital units.

There were significant differences in the number of bacterial isolates in the orthopedic/surgical departments in both hospitals. Several factors may contribute to this; the difference in quality of the ventilation system, the difference in cleaning procedures and the difference in traffic in these areas as revealed by Moges et al. (2014). It was also noted that about 20% of hospital dump site waste samples in both public and private hospital departments, showed no growth at all. This could probably be due to the nature of the organism or the effect of possible pre-treatment given to wastes as researched by Sridhar and Olajumoke

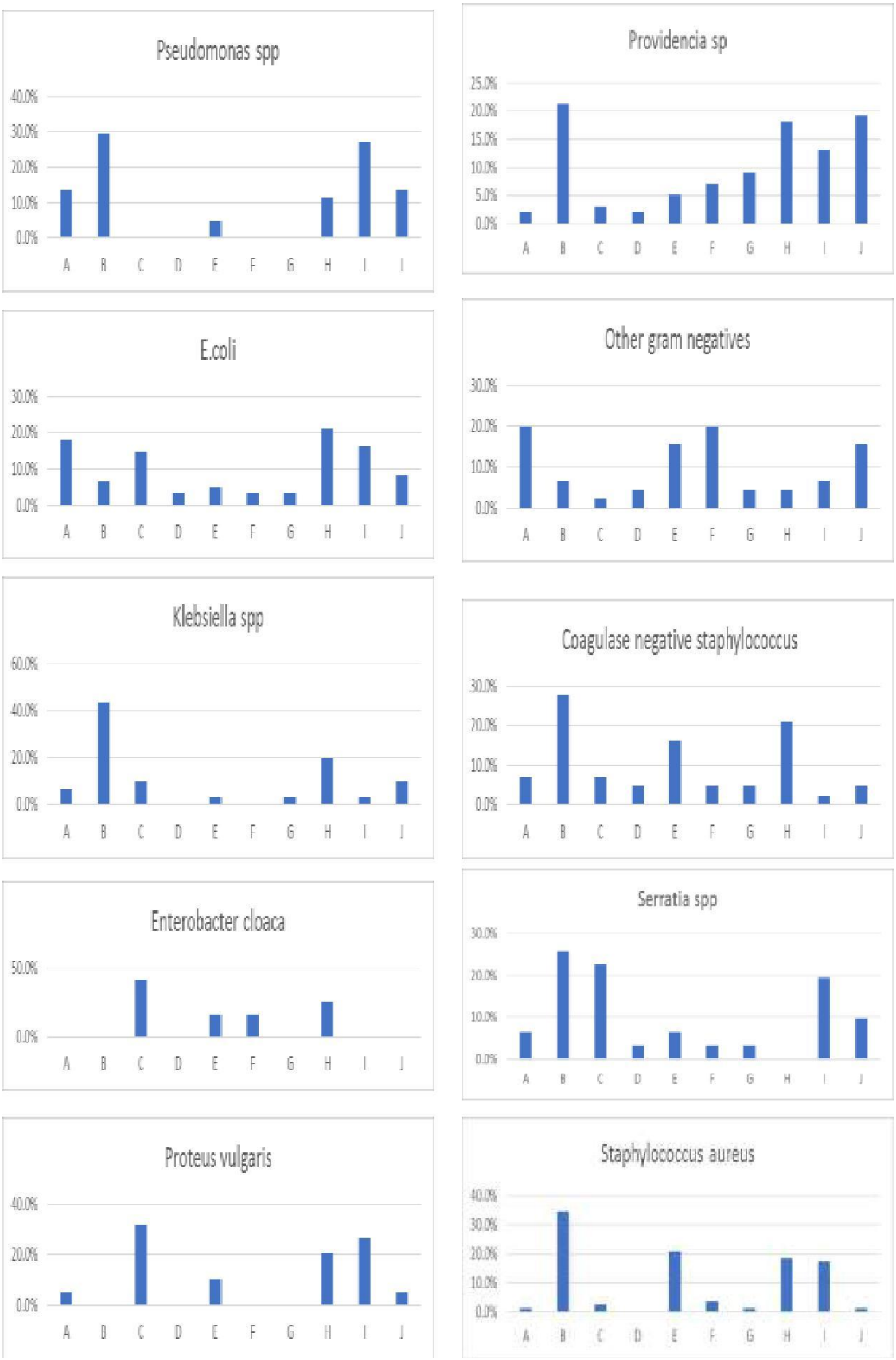

Figure 1. Frequency of each bacterium isolated from each sample point (hospital departments).

(2003).

Many of the bacterial isolates found in the waste samples reported here are also known to cause hospital acquired or nosocomial infections (from the records of Hospital, 2014). It is however believed that hospital surfaces and medical wastes are the least possible source of a hospital-acquired infection. This study confirms this point, but cautions that in the communities, these wastes can be a health risk. There is need to manage them properly and also to train waste generators and handlers on safe work practices during collection, storage and transportation. Both lactose fermenting and non-lactose fermenting bacteria were isolated and identified. From the result, more Gram-negative organisms [especially members of the Enteriobacteriaceae 341 (72.3%)] were isolated than Gram positive organisms 130 (27.7%). This agrees with research done in Markudi, Benue State, Nigeria by Omoni et al., 2015, who revealed that more Gram negatives were present than Gram positive in samples collected from hospital settings. In the study, *Providentia* spp. (21%) and *E. coli* (13%) were among the Gram-negative bacteria while *S. aureus* was amongst the Gram-positive bacteria (18%); among the majority isolated from the samples collected from the current study. The high frequency of pathogenic bacterial in this study may be due to high admission of cases with bacterial infections, which is common in developing countries like Kenya (Hospital records). This study also conforms to the work of Anitha and Jayraaj (2012) who reported *E. coli* a Gram negative bacteria as the predominant organism in hospital wastes and also there was presence of Gram-positive isolates such as *Bacillus subtilis* and *S. aureus* in biomedical wastes collected in a public and private hospital in Coimbatore, India. Characterization of pathogen strains showed the predominance of Gram negative bacteria from surfaces and hands of health professionals. Gram positive pathogens such as staphylococcus strains show much higher transmission rates as compared to Gram negatives. That could be explained by diminished survival time of Gram negatives in the environment (Gastmeier et al., 2006). Infact, Gram negative bacteria other than *Acinetobacter* species (Wendt et al., 1997), survive on dry surfaces for few hours only, while the survival time can be several days for *Staphylococci* (Hirai, 1991).

In this study, the pathogenic bacterial isolated from the medical waste and hospital environment included *Providentia* spp. (21%), *S. aureus* (18.5%), *E. coli* (13%), *Pseudomonas* spp. (9.3%), and other coagulase negative *Staphylococci* (9.13%), *Serratia marcescens* (6.6%), *Klebsiella* spp. (6.4%), *Proteus vulgaris* (4%), and *E. cloaca* (3%) among others. Some of these isolates have been reported by earlier researchers (Yagoub and Agbash, 2010). Similar reports by Ekhaise and Omavwoya (2008) in Benin hospital and Vichal et al. (2011) showed that the bacterial genera, *Klebsiella, Pseudomonas* and *Serratia* were the most frequently distributed isolates in the hospital wastewater. In another study, *Pseudomonas* spp. was found to be the most prevalent by 20.7% (Ashfaq et al., 2013). In the study conducted by Oyeleke and Istifanus (2009), the most predominant pathogens isolated from hospital wastes were *Bacillus* and *S. aureus* (80 to 90%); however, findings by Oyiasogie et al. (2010) showed that *P. aeruginosa* was among the highest Gram negative organism isolated from hospital waste accounting for about 25.00% overall of all the isolates. In a study carried out in Erbil city, Rhizgari by Aziz et al. (2014) revealed that *E. coli* was mostly isolated (100%) from a hospital wastewater. It is widely accepted that these pathogens are the major cause of hospital acquired infections which is in agreement with this study that *E. coli* strains were obtained (13%) from both hospitals being second to *Providentia* spp. A similar observation was made in hospitals in Ethiopia (Yismaw et al., 2010) where it was reported to be among the most frequent isolates. The high occurrence of *Providentia* spp. and *E. coli* isolates in these samples could be attributed to poor hygienic conditions in the hospitals studied and the conditions in other hospitals are not different as the country lacks adequate number of healthcare facilities (Yismaw et al., 2010). These results in overcrowding in the few hospitals available and hence the unhygienic conditions.

In the present study, *Salmonella* and *Shigella* species showed positive growth in the *Salmonella-Shigella* agar but were not positively identified from the surface swabs and wastes collected in hospitals in the confirmatory tests using API-20E. This may probably be due to the nature of the organism; viable but non-cultivable or the effect of possible pre-treatment given to wastes. Dudley et al. (1980) also reported variety of pathogenic bacterial in sewage sludge; however, *Shigella* spp. were not detected in their study due to low sensitivity of enrichment procedure and high temperature which decreased its survival in their study.

Providentia spp. are members of Enterobacteriaceae and uncommon cause of infections, although among the species *Providentia rettgeri* and *Providentia stuartii* are the most common causes of infections, especially urinary tract infections (UTIs) and bacteremia in hospitalized patients or nursing care facilities. A few studies have been published on the subject. In a review done by Kim et al. (2007), *Providentia* spp. incidence was 0.16%; our study confirms that *Providentia* spp. is uncommon and that the incidence rate in this study was higher than that by Kim et al. (2007). *Providentia* spp. are the most frequently isolated from elderly patients or patients with urinary catheters. The reason for the variable incidence of *Providentia* is not apparent, but the types of patients and institution might contribute to such a difference. There were significant number of bacteria especially *Providentia* spp. on the floors of various areas in the operating suite; several factors may contribute to this.

First, the difference in quality of the ventilation system; secondly, the difference in cleaning procedures; thirdly, the difference in traffic in these areas. We consider the major contributing factor to be the difference in cleaning procedures. On the basis of researchers' observations, it is recommendable that, there should be regular use of disinfectant in cleaning the operating room floor after every operation. There are several reports on the use of disinfectant on cleaning the floors. Rutala and Weber (2014) reported a significant reduction in floor bacteria with the use of a germicidal detergent. He also reported that the floors in the inner zones of the operating suite cleaned with disinfectant showed low level of bacterial contamination.

S. aureus strains were the second most frequently isolated bacterium (18.5%) from this study. This finding is similar to Yagoub (2010) report who found that Gram positive bacteria such as *S. aureus* in particular as most pre-dominant bacterium in their study. These results were also observed by Perwaiz et al. (2007) who obtained an isolation rate of *S. aureus* at 13% and the second most frequent pathogen. It has been frequently isolated from nurses/doctors' hands including nurses' staff table. Several studies have reported the importance of frequent and adequate hand washing to reduce rates of hospital acquired infections (Rupp et al., 2008), showing that hands regularly acquire bacterial pathogens responsible of nosocomial infections and can survive on dry surfaces for several weeks (Frost and Sullivan, 2010). Elevator buttons had more coagulase negative *Staphylococcus* spp. (9.3%) than other surfaces; this could be due to the fact that they are touched repeatedly by ungloved hands by multiple individuals who will later go on to contact patients colonized by bacteria that were not pathologic in most case but overall prevalence rate exceeded sink surfaces. Furthermore, if hand hygiene practices are suboptimal, microbial colonization is more easily established and/or direct transmission to patients or a fomite in direct contact with the patient may occur as concluded by Allegranzi and Pittet (2009). It has been reported that organisms are capable of surviving on hands of health care workers for at least several minutes following contamination (Allegranzi and Pittet, 2009); hence, the necessity of a hand washing facility at most points in a health care institution. Thus, risk of infection is high in individuals occupationally exposed to wounds or wound dressing indicating a need to screen individuals in hospitals for risk exposures and infections, to avoid outbreak and cross infections in hospitals for risk exposures and infections as described by Perwaiz et al. (2007) in their research work. *Staphylococcus* strains has been incriminated in various diseases such as post-operative infections, urinary tract infections, skin diseases, respiratory infections and food poisoning (Murray et al., 1995; Buchanan and Gibbons, 1974). The *S. aureus* strains were mostly isolated from hand swab of the nurses from this hospital and were almost the same as compared to the earlier report of Boyce (2007) and Ekrami et al. (2011). The high prevalence of the *S. aureus* from hand swabs and door handles in this work might be as a result of inadequate hand hygiene and this could be one of the attributing factors of the distribution of the pathogen in the hospital environmental surfaces as reported earlier by Olalekan et al. (2011). The low prevalence rate of *S. aureus* on beddings and bed rails in this hospital is not in agreement with 100% prevalence on bedrail as reported by Boyce (2007). Also, 26% of *S. aureus* reported on door handle by Carvalho et al. (2007) is higher to the prevalence rate of the *S. aureus* on door knob/door handle of 17% from these hospitals in the current study. The prevalence rate of 16% of *E. coli* on door knobs/door handles confirms the early report of Nworie et al. (2012) from some parts of Abuja metropolis that the contamination of door knob/door handle can be as a result of poor hand hygiene after using toilet. In addition, results from this investigation, recommends that materials contaminated with patients' secretions, such as saliva, sputum and mucus, should be cleaned with disinfectant or discarded. This is especially true of patients' pillows, which are usually contaminated with secretions from mouth, nose and trachea. In one instance, *S. aureus* was found in a pillow (beddings and bed rails category). Contamination of the operating light in the operation theatre was reported by Husein et al. (2001). Since operating lights are cleaned daily with disinfectant, it was not found holding any contamination. It was found that *S. aureus* and coagulase-negative *Staphylococci* species was the major species contaminating floors and other surfaces in the operating rooms. *Staphylococci* are usually human in origin and point to the restriction of traffic in operating rooms,

Pseudomonas strains were obtained in this study with a prevalence rate of 9.3%. Similar prevalence rate of 9.3% was reported by Srinivas et al. (2015) in Andhra Pradesh, India. In comparison, higher prevalence rate of 32.1 and 20.3% was reported by Rajat et al. (2012), in Gujarat, India, respectively. This varied prevalence of *P. aeruginosa* in different places may be attributed to the type of swab received for examination, type of hospitals and geographical positions. It is widespread in natural environments and it is an opportunistic pathogen for humans lead to a broad spectrum of disease such as urinary, burn, respiratory infections and septicemia. *Pseudomonas* spp. is one of the most common isolated pathogens from hospitalized people and that it thrived on moist surfaces as also confirmed by Nagoba et al. (1997), heightening the risk of infection for patients with catheters or ventilators; from its commonly found wet places it reaches sick patients admitted in hospital and causes a variety of serious infections in hospitalized patients with impaired defenses. It causes serious infections such as bacteremia pneumonia, sepsis, burn wound infections and meningitis. In our studies, the

highest number of *Pseudomonas* spp. was isolated from sinks (20.45%), floors and waste water drainages. The isolation of *Pseudomonas* spp. from the sinks confirms the report of Udeze et al. (2012) that sinks are the most common place in hospital environment where *Pseudomonas* spp. are predominantly found. Sinks are the most common article of contact by the people. It is therefore and not surprising that it also gave very high *P. aeruginosa* isolates since people with wet hands (water or sweat) may easily come into contact with it. The places with least number of isolates were the bedrails, stretchers, nurses staff tables, etc., and these are places that are likely to be dry most of the time in the hospitals. Also, the prevalence rate of *Pseudomonas* spp. on operation table of the hospitals in the current study hospital was still higher (18.18%) than a work reported by Pal et al. (2010) with about 9.6% of the pathogen was isolated from operation table in a hospital in India. The presence of this pathogen on operation table can contaminate open wounds of the patients in course of the operation.

Serratia spp. also isolated in the current study is an opportunistic, Gram negative pathogen which belongs to family Enterobacteriaceae. It was originally considered as non-pathogenic, but it was discovered that ICU are often involved in the epidemics of the colonization and the infection with *Serratia marcescens*. The important reservoirs in epidemics are the digestive and respiratory tracts. The current study of *S. marcescens* was found mostly in ICU with the highest population sinks, door surfaces and waste in ICU and this was confirmed by research done by Mlynarczyk et al. (2007); it accounts for only 1 to 2% of the nosocomial infections and caused by instrumentation (urinary catheterization or placement of the endotracheal tube for ventilation).

Proteus mirabilis was isolated in some of the units in this study with a prevalence rate of 4%. This species is implicated in many clinical conditions. In other studies, it was also isolated in some residential areas not close to any health care facility (Giske et al., 2008), which suggests that it is present in the general environment.

Results from the current study reveals that bacterial isolates found in the hospital surfaces, waste samples and dumpsites reported here are also known to cause hospital acquired or nosocomial infections (from the records of KNH and KMH, 2015). Bacterial pathogens may develop in wastes undergoing decomposition in soils that suffer from environmental pollution as a result of indiscriminate disposal of pollutants. These bacterial pathogens, when increased in population, pose great risk to human health (Onweremadu et al., 2009). Soil-transmitted pathogens play an important role to the emergence of community-acquired infections, contributing to the burden of communicable disease morbidity and mortality. The bacterial pathogens in the soil and wastes are not considered as public health concern (Santamaria and Toranza, 2010). Little information is available on the types of microorganisms associated with and isolated in waste dumpsite soil consequently; comprehensive assessments on pathogenic organisms must be established to build local knowledge about public health issues and trends in hospital infections and waste management. Other Gram negative bacteria species for example, *Pantoea* spp. was also isolated (12 isolates) in this study. Actually, several studies have reported the association of this germ with nosocomial infections (Liberto et al., 2009). The fungi that were morphologically identified in this study were suspected to be *Fusarium* and *Penicillin* spp.; their spores are common in environment and are responsible for allergic infection of human and animals (Thurston and Cysewsk, 1979). It is however believed that hospital wastes are the least possible source of a hospital-acquired infection. This study confirms this point, but cautions that in the communities, these hospital surfaces and wastes can be a health risk. There is need to manage them properly and also to train waste generators and handlers on safe work practices during collection, storage and transportation. In conclusion, there is need to study antimicrobial resistance rate in hospitals and the possible dissemination of resistant bacteria in the inanimate surfaces or the hands of health professionals reinforce the need for knowledge and control of the sources of pathogens in the hospital environment. The evaluation of the environmental role in the acquisition of healthcare associated infections is needed to collaborate with infection control committees. The establishment of a control system is also required in hospitals for the reduction of length of stay, costs and morbid-mortality. Such a surveillance system should continuously report the prevalence of microorganisms and their resistance pattern to hospital wards; this information will be used in defining policies for control of hospital environments, and building awareness especially in Kenyan hospitals where antimicrobial prescription is sometimes inappropriate.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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