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MICROBIAL CONTAMINATION IN THE SELECTED OPERATING THEATRES AT KENYATTA NATIONAL HOSPITAL IN KENYA
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# MICROBIAL CONTAMINATION IN THE SELECTED OPERATING THEATRES AT KENYATTA NATIONAL HOSPITAL IN KENYA

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## ABSTRACT

*Background*: **Surveillance of operating theatres is essential to characterize and aid control and prevention of nosocomial infections spread to surgical patients due to pathogenic bacteria and fungi.**

*Aim*: **To characterize pathogenic bacteria and fungi in different operating theatres at Kenyatta National Hospital.**

*Methods*: **A total of 1,372 samples from 12 operating theatres were collected from December 2017 to February 2018. Surface samples were collected using sterile wet swabs from different equipment while exposed agar plates obtained aerial samples. One thousand two hundred (1,200) study samples and 172 study controls were processed. Colony-forming unit per cubic metre and settle plate methods enumerated and characterized bacterial and fungal isolates.**

*Findings*: **Coagulase-Negative *Staphylococci* 86(44.5%) and *Staphylococci aureus* 44(22.8%) predominated swab samples; air contaminant in agar plates was dominated by *Staphylococcus epidermidis* 185(73%) and *coliforms* (21%); *Aspergillus spp* 81(71.64%) was the major fungal isolate with *Aspergillus fumigatus* alone constituting 36 (31.9%).**

*Conclusion*: **The aforementioned microbial isolates contaminate and colonize the operating theatres. This may initiate infection to surgical patients. Thus, it is necessary to maintain and frequently monitor operating theatres to minimize growth and proliferation of pathogenic bacteria and fungi.**

## INTRODUCTION

There has been a rise in the volume of surgeries performed worldwide as a medical intervention. According to Rose *et al.*, the global population of about 6.9 billion in 2010 needed at least 321.5 million surgical procedures (1). Similarly, according to data derived from 56 countries in 2004, about 187 to 281 million surgery operations were conducted, translating to one operation for every 25 human beings alive (2). This large volume of surgeries performed globally has implications to public health concern, as the annual volume of childbirths is merely half of the surgery operations conducted internationally (3). This demands high quality surgical care by the theatre personnel in the operating room to ensure survival and wellbeing of patients undergoing surgery (4). Surgical procedures as part of medical treatment are supposed to be conducted in a clean operating theatre and uncontaminated environment, since bacterial and fungal contamination of the environment increases the prevalence of nosocomial infections, contributing to surgery complications (5,6). The operating theatre environment plays an important role in the causation of postoperative infections, constituting a third of all nosocomial infections which can be minimized through preventive measures practised by theatre personnel and other infection control units (7–9).

A survey conducted in 14 countries by WHO attributed 8.7% prevalence of nosocomial infections to the hospitalization of patients in 55 hospitals (10). The nosocomial infections prolong hospital stay of affected patients, drain healthcare resources and may lead to loss of lives (1,11).

A number of bacterial and fungal species are associated with nosocomial infections, often with devastating effects to surgical patients. For instance, more than 1.4 million people worldwide have developed nosocomial bacterial infection complications due to resistant strains of the so-called 'superbugs.' Methicillin-resistant *Staphylococcus aureus* (MRSA) is one of the superbugs and is a strain of bacterium which does not respond to methicillin drugs (semi-synthetic penicillin) and other antibiotics like oxacillin and flucloxacillin among others (12). Likewise, dissemination of *Candida spp,* in particular to immunocompromised patients is quite disturbing, as some *Candida spp* are resistant to conventional antifungal drugs, raising possibilities of losing lives of patients while undergoing treatment (13,14).

The colonization of theatre personnel as well as patients and visitors in the healthcare facilities with MRSA and *Candida spp* facilitates transmission of these infections (12,15). In addition, *Aspergillus spp* spores in poorly aerated healthcare facilities may serve as a source of nosocomial infection to surgical patients (16). MRSA and *Candida spp* can be harboured in the mucosal membranes of the throat, nostrils, and even on the skin in these asymptomatic carriers. From the asymptomatic persons, MRSA enters the susceptible patients through the damaged or diseased skin, which may lead to dermatitis, eczema or chronic wounds; inadvertent spread of *Candida spp* from unprotected carriers to susceptible patients may result in candidiasis manifesting in different forms such as oral thrush. Likewise, the route entry for *Aspergillus* spores is mainly inhalation, resulting in nasopharyngeal colonization, ensuing pulmonary infection to the susceptible patients. The unclean theatre environment, its surfaces or shared patient equipment and other items are also reservoirs for the aforementioned nosocomial infection (15–17).

Notwithstanding efforts by public health and infection control units, nosocomial

infections have persisted to arise in hospitalized patients. Lowered immunity in hospitalized patients is a factor contributing to persistent nosocomial infections. Medical procedures and invasive techniques during surgical procedures create potential routes for pathogenic invasion; hence, the transmission of drug-resistant pathogens among patients (10). Modern surgical procedures and therapeutic interventions are also sources of nosocomial fungal and bacterial infections (18).

Reducing the burden of nosocomial infections is a necessity, and the operating theatres are at the centre of such efforts, since surgical procedures, with both environmental impact and equipment like anaesthetic apparatus, operating devices or instruments, theatre personnel among others occurring there may be a source of sepsis to patients (7). Infection Control Units and other mandated departments in hospital facilities, both in developing and developed countries ought to continue playing an essential role to avert mortalities caused by nosocomial infections. Use of preventive measures and treatments designed to lower infection in healthcare facilities and theatres ought to be prioritised in reducing such infections (17).

Taken together, infection control and surveillance are supposed to be conducted periodically to assess the general status of theatres, necessary for infection prevention. The meticulous effort by use of infection control measures in theatres is essential to minimize postoperative sepsis. This is particularly useful in developing countries where general health care systems are quite low. To this end, the study endeavoured to characterize the major bacterial and fungal isolates in some of the operating theatres at Kenyatta National Hospital. This was expected to establish the functionality of the infection control measures deployed at this healthcare facility-largest referral hospital in East and Central Africa.

## MATERIALS AND METHODS

*Study Setting Area*

The study was performed at Kenyatta National Hospital (KNH), situated at Upper Hill area of Nairobi, the capital city of Kenya. The hospital has a 2000 bed capacity and receives patients from all the 47 Kenyan county referrals and their associated county hospitals and patient referrals from East and Central African countries.

*Study population*

KNH has 12 operating theatres, one receiving area, and one recovery ward. Each of the 12 theatres has one operating bed, one scrubbing area, one anaesthetic room, 6 sterile instruments setting areas as each is shared by two theatres and two sterile instruments stores serving all theatres with three sluice rooms each serving 4 theatres.

*Study design and sample collection*

This was a hospital-based cross-sectional study where 1200 study samples and 172 internal study controls were collected twice per month between December 2017 and February 2018. This was to ensure adequate coverage of at least all the operating theatres. The study samples and internal study controls in each specified area were collected early in the morning when all areas had been cleaned adequately ready for the daily operating procedures. The study samples and internal study controls were obtained in the following designated theatres: Emergency theatre 1, Reproductive health theatre 2, Urology theatre 3 and 6, Orthopaedic theatre 4 and 5,Specialized theatre 7, Ear, Nose and Throat theatre 8, Neurology theatre 9, Amenity theatre 10, Cardiothoracic theatre 11 and Paediatric theatre 12.

*Swab method*

A swab soaked in the sterile nutrient broth was used to collect samples from the 12 selected operating theatres, anaesthetic machines, recovery room patient monitors, operation tables, suction bottles and

receivers used for operating room procedures. These were retrieved from operating beds, anaesthetic machines, suction bottles, and post-anaesthetic care unit patient monitors. All the samples were properly labelled and immediately transported in a sterile manner to the Department of Medical Microbiology, University of Nairobi, where standard bacterial and fungal identification and characterization was done.

*Settle plate method*

Sterile agar plates facilitated the collection of airborne microbial organisms. This was done by exposing the agar plates to air freely circulating in the 12 designated operating theatres. The agar plates were placed in specific areas (sterile setting area, sterile theatre stores, scrubbing areas, operating theatres, receiving areas, post-anaesthetic care unit, and anaesthetic room and sluice rooms), and exposed for 30 minutes to maximize exposure time thereby allowing the collection of air sediment biological particles. After this exposure, the agar plates were taken back using a sterile technique, covered and ferried to the Department of Medical Microbiology, University of Nairobi for standard microbiological laboratory processing.

*Internal quality controls*

The quality of exposure agar plates was assessed by including closed sterile agar plates which were not exposed and incubated alongside sampling agar plates for exposures from the 12 operating theatres. Sterile swabs were used and also soaked in sterile normal saline. Positive controls included known bacterial cultures of: *Staphylococcus aureus* (ATCC29213/ATCC25922), *E.coli* (ATCC25922), and *Pseudomonas aeruginosa* (ATCC25923), obtained from the Department of Medical Microbiology, University of Nairobi, where bacterial and fungal growth and identification was conducted.

*Standard Bacterial and Fungal Laboratory processing*

Internal study controls and study samples isolated from different theatre environment and equipment surfaces were streaked on blood agar plates and Mac-Conkey agar for bacterial growth, and Sabouraund Dextrose Agar for fungal growth. These culture plates were incubated under aerobic conditions for 48 hours at $37^0$C for bacteria and at $25^o$C for 5 days for fungi. After incubation, the colonies were counted, and identification of isolates done based on their macroscopic colonial morphological characteristics and biochemical tests. Microbial growth count was expressed in terms of colony-forming unit per cubic metre (cfu/ $m^3$), calculated by the aid of the following formula: $cfu/m^3 = a \times 1000\ p \times t \times 0.2$; where a = number of colonies on settle plate, p = surface measurement of plate used, t = time of exposure of settle plate.

*Data management and analysis*

Data was entered, edited, and analysed by Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA, USA). Descriptive statistics incorporated sample collection sites and the different samples collected.

## RESULTS

**Table 1**

*Microbial isolates Swabbed during the study period*

| **Microbial Isolates** | **Week 1** | **Week 2** | **Week 3** | **Week 4** | **Week 5** | **Week 6** |
|---|---|---|---|---|---|---|
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| No growth | 16(31.4) | 22(43.1) | 21(41.2) | 16(31.4) | 16(31.4) | 22(43.1) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Coagulase-negative *staphylococci* | 15(29.4) | 14(27.5) | 20(39.2) | 9(17.6) | 11(21.6) | 11(21.6) |
| *Staphylococcus aureas* | 5(9.8) | 5(9.8) | 3(5.9) | 6(11.8) | 11(21.6) | 7(13.7) |
| *Micrococcus spp* | - | 2(3.9) | - | 7(13.7) | 2(3.9) | 1(2.0) |
| *Klebsiella spp* | 3(5.9) | 2(3.9) | 1(2.0) | - | 1(2.0) | - |
| *Pseudomonas spp* | 2(3.9) | - | 1(2.0) | 1(2.0) | 3(5.9) | - |
| *Candida spp* | 1(2.0) | - | - | - | 1(2.0) | 1(2.0) |
| *Bacillus spp* | 2(3.9) | 1(2.0) | - | - | 1(2.0) | - |
| *E. feacalis* | - | 1(2.0) | - | - | 2(3.9) | - |
| *E. coli* | - | - | 1(2.0) | - | - | - |
| *Granulicatella elegans* | - | - | - | 1(2.0) | - | - |
| Coagulase-negative *staphylococci* and *Staphylococcus aureas* | 4(7.8) | 2(3.9) | 3(5.9) | 4(7.8) | 2(3.9) | 5(9.8) |
| Coagulase-negative *staphylococci* and *Micrococcus spp* | - | - | - | 2(3.9) | - | - |
| Coagulase-negative *staphylococci* and *Klebsiella spp* | - | 1(2.0) | 1(2.0) | - | - | - |
| Coagulase-negative *staphylococci* and *Candida spp* | 1(2.0) | - | - | - | - | - |
| Coagulase-negative *staphylococci* and *Bacillus spp* | 1(2.0) | - | - | - | - | - |
| Coagulase-negative *staphylococci* and *E. feacalis* | - | - | - | - | - | 1(2.0) |
| *Staphylococcus aureas* and *Micrococcus spp* | - | - | - | 2(3.9) | 1(2.0) | - |
| *Staphylococcus aureas* and *Klebsiella spp* | - | - | - | - | - | 1(2.0) |
| *Staphylococcus aureas* and *Pseudomonas spp* | - | - | - | 1(2.0) | - | - |
| *Staphylococcus aureas* and *E. feacalis* | - | - | - | - | - | 1(2.0) |
| *Staphylococcus aureas* and *E. coli* | - | - | - | 1(2.0) | - | - |
| *Pseudomonas spp* and *Candida spp* | - | - | - | 1(2.0) | - | - |
| *Candida spp* and *Bacillus spp* | 1(2.0) | - | - | - | - | - |
| *E. feacalis* and *E. coli* | - | 1(2.0) | - | - | - | - |
| *Staphylococcus aureas, Klebsiella spp* and *E. feacalis* | - | - | - | - | - | 1(2.0) |

Only *Candida spp* was isolated singly or part of other swabbed bacterial isolates.

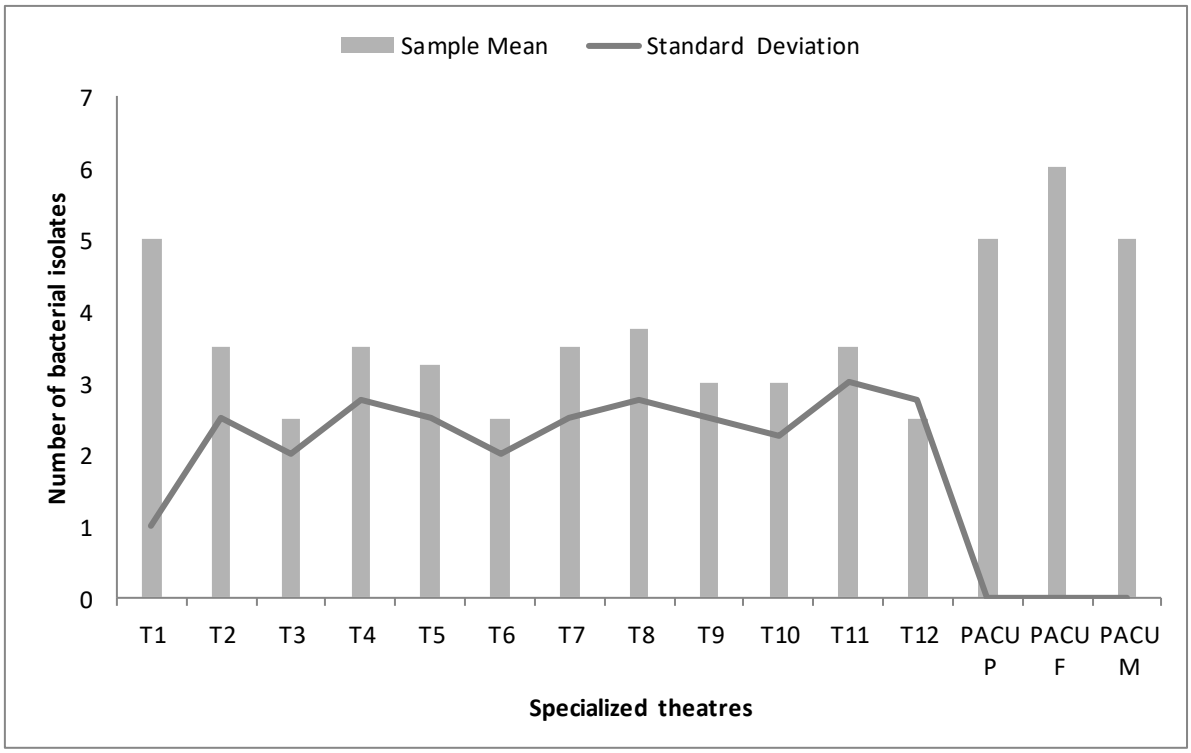


***Figure 1: Bacterial growth pattern in different theatres within the entire study period***

*KEY:T1-Theatre 1 (Emergency);T2-Theatre 2 (RH);T3-Theatre 3 (Urology);T4-Theatre 4 (Orthopaedics);T5-Theatre 5 (Orthopaedics);T6-Theatre 6 (Urology);T7-Theatre 7 (Specialized);T8-Theatre 8 (Ear, Nose and Throat);T9-Theatre 9 (Neurology) T10-Theatre 10 (Amenity);T11- Theatre 11 (Cardiology) ;T12-Theatre 12 (Paediatric);PACU P-Post anaesthetic care unit for paediatrics; PACU F-Post anaesthetic care unit for female; PACU M-Post anaesthetic care unit for male*

There was no significant difference in mean growth between different specialized theatres.

**Table 2**

*Agar Plate Bacterial isolates analysis in the three months study period*

| | Microbial Isolate | Up to 5 cfu/$m^3$ | 6-15 cfu/$m^3$ | Above 15 cfu/$m^3$ | Total |
|---|---|---|---|---|---|
| 1St Week | *Staphylococcus albus* | 41 | 8 | - | 49 |
| | Environmental *Bacilli* | 1 | - | - | 1 |
| | Coli-form | 7 | - | - | 7 |
| | No Growth | 19 | - | - | 19 |
| 2nd Week | *Staphylococcus albus* | 30 | 3 | - | 33 |
| | Environmental *Bacilli* | - | - | - | - |
| | Coli-form | 5 | - | 1 | 5 |
| | No Growth | 31 | - | - | 31 |
| 3rd Week | *Staphylococcus albus* | 13 | 28 | 1 | 42 |
| | Environmental *Bacilli* | - | - | - | - |
| | Coli-form | 7 | - | - | 7 |
| | No Growth | 19 | - | - | 19 |
| | *pseudomonas aeruginosa* | - | 1 | - | 1 |
| 4th Week | *Staphylococcus albus* | 37 | 7 | - | 44 |
| | Environmental *Bacilli* | 4 | - | - | 4 |
| | Coli-form | 15 | - | - | 15 |
| | No Growth | 26 | - | - | 26 |
| | *pseudomonas aeruginosa* | - | - | - | - |
| 5th Week | *Staphylococcus albus* | 16 | 1 | - | 17 |
| | Environmental *Bacilli* | 3 | - | - | 3 |
| | Coli-form | 4 | - | - | 4 |
| | No Growth | 42 | - | - | 42 |
| | *Pseudomonas aeruginosa* | - | - | - | - |
| 6th Week | Environmental *Bacilli* | 5 | - | - | 5 |
| | Coli-form | 15 | 1 | - | 16 |
| | No Growth | 46 | - | - | 46 |
| | *Pseudomonas aeruginosa* | - | - | - | - |
| | *Staphylococcus albus* | 1 | - | - | 1 |
| | Fungi | 2 | - | - | 2 |
| Total | | | | | 439 |

*Key: CFU-Colony forming unit; $M^3$-cubic metres;-means nil*

**Table 3**

*Agar plate Bacterial isolate levels in KNH Theatres during study period*

| | Colony-Forming Units | | Settle rate | |
|---|---|---|---|---|
| | Up to 5 Cfu's | Above 5 Cfu's | Up to 0.5 | Above 0.5 |
| Study Area | N (%) | N (%) | N (%) | N (%) |
| PACU, Stores and Receiving area | 7(53.8) | 6(46.2) | 13(100.0) | - |
| Theatre 1 | 12(54.5) | 10(45.5) | 20(100.0) | - |
| Theatre 2 | 19(65.5) | 10(34.5) | 28(100.0) | - |
| Theatre 3 | 11(73.3) | 4(26.7) | 13(100.0) | - |
| Theatre 4 | 9(90.0) | 1(10.0) | 9(100.0) | - |
| Theatre 5 | 8(100.0) | - | 8(100.0) | - |
| Theatre 6 | 11(73.3) | 4(26.7) | 13(100.0) | - |
| Theatre 7 | 10(66.7) | 5(33.3) | 15(100.0) | - |
| Theatre 8 | 9(64.3) | 5(35.7) | 12(92.3) | 1(7.7) |
| Theatre 9 | 13(76.5) | 4(23.5) | 15(93.8) | 1(6.3) |
| Theatre 10 | 11(100.0) | - | 10(100.0) | - |
| Theatre 11 | 10(90.9) | 1(9.1) | 10(100.0) | - |
| Theatre 12 | 13(81.3) | 3(18.8) | 15(93.8) | 1(6.3) |
| Setting area 1 and 8 | 3(75.0) | 1(25.0) | 4(100.0) | - |
| Sluice room 1 and 2 | 3(75.0) | 1(25.0) | 4(100.0) | - |
| Setting area 2 and 7 | 2(50.0) | 2(50.0) | 4(100.0) | - |
| Sluice room 3 and 4 | 6(85.7) | 1(14.3) | 7(100.0) | - |
| Setting area 3 and 6 | 5(71.4) | 2(28.6) | 7(100.0) | - |
| Setting area 4 and 5 | 1(100.0) | - | 1(100.0) | - |
| Sluice 5 and 6 | 5(100.0) | - | 5(100.0) | - |
| Sluice room 7 and 8 | 5(71.4) | 2(28.6) | 7(100.0) | - |
| Sluice room 9 and 10 | 2(40.0) | 3(60.0) | 5(100.0) | - |
| Setting area 9 and 12 | 5(83.3) | 1(16.7) | 6(100.0) | - |
| Setting area 10 and 11 | 2(100.0) | - | 1(100.0) | - |
| Sluice room 11 and 12 | 4(50.0) | 4(50.0) | 7(100.0) | - |

*Key: PACU-Post Anaesthetic care unit; CFC-Colony forming unit;-means nil*

**Table 4**

*Fungal isolates during three months period*

| **Isolated fungal species** | **Week 1** | **Week 2** | **Week 3** | **Week 4** | **Week 5** | **Week 6** |
|---|---|---|---|---|---|---|
| *Acremonium spp* | - | - | 2 | 2 | 2 | 1 |
| *Aspergillus fumigatus* | 15 | - | - | - | - | - |
| *Aspergillus niger* | 1 | - | - | - | - | - |
| *Aspergillus spp* | 2 | - | 14 | 15 | 2 | 12 |
| *Aspergillus spp* and *candida spp* | - | - | 1 | - | - | - |
| *Aspergillus terreus* | 4 | - | - | - | - | - |
| *Candida spp* and *Aspergillus spp* | - | - | - | - | - | 1 |
| *Penicillin spp* and *Fusarium spp* | - | - | 1 | - | 6 | - |
| Yeast | - | - | - | - | 1 | - |

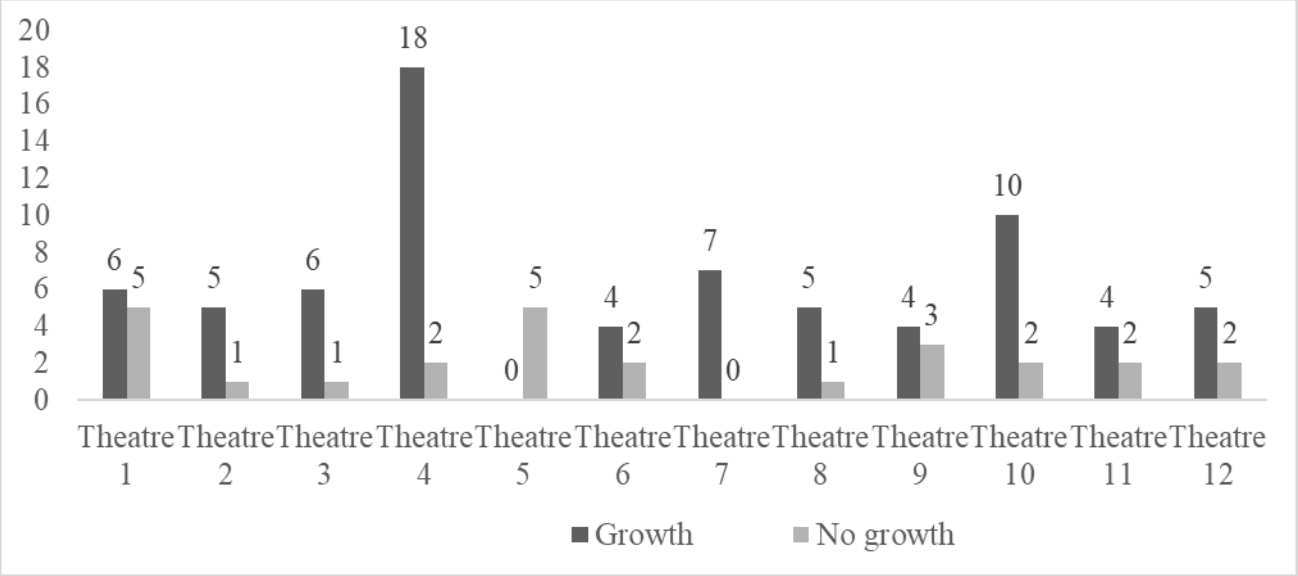


***Figure 2: Fungal growth pattern across different operating theatres***

## DISCUSSION

This study observed Coagulase-negative *staphylococci* (44.5%), *staphylococci aureus* (22.8%), and *Granulicatella elegans (*bacterial species) in the selected operating theatres at Kenyatta National Hospital. Gelaw *et al.* also isolated coagulase-negative *staphylococci* (68.3%) and *staphylococci aureus* (30.7%) from the hospital environment, patients and staff at the University of Gondar Hospital, Northwest Ethiopia. Contamination and colonization of the theatre environment by the aforementioned bacterial species may contribute to nosocomial infections (19). Similarly, a Nigerian study observed higher levels of coagulase-negative *Staphylococci* (28.3%) compared to *staphylococci aureus* (0.83%) in surgical wards in Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria. Conversely, the level of *Pseudomonas aeruginosa* (23.3%) by the Nigerian study was slightly higher compared to the level of *Pseudomonas aeruginosa* (4.1 %.) observed by this study (20). Moreover, A. Mishra *et al.* observed *coliforms* in delivery theatres, attributing it to the normal flora in the gut which may contaminate the theatres during delivery (11). Furthermore, J.lapins *et al.* linked coagulase-negative *staphylococci* to skin lesions, as it was identified in suppurativa lesions of study participants. The levels of the aforementioned bacterial species contaminate and colonize the theatre environment, contributing to nosocomial infections (21). In addition, J. P. Casalta *et al.* characterised *Granulicatella elegans* using broad-range PCR primers, linking it with infectious endocarditis (22).

This study also isolated *Aspergillus spp* (39.8%), with *Aspergillus fumigatus* alone constituting (31.9%) of the *Aspergillus* species isolated. *Candida spp* (<1%) was the least observed fungal isolate. The mixed growths of *Penicilium spp* (9.7%) were also identified. Similarly, A. Gniadek *et al.* observed predominant presence of *Aspergillus* species among other pathogenic fungi in hospital operating theatre environment in one of the hospitals at Kraków in Poland. The study implied negligence to decontamination processes by the hospital due to the significant increase of *Aspergillus* species (23). Moreover, E.O.Akinkunmi *et al.* observed *Candida spp*

in the surgical wards in Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria among bacterial isolates (20). Oliver et al. observed *Penicilium spp* and *Aspergillus spp*, and demonstrated that the effectiveness of air-handling systems in the hospital environments dramatically reduced presence of the aforementioned fungal species (24).

The studied microbial isolates in the selected operating theatres had mean settle rate of < 0.5. The colony-forming units were less than 5cfu/$m^3$ in all the operating areas where bacterial and fungal isolates were collected, and less than 30% between 6cfu/$m^3$ and 15cfu/$m^3$, which was within acceptable clean operating theatres as set by Dancer (25).

Microbial levels within the operating theatre may differ over time depending on the contaminants. Therefore, what was captured over the 3 month study period may be limited in the representation of the entire period of theatre status. Moreover, this study only concentrated in the main operating theatres at Kenyatta National Hospital excluding peripheral operating theatres which may have different microbial distribution.

## CONCLUSION

This study observed bacterial and fungal isolates levels less than 10cfu/$m^3$ and settle rates were also less than 0.5, which were within internationally acceptable levels. This implies infectious control measures deployed by Kenyatta National Hospital are functional and need to be maintained. However, the presence of pathogenic *Staphylococci spp* and *Aspergillus spp* evidenced by this study necessitates more effective cleaning and disinfection of equipment and floors to minimize the spread of the aforementioned pathogenic microbes to susceptible surgical patients. Furthermore, regular surveillance of microbial loads on equipment and theatre personnel in the operating theatres at Kenyatta National Hospital is necessary to aid the monitoring and institute control measures to avert any spread of aforementioned pathogenic microbes to susceptible surgical patients.

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