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The bacterial profile and antibiotic sensitivity of the isolated pathogens from medical equipment and surfaces in the children's emergency room of a Nigerian hospital

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Abstract

Objective: Nosocomial infections are those acquired in hospitals or healthcare service units that first appear 48 hours or more after admission or within 30 days after discharge following in-patient care. Knowledge of the bacterial profile and sensitivity patterns of any hospital environment is a key factor in infection control and good antibiotic stewardship.

Material and Methods: This hospital-based cross-sectional study was conducted in the Children's Emergency Room (CHER) of Enugu State University Teaching Hospital, Enugu, Nigeria. Samples for culture were collected from equipment and hospital surfaces. Antimicrobial susceptibility testing was determined for each isolate by the Agar diffusion method using Standard Nutrient Agar 1 discs.

Results: Bacterial growth was observed in 83 (70.3%) specimens. *Staphylococcus aureus* (53.4%) was the most common isolate cultured followed by Coagulase-negative *Staphylococcus* (18.8%), then *Escherichia coli* (13.9%). Among *Staphylococcus aureus* isolates, 25.9% were MRSA. Ampicillin resistance of the gram negatives was high. All the Gram-negative isolates were susceptible to Ciprofloxacin and Ceftriaxone.

Conclusion: *Staphylococcus aureus*, Coagulase-negative *Staphylococcus*, and *Escherichia coli* were the commonest isolates. More efforts are needed to ensure improved hygiene standards in order to reduce the burden of nosocomial infections.

Keywords: Bacterial profile, sensitivity patterns, surfaces, Nigeria

Introduction

The hospital environment is a significant reservoir of pathogens for transmission to patients in different ways including contaminated surfaces. This is more so in emergency rooms because of the high influx of patients, patients' relations and health care providers. They may harbor potential pathogens and contaminate surfaces, or equipment they come in contact with. Contaminated surfaces have been reported to increase the prevalence of nosocomial infections especially at both extremes of life (1). Nosocomial infections, otherwise known as hospital-acquired infections (HAI) are those infections acquired in hospitals or healthcare service units, that first appear 48 hours or more after hospital admission or within 30 days after discharge following in patient care (2). Many surfaces and equipment in the hospital environment may not be adequately decontaminated and can become reservoirs of pathogens.

It has been reported that commonly used disinfection techniques are sometimes incapable of eradicating fomites reservoirs of nosocomial pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) (3). This is a major public health concern because antimicrobial resistant organisms are increasingly responsible for higher morbidity and mortality rates from nosocomial infections (2-4). There is increasing evidence that contaminated inanimate surfaces especially those frequently touched by hand, can contribute to the spread of healthcare associated pathogens (5-7). Every year approximately two million patients in the United States acquire nosocomial infections, and at least 90,000 of them die (8-10). There is poor documentation about the prevalence of hospital acquired infections in developing countries; however, published data show that the burden of HAI is greater in Africa than in developed countries (6,11). There is also paucity of data on the

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bacterial profile of frequently used medical equipment and surfaces in hospitals especially in the context of developing countries; only nine studies have been carried out at in over 50 teaching hospitals in Nigeria (1,5,12-18).

Knowledge of the bacterial profile and sensitivity patterns of any hospital environment is a key factor in infection control and good antibiotic stewardship. De-escalation to pathogen-directed therapy is one of the "4 D's of optimal antimicrobial therapy." It is based on the clinical response, culture and susceptibility results as well as local resistance patterns in order to avoid the emergence of bacterial resistance (19). In addition, the spread of pathogenic strains can also be controlled by appropriate hospital hygiene measures (20). Thus this study aimed to determine the profile of nosocomial bacteria isolated from medical equipment and surfaces in the children's emergency room of Enugu State University Teaching Hospital and their sensitivity patterns in order to fight against healthcare-associated infections.

Materials and Methods

This hospital-based cross sectional study was conducted in the Children's Emergency Room (CHER) of Enugu State University Teaching Hospital, Enugu, Nigeria (ESUTH) between April and May 2019. It is the Enugu State owned Teaching Hospital, located at the center of Enugu, the capital city of Enugu State. It is a major referral center for the state and other border states. The Children's Emergency Room is a 14-bedded ward, and it attends to an average of 70 patients every week. Ethical approval for the study was obtained from Research and Ethics Committee of the ESUTH, Enugu before the commencement of the study (ESUTHP/C-MAC/RA/034/104; 11th April 2019). Information about cleaning of hospital surfaces was obtained from the cleaning staff of the emergency room.

Data collection and laboratory methods: The sample size was 118 taking into account the number of Bed surfaces (7 side bed-rails and 4 foot bed-rails), Electrical appliances (11 fan switches, 8 light switches, 1 X-Ray viewing box switch, 3 suction machine plug-ins, 2 oxygen concentrator plug-ins, 2 nebulizer plug-ins, 1 electric kettle plug-in, 1 X-Ray viewing box plug-in, 1 drugs refrigerator handle), Furniture surfaces(6 desks surfaces, 10 chairs arm-rests, 3 table drawer handles, 7 bedside tables), Door knobs(14),Wall/floor surfaces (n=25) (8 wall surfaces, 5 floor surfaces, 4 curtain poles, 8 pillars), and Portable medical apps n=12 (4 drip stands, 3 "veronica" bucket taps, 1 bassinet scale, 1 food trolley, 2 ward stethoscope, 1 ward mercury in-glass thermometer) in the ward. See table 1.

Table 1: Swabbed surfaces

Surface	Number
Bed surfaces	11
Electrical appliances	30
Furniture surfaces	28
Door knobs	14
Portable medical appliances	12
Wall/ floor surface	25

Samples were collected from the surfaces using sterile cotton swabs moistened with normal saline (0.9% w/v). Collection commenced in the morning, two hours after routine cleaning. The samples were sent to Spectrum Diagnostic and Research Laboratories (Proficiency testing by European Society for External Quality Assessment (ESfEQA) and inoculated into Cystine–lactose–electrolyte-deficient agar (CLED), Salmonella Shigella Agar and blood agar plates. The inoculated agar plates were incubated at 37^{o}C for 24 – 48hrs for primary bacterial isolation. Distinct bacteria strains were selected on the basis of colony, morphology, gram staining, lactose fermentation, coagulase and or catalase test. Full identification of the bacteria was done by conventional biochemical tests depending on the organism isolated. Antimicrobial susceptibility testing was determined for each isolate by the Agar diffusion method using Standard Nutrient Agar 1 discs containing the following antibiotics: Cefoxitin (30µg), Ciprofloxacin (5µg), Erythromycin (5µg), Gentamicin (10µg), Amoxicillin-Clavulanate (30µg), Ampicillin (10µg), Nitrofurantoin (300µg), Levofloxacin (5µg), Ceftriaxone (30µg), Ceftazidime (30µg), Cefuroxime(30µg), Ofloxacin (5µg), Ofloxacin+Ornidazole (10µg), Cefixime+Clavulanate (30µg), Cloxacillin (5µg). Methicillin resistant *Staphylococcus aureus* (MRSA) was detected by Cefoxitin disc using diffusion method; the Cefoxitin disc was produced by Oxoid Ltd. Company, UK.

Data Analysis and Interpretation: The data obtained were analysed using SPSS version 20.0 (Chicago IL). Frequency distribution statistical analysis was used to compute the results. Results were presented in prose, tables and charts.

Results

Out of 118 samples collected from various sites, bacterial growth was observed in 83 (70.3%) specimens while the remaining 35(29.7%) did not show bacterial growth. A total of 101 bacterial isolates were cultured from the 83 sites. Mixed bacterial flora were isolated from various sites. There were 72.2% gram positive bacteria and 27.8% gram negative bacteria. *Staphylococcus aureus* was the most common isolate cultured from 54 different sites. Details of specimen and bacterial isolates are depicted in Table 2. Majority of Staphylococcus aureus isolates were from furniture surfaces 27.8% (15/54), followed by walls/floor surfaces 24.1% (13/54), bed surfaces 14.8% (8/54), electrical appliances 14.8% (8/54), door knobs 9.3% (5/54) and portable medical appliances 9.3% (5/54). Among *Staphylococcus aureus* isolates, 25.9% (14/54) were MRSA and remaining were methicillin-susceptible *Staphylococcus aureus* (MSSA). The antimicrobial resistance pattern of Staphylococcus aureus isolates is shown in Table 3. All the isolates of *Staphylococcus aureus* were susceptible to Levofloxacin and Cefixime+Clavulanate. Among Gram negative bacteria, Escherichia coli, *Klebsiella* species and *Proteus* species were isolated. All the Gram negative isolates were susceptible Ciprofloxacin and Ceftriaxone. The antimicrobial resistance pattern of Gram negative isolates is depicted in Table 4. Figure 1 shows the overall distribution of the bacterial isolates.

Table 2: Swabbed Surfaces and their bacterial isolates

Swabbed Surfaces		*S. Aureus* (n=54)	*E. Coli* (n=14)	*Klebsiella* S. (n=13)	*CoNS** (n=19)	*Proteus* S. (n=1)	Total
Bed surfaces	11	8 (14.8%)	1 (7.1%)	1 (7.7%)	1 (5.3%)	-	11(100%)
Electrical apps	30	8 (14.8%)	2 (14.3%)	7 (53.8%)	7 (36.8%)	1 (100%)	25 (83.3%)
Furniture	26	15 (27.8%)	5 (35.7%)	3 (23.1%)	5 (26.3%)	-	28 (107.7)
Door knobs	14	5(9.3%)	2 (14.3%)	1 (7.7%)	-	-	8 (57.1)
Wall/floor surfaces	25	13 (24.1%)	3 (21.4%)	-	4 (21.1%)	-	20 (80%)
Portable medical appliances	12	5 (9.3%)	1 (7.1%)	1 (7.7%)	2 (10.5%)	-	9 (75%)

*Coagulase-negative staphylococci (CoNS)

Table 3: Antibiotic resistance pattern of *Staphylococcus aureus* (MRSA and MSSA) isolates

Antibiotics	*S. aureus* isolates (n=54) Frequency (%)	MRSA isolates (n=14) Frequency (%)	MSSA isolates (n=40) Frequency (%)
Augmentin	1	0	1 (100)
Ofloxacin	8	2 (25)	6 (75)
Cloxacillin	9	6 (66.7)	3 (33.3)
Erythromycin	29	7 (24.1)	22 (75.9)
Ceftriaxone	3	3 (100)	0
Gentamycin	2	2 (100)	0
Cefuroxime	1	1 (100)	0
Ceftazidime	45	12 (26.7)	33 (73.3)
Oflox + Ornidazole	0	0	0
Levofloxacin	0	0	0
Cefixime + Clavulanate	0	0	0

Table 4: Antibiotic resistance pattern of Gram negative isolates

Antibiotics	*E. coli* n=14 (%)	*Klebsiella* n=13 (%)	*Proteus* n=1
Ampicillin	8 (57.1)	8 (61.5%)	0
Nitrofurantoin	1 (7.1%)	0	0
Gentamycin	1 (7.1%)	0	0
Cefuroxime	1 (7.1%)	3 (23.1%)	0
Ceftazidime	2 (14.3%)	1 (7.7%)	0
Ciprofloxacin	0	0	0
Ceftriaxone	0	0	0

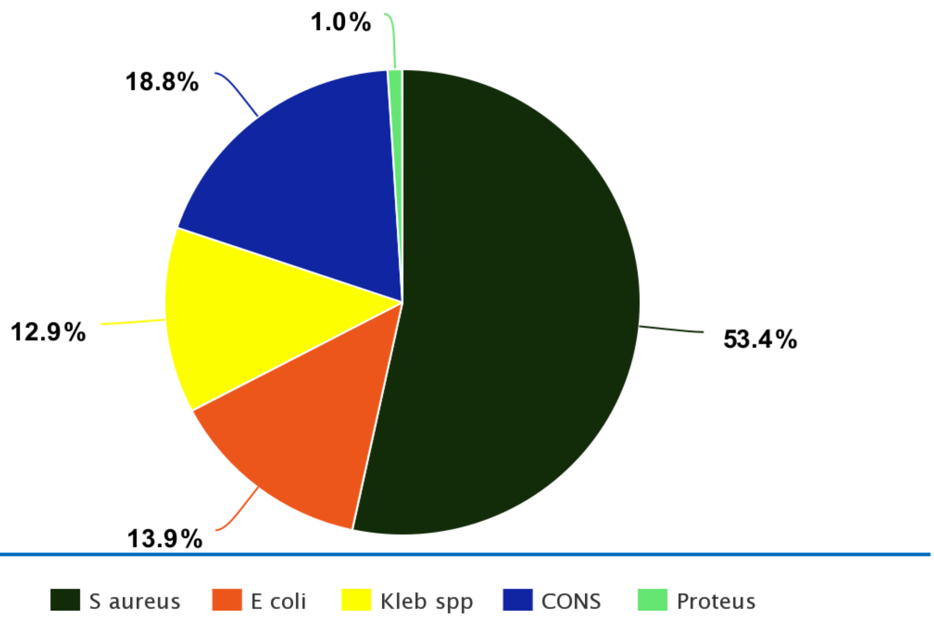

Figure 1: Bacterial isolates

Information obtained from the cleaning staff of the emergency room, revealed that the floors are mopped twice or thrice a day with detergent solution and occasionally with bleach. There are no standardized practices of cleaning/disinfecting table tops and benches, surface of electrical appliances, wall surfaces, ceilings, door knobs and portable medical appliances. The cleaning staff received no periodic training or assessment for competence.

Discussion

The bacteriological profile of surfaces and commonly used equipment in this study, yielded a wide range of organism including *Staphylococcus aureus*, Coagulase negative staphylococcus (CoNS), *Escherichia coli (E. coli), Klebsiella species, and Proteus species.* The overall prevalence of bacterial contamination of hospital surfaces and equipment was 70.3%. This is similar to results obtained by Saka et al. (69.7%), Okon et al. (70%) and Bhatta et al. (78%) at Ilorin, Maiduguri and Nepal respectively (5,8,12). However, it was significantly higher than the result obtained from Ethiopia (43.8%) by Worku et al. (3). The difference may be explained by the presence of sanitary team leaders who supervise sanitary teams employed by the government of Ethiopia, to ensure disinfection of hospital surfaces.

The predominant bacterial contaminant in this study was *Staphylococcus aureus* accounting for 53.4% of the organism isolated followed by CoNS. It was the most frequent isolate on all the surfaces and equipment cultured. Similarly, Saka et al. (5), Bhatta et al. (8), and Muhammed et al. (13) reported predominance of *Staphylococcus aureus* in their various studies at Ilorin, Sokoto and Nepal respectively. The higher prevalence of *Staphylococcus aureus* may be due to ubiquitous distribution in human body as part of the normal flora of the anterior nares, nasopharynx, and the skin (21). Also *Staphylococcus aureus* has predilection for inanimate surfaces and is relatively resistant to drying, heat and sodium chloride (5). On the other hand, Okon et al. (12) reported a predominance CoNS at Maiduguri, and Gracia- cruz et al. (22) in Mexico reported predominance of *Klebsiella spp*. Coagulase negative staphylococcus was the second most common isolate in this study, accounting for 18.8% of isolates. Because CoNS may contaminate clinical specimens, care has to be exercised in assessing its significance especially from superficial sites (23). However, it has been reported as the most common cause of colonization of central lines and hence central line associated blood stream infections (24). Furthermore, it has been found to cause pronounced systemic infections in immunocompromised hosts (23). Of the gram negative organisms identified in this study, *Escherichia coli* was the most common isolate accounting for 13.9%. Others were *Klebsiella spp* (12.9%) and *Proteus spp* (1%). Similar studies have shown the presence of *Escherichia coli, Klebsiella spp, and Proteus spp* on inanimate objects in hospitals (5,3,13). These organisms especially *Escherichia coli* are well implicated in nosocomial infections (25).

Furniture surfaces yielded the most isolates. These surfaces are frequented by patients, visitors and health care workers making for easy spread of the potential pathogens among unsuspecting users. 53.5% (15/28) specimens collected from furniture surfaces showed growth of *Staphylococcus aureus* and 17.8% (5/28) yielded *Escherichia coli*. Bed rails contamination rate was 100% (11/11) of which *Staphylococcus aureus* was the most predominant isolate. Similarly, high bed rails contamination rate was reported by Saka et al. (5).

Door handle contamination in this study was recorded to be 57.8% (8/14). The implicated organisms were *Staphylococcus aureus. Escherichia coli,* and *Klebsiella spp*. Similarly, Odigie et al. (18) reported *Staphylococcus aureus*, *Pseudomonas spp,* and *Escherichia coli* as common isolates from door handles. The risk of transmission of pathogens through door handles is increased as nursing staff, clinicians, and visitors frequently touch them (8). Majority of the medical devices in the present study yielded bacterial growth with *Staphylococcus aureus* being the most predominant isolate. Similarly, Uneke et al. (16) and Shiferaw et al. (26) reported a prevalence of 79% and 87% respectively. This is not surprising as it has been reported that health care workers and medical students have been found not to follow standard cleaning protocols for medical equipment such stethoscopes (3).

There was a high percentage of ceftazidime resistant *Staphylococcus aureus* (83.3%). Although there is paucity of data in clinical settings about *Staphylococcus aureus* resistance to ceftazidime, in vitro studies have shown that ceftazidime is less active against *Staphylococcus aureus* (27). Among *Staphylococcus aureus* isolates, 25.9% were MRSA. The presence of MRSA is a source of concern because of the risk of MRSA associated nosocomial and community infections. The organism can survive for days in hospital settings due to the ability to form biofilm on inanimate objects which prolongs their survival and spread (8,20). All the cultured gram negative organisms were sensitive to Ciprofloxacin and Ceftriaxone. There was no documented resistance of *Staphylococcus aureus* to Levofloxacin and Ofloxacin+Ornidazole. A high rate of erythromycin resistant *Staphylococcus aureus* was also demonstrated in this study (53.7%). Similarly, Bhatta et al (8) reported 56.8% resistance to erythromycin by *Staphylococcus aureus*. This resistance to erythromycin may be explained by the use of other macrolides to treat infections caused by bacteria other than *Staphylococcus aureus*. Thus commensal staphylococci in humans will be exposed to macrolides and this may contribute to erythromycin resistance being commonly encountered in clinical isolates (28).

Ampicillin resistance of the gram negatives was significantly high with 57.1% resistance documented by *Escherichia coli*. A similar result was obtained by Hammuel et al. (14). This resistance to ampicillin is due to production of β-lactamase enzyme by *Escherichia coli* and it is a major therapeutic challenge today in the treatment of hospitalized and community-based patients (29).

Standard cleaning protocols for hospitals emphasize consistency and thorough scrubbing of surfaces. For instance, the South Australian health cleaning policy requires daily cleaning with detergent and disinfectant of all elements in a patient's room, spot cleaning of walls and ceiling as spills occur (30). However, there are no standard cleaning protocols for most hospitals in Nigeria. Based on information obtained from the cleaning staff in the present study, there was no awareness of established cleaning protocols and the need for periodic training or assessment programs. They were also unaware of the need for consistency and thoroughness while cleaning surfaces. Worku et al (3). in Ethiopia documented similar findings by members of the sanitary team who had no idea of regular cleaning and disinfection of walls and ceilings except in situations where there was visible contamination. It has been recommended that cleaning staff be properly trained and knowledgeable in hygiene matters appropriate to their work activities with yearly assessments for competency (30).

Conclusion

Staphylococcus aureus, Coagulase negative staphylococcus and Escherichia coli were the commonest isolates. TheSre was high ampicillin resistance by gram negatives but all the Gram negative isolates were susceptible to Ciprofloxacin and Ceftriaxone. There were no established cleaning protocols or periodic assessment of cleaning staff to identify competency issues. More efforts are needed to ensure improved hygiene standards in order to control the contamination of surfaces and reduce the burden of nosocomial infections.

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References

1. Saka KH, Akanbi AA, Obasa TO, Raheem RA, Oshodi AJ. Bacterial Contamination of Hospital Surfaces According to Material Make, Last Time of Contact and Last Time of Cleaning/Disinfection. J Bacteriol Parasitol. 2017 Aug 7;08(03):8–11.

2. Samuel SO, Kayode OO, Musa OI, Nwigwe GC, Aboderin AO, Salami TA, et al. Nosocomial infections and the challenges of control in developing countries. Afr J Cln Exper Microbiol. 2010 May;11(2):102-110.

3. Worku T, Derseh D, Kumalo A. Bacterial Profile and Antimicrobial Susceptibility Pattern of the Isolates from Stethoscope , Thermometer , and Inanimate Surfaces of Mizan-Tepi University Teaching Hospital , Southwest Ethiopia. Int J Microbiol. 2018 Jun 27;2018:1-7

4. Stibich M, Gubb J, Stachowiak J, Chemaly RF, Rodriguez M, Simmons S, et al. The role of the healthcare environment in the spread of multidrug-resistant organisms: update on current best practices for containment. Ther Adv Infect Dis. 2014;2(3–4):79–90.

5. Saka KH, Akanbi II AA, Obasa TO, Raheem RA, Oshodi AJ, Kalgo ZM. Pathogenic Aerobic Bacterial Contaminants on Non-Critical Hospital Surfaces within Paediatric Ward of a Nigerian Hospital. J Med Microbiol Diagn. 2016 Oct 3;5(241):2161-0703.

6. Weber DJ, Rutala WA. Understanding and Preventing Transmission of Healthcare-Associated Pathogens Due to the Contaminated Hospital Environment. Infect Control Hosp Epidemiol. 2013 May;34(05):449–52.

7. Dancer SJ. The role of environmental cleaning in the control of hospital-acquired infection. J Hosp Infect. 2009 Sept 1;73(4):378–85.

8. Bhatta DR, Hamal D, Shrestha R, Hosuru Subramanya S, Baral N, Singh RK, et al. Bacterial contamination of frequently touched objects in a tertiary care hospital of Pokhara, Nepal: how safe are our hands? Antimicrob Resist Infect Control. BioMed Central; 2018 Dec;7(1):97.

9. Stone PW, Braccia D, Larson E. Systematic review of economic analyses of health care-associated infections. Am J Infect Control. 2005 Nov;33(9):501–9.

10. Sydnor ERM, Perl TM. Hospital epidemiology and infection control in acute-care settings. Clin Microbiol Rev. 2011 Jan;24(1):141–73.

11. Ochola E, Filia A, Kayanja A, Molteni T, Kellar Ayugi H, Granata V, et al. Prevalence of hospital-associated infections can be decreased effectively in developing countries. J Hosp Infect. 2013 May 1;84(2):138–42.

12. Okon KO, Osundi S, Dibal J, Ngbale T, Bello M, Akuhwa RT, et al. Bacterial contamination of operating theatre and other specialized care unit in a tertiary hospital in Northeastern Nigeria. Afr J Microbiol Res. 2012 Apr 9;6(13):3092-6.

13. Muhammad UK, Isa MA, Aliyu ZM. Distribution of potential nosocomial pathogens isolated from environments of four selected hospital in Sokoto, North Western Nigeria. J Microbiol and Biotech Res. 2013;3(1):139-43.

14. Hammuel C, Jatau ED, Whong CM. Prevalence and antibiogram pattern of some nosocomial pathogens isolated from Hospital Environment in Zaria, Nigeria. Aceh Int J Sci Tech. 2014 Sept 19;3(3):131-9.

15. Yusha'u M, Bukar A, Aliyu BS, Abdulkareem A. Bacterial contamination of some hospital equipments in Kano, Nigeria. Hamdard Medicus. 2012;55(3):39-42.

16. Uneke CJ, Ogbonna A, Oyibo PG, Onu CM. Bacterial contamination of stethoscopes used by health workers: public health implications. J Infect Dev Ctries . 2010 May 11;4(07):436-41.

17. Kesah CN, Egri-Okwaji MT, Iroha E, Odugbemi TO. Aerobic bacterial nosocomial infections in paediatric surgical patients at a tertiary health institution in Lagos, Nigeria. Nig Post Med J. 2004 Mar;11(1):4-9.

18. Odigie AB, Ekhiase FO, Orjiakor PI, Omozuwa S. The role of door handles in the spread of microorganisms of public health consequences in University of Benin Teaching hospital (UBTH), Benin city, Edo state. Pharm Sci Tech. 2017Aug 9;2(2):20-26.

19. Joseph J, Rodvold KA. The role of carbapenems in the treatment of severe nosocomial respiratory tract infections. Expert Opin Pharmacother. 2008 Mar 1;9(4):561–75.

20. Houngbegnon O, Doscoph Afle FC, Jerrold Agbankpe A, Houssou SC, Bankole HS, Christian Johnson R. Hospital Acquired Infection: Bacteriological Profile of Species from Environmental Surfaces of Cotonou 5 Hospital in South Benin (West Africa). Int J Curr Microbiol Appl Sci. 2018 Apr 10;7(04):1503–15.

21. Taylor TA, Unakal CG. Staphylococcus aureus. StatPearls [Internet]. 2019 Jan [cited 2019 May 12] Available from: https://www.ncbi.nlm.nih.gov/books/NBK441868/

22. Garcia-Cruz CP, Josefina M, Aguilar N, Arroyo-Helguera OE. Fungal and Bacterial Contamination on Indoor Surfaces of a Hospital in Mexico. Jundishapur J Microbiol. 2012 Jul 1;5(3):460-464.

23. Greenwood D, Slack RC, Barer MR, Irving WL. Medical Microbiology E-Book: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control. Elsevier Health Sciences; 2012.

24. Patil HV, Patil VC, Ramteerthkar MN, Kulkarni RD. Central venous catheter-related bloodstream infections in the intensive care unit. Indian J Crit Care Med. 2011 Oct-Dec; 15(4): 213–223.

25. Khan HA, Ahmad A, Mehboob R. Nosocomial infections and their control strategies. Asian Pac J Trop Biomed. 2015 Jun 16;5(7):509-14.

26. Shiferaw T, Beyene G, Kassa T, Sewunet T. Bacterial contamination, bacterial profile and antimicrobial susceptibility pattern of isolates from stethoscopes at Jimma University Specialized Hospital. Ann Clin Microbiol Antimicrob. 2013 Dec 13;12(1):39.

27. Richards DM, Brogden RN. Ceftazidime. Drugs. 1985 Feb 1;29(2):105-61.

28. Foster TJ. Antibiotic resistance in Staphylococcus aureus. Current status and future prospects. FEMS Microbiol Rev. 2017 May 1;41(3):430-49.

29. Rawat D, Nair D. Extended-spectrum β-lactamases in Gram Negative Bacteria. J Glob Infect Dis. 2010 Sep;2(3):263.

30. Cleaning Standard for South Australian Healthcare Facilities. Government of South Australia [Internet]. 2017 Dec [cited 2019 May 12] Available from: https://www.sahealth.sa.gov.au/wps/wcm/connect/18741180499970f0891e8faa8650257d/SA-Health-cleaning-standard-2014_%28v1.1%29-cdcb-ics-20180301.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-18741180499970f0891e8faa8650257d-mMENa7P