ORIGINAL RESEARCH

MICROBIAL CONTAMINATION OF NON-CRITICAL MEDICAL EQUIPMENT IN THE EMERGENCY DEPARTMENT OF A TERTIARY HOSPITAL IN PORT HARCOURT, NIGERIA AND THEIR ANTIBIOTIC SUSCEPTIBILITY PATTERNS

https://doi.org/10.60787/ajrmhs.v3i1.68

Buowari Dabota Yvonne

Department Of Emergency Medicine, University of Port Harcourt Teaching Hospital, Port Harcourt, Nigeria.

***Correspondence:** Buowari DY **Email:** dabotabuowari@yahoo.com

Abstract

Introduction: Medical devices can sometimes become contaminated with various microorganisms. It becomes a source of infection when such contaminated medical devices are used. This study aimed to investigate the microbial burden on medical equipment used in the Emergency Department of the University of Port Harcourt Teaching Hospital (UPTH), Nigeria, and their antimicrobial sensitivity patterns.

Methods: Sterile swabs were taken from noncritical medical equipment at the Emergency Medicine Department of the University of Port Harcourt Teaching Hospital, Nigeria. The sterile swab stick was moistened with normal saline and then swabbed on the medical equipment. It was then inoculated on an agar plate. Isolates were identified and subjected to antibiotic sensitivity testing.

Results: Six bacterial species and four fungal species were isolated. There was no growth on 18 (24.7%) items, and microorganisms were isolated from 55(75.3%) of the noncritical medical equipment.

Conclusion: Non-critical medical equipment in the emergency medicine department was contaminated with microorganisms. This can lead to hospital-acquired infections, which are resistant to antimicrobial agents available in the locality.

Key words: Microbial contamination, Medical Equipment, Healthcare-Associated Infections, Emergency Department

Cite as: ***Buowari DY. Microbial Contamination of Non-Critical Medical Equipment in the Emergency Department of A Tertiary Hospital in Port Harcourt, Nigeria and Their Antibiotic Susceptibility Patterns. AJRMHS. 2025; 3(1):60-67***

INTRODUCTION

Several medical equipment and instruments are used to provide dental and medical care to diagnose and administer treatment.1,2 Some of these have direct contact with mucous membranes or skin, while some others come in contact with deeper body tissues like the veins. Some of this equipment is manufactured for single use while others can be used on more than one individual; this distinction is not clear-cut. In developing countries like Nigeria, some medical equipment manufactured for single use are used on several patients due to limited availability of medical supplies, leading to contamination. Contamination with microorganisms refers to when microbial agents, toxins and their by-products are introduced unintentionally unto different equipment and surfac in the hospital, leading to infection being transmitted.3 Non-critical medical equipment can therefore become a potential reservoir of cross-infection when they are used.1,4 The chances of cross-infection between patients while using medical equipment are worse when more than one healthcare worker handles the medical equipment and when it is used on several patients.3 Healthcare professionals, patients, patients' companions, and relatives, including visitors to the hospital, can transmit microbes when they touch medical devices, equipment and inanimate surfaces that are already contaminated.4 For example, bed rails, stethoscopes, medical charts, ultrasound machines, sphygmomanometers, glucometers, and furniture. Therefore, the environment of a hospital is an infection reservoir5. Microorganisms can attach to medical equipment, whether it is critical or non-critical. This can be a source of hospital acquired infection.6 The Emergency Department (ED) serves as an entry point into a health facility as it renders life saving medical care to patients who are acutely and critically ill and also the injured.7 Here, patients are resuscitated, stabilized, and when necessary, referred to other specialist teams, leading to the transfer to other specialist wards to continue management.8 That is why the ED is usually chaotic due to the high traffic of people, which is a challenge concerning infection control as it may cause a breach in implementing standard infection prevention and control and cleaning protocols.9 Consequently, the ED may contain pathogens and contaminants on the equipment used for the provision of emergency and trauma care and also on surfaces and furniture such as chairs and tables.5 Hospital-acquired infection is a global challenge of public health concern in both developing and developed countries.10,11 Hospital-acquired infections are also a global problem.12 Some of the microbes that cause hospital-acquired infections are found on inanimate medical equipment and surfaces in health facilities. It is estimated that about 60% of the surfaces in the health facility are already contaminated with microbes that can cause hospital-acquired infection.12 Hospital-acquired infections are sometimes contracted from the hands of healthcare professionals.13,14 The microbes that cause hospital-acquired infection may develop multidrug resistance to antibiotics they were previously sensitive to.10,12,13. Disinfectants do not eliminate all microbes that contaminate medical equipment and surfaces that may be sources of hospital-acquired infections, as some microbes form a protective covering known as biofilm15. This means that even if standard disinfection protocols are applied and adhered to, they could still exist. Therefore, contaminated medical equipment is an important cause of hospital-acquired infections.10,16 It has also led to outbreaks of hospital-acquired infections17,18. Microbial contamination of medical equipment is a problem in low and middle-income countries (LMIC) like Nigeria with poor health systems and resources.19,20 It could lead to longer hospital stays, and increases the financial burden on the patient or the sponsor of the patient's medical bills.21 Even with the several technological advancements in public health, microbes are acquired from health facilities14 The morbidity and mortality rates that are linked to hospital-acquired infections are on the rise.14 Since equipment may serve as reservoirs of pathogens that are multi-drug resistant, understanding the microbial profile on medical equipment and surfaces in health facilities and their sensitivity pattern aids infection prevention and control, antibiotic stewardship and reduction in hospital-acquired infection.5,22 Research have also reported that surfaces in healthcare facilities are contaminated with infection causing pathogens22. There is diversity in their prevalence and susceptibility to antibiotics, which may differ even within different departments in the same hospital at different times.4 In a study conducted in two public hospitals in Kenya where samples were taken from the environment and surfaces in the hospitals, the following bacteria were isolated: Providencia species, Staphylococcus aureus, Escherichia coli, and other some gram-negative bacteria including Pseudomonas species, coagulase negative Staphylococcus species, Serratia species, Klebsiella species, Proteus species and Enterobacter species.23 All the isolates were 100% sensitive to imipenem with Escherichia coli isolates more sensitive generally. A study on bacterial contamination of medical equipment and surfaces at the operating theatre and the children's emergency room (CHER) at the Enugu State University Teaching Hospital, Nigeria reported high levels of coagulase-negative Staphylococci (CoNS), Staphylococcus aureus and Escherichia coli isolated from the walls, windows, knobs doors, surfaces of furniture, and other portal medical equipment.5,7 All the gram-negative isolates at the CHER were sensitive to ciprofloxacin and ceftriaxone while a large proportion were resistant to ampicillin, furniture gave the highest yield.5 Russotto et al identified medical charts in the intensive care unit

as as a reservoir of pathogens.10 A study conducted in Doula, Cameroon, identified surfaces and medical equipment in the hospital as highly contaminated with bacteria and pathogenic yeasts which were susceptible to the antibiotics available in the region24 . Another study of stethoscopes, tourniquets, bandage scissors, reflex hammers, tuning fork and nystagmus glasses showed that stethoscopes had the highest yield1. Working in the ED puts healthcare workers and their patients at risk of contracting infections and microbes.8 There is an increase in the emerging pathogenic bacteria, which spread within the healthcare system posing challenges to microbiological, epidemiological and IPC practices and strategies.25 A study conducted in Edo state, Nigeria, reported a high bacterial contamination of ED, laboratories and outpatient departments With Staphylococcus aureus, Streptococcus species, Proteus species, Klebsiella species, and Escherichia coli, especially in the ED and outpatient department.26 This was attributed to the high traffic of patients and their relatives in these areas of the hospital. Diaphragms of stethoscopes in the ED were more contaminated (53.33%) than the bell region (21.33%).3 The high influx of critically ill and trauma patients in the ED and the sharing of stethoscopes between the nurses, might not have afforded enough time for appropriate disinfection between patients. A study in Morocco, showed that the ED was more contaminated than other units of the hospital25. Contaminated medical equipment has led to outbreaks of nosocomial infections.21,27 This study investigated the microbial burden on medical equipment used in the ED of the University of Port Harcourt Teaching Hospital (UPTH), Nigeria and their sensitivity.

MATERIALS AND METHODS

Research Design

This was a descriptive cross-sectional study that was carried out at the UPTH ED located in Rivers State, southern Nigeria. The UPTH ED is divided into the resuscitation area, trauma ward and the male and female lying-in bays with an emergency operating theatre. The population of the study was a census of non-critical medical equipment and surfaces of the ED at the UPTH. The medical equipment in cooperated into this study were randomly selected. Table I shows the types of non-critical medical equipment and surfaces that were incorporated into this study. The total number of samples collected is 73 Non-Critical Medical Device.

Table 1: Description of the Non-Critical Medical Device

S/N	Non-Critical Medical Device	Number	Area(s) Swabbed	Number of samples collected N- 73
1	Stethoscope	17	• Diaphragm • Tubing • Earpiece	51
2	Pulse Oximeter	2	• Probe • Monitor	4
3	Sphygmomanometer	8	• Cuff • Tubing	16
4	Glucometer	1	Test strip port	1
5	Infrared Thermometer	1	Handle	1

Specimen Collection, Culture and Isolation, Microorganism Identification and Antimicrobial Susceptibility Test

The specimen was collected using a sterile swab stick that was made moist with sterile 0.9% normal saline. The medical device and surface were swabbed in one direction only to avoid contaminating other aspects of the medical device. It was then inserted into a sterile swab stick tube, which was transported for culture in biohazard bags to the clinical microbiology laboratory. The swab stick was inoculated onto agar plates. Sabouraud dextrose agar was used for the isolation of fungi, while MacConkey agar and chocolate agar were used for the identification of bacteria. Isolates were identified through Gram and biochemical reactions to coagulase and glucose fermentation sugars. Muller Hinton Agar was used for susceptibility testing. The antibiotics used for sensitivity in this study were chosen based on the classes and what was available at the time the study was conducted. Identified bacteria were subjected to antibiotic sensitivity of 5 commonly prescribed antibiotics at the UPTH ED: cefixime (a third-generation cephalosporin administered orally), ceftriaxone (a third-generation cephalosporin administered parenterally), Vancomycin (Glycopeptide), moxifloxacin (quinolones) and gentamycin (aminoglycosides). No susceptibility test was done for the fungi isolated.

Table 2: Antibiotics used for the sensitivity testing

S/N	Antibiotic	Class
1	Cefixime	Third-generation cephalosporin (administered orally)
2	Ceftriaxone	Third-generation cephalosporin (administered parenteral)
3	Vancomycin	Glycopeptide
4	Moxifloxacin	Quinolone
5	Gentamycin	Aminoglycoside

Identified microbes and antibiotic sensitivity were presented using descriptive statistics using tables. The Research and Scientific Ethical Committee of the UPTH approved the study (UPTH/ADM/90/S.11/VOLXI/1490).

RESULTS

Various microorganisms were isolated, which included bacteria and fungi. However, there was no growth in some. There was no growth from the swab taken from the infrared glucometer. *Candida albicans* was isolated from the glucometer test strip port. Concerning the two pulse Oximeter swabs, no growth was observed in one of the pulse Oximeters, and bacteria were isolated from the second one. The one in which no microorganism was isolated belonged to a nurse. Microorganisms were isolated from 55(75.3%) samples, while there was no growth on 18(24.7%) samples. These isolates were 6 bacterial species and 3 fungal species.

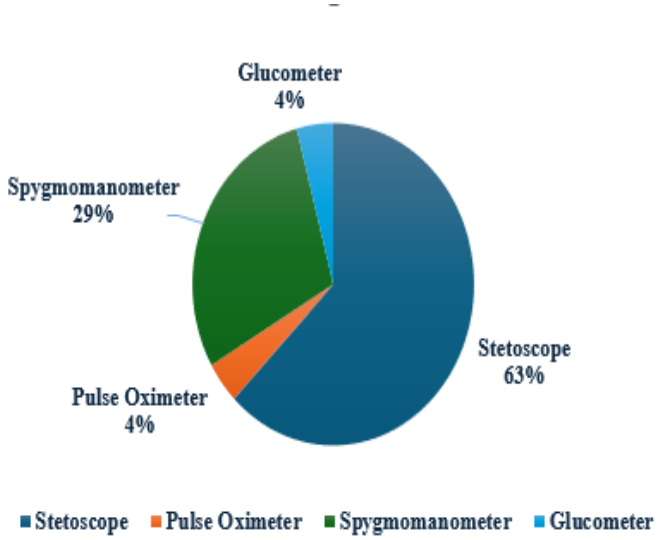

Figure 1: Contaminated Medical Equipment

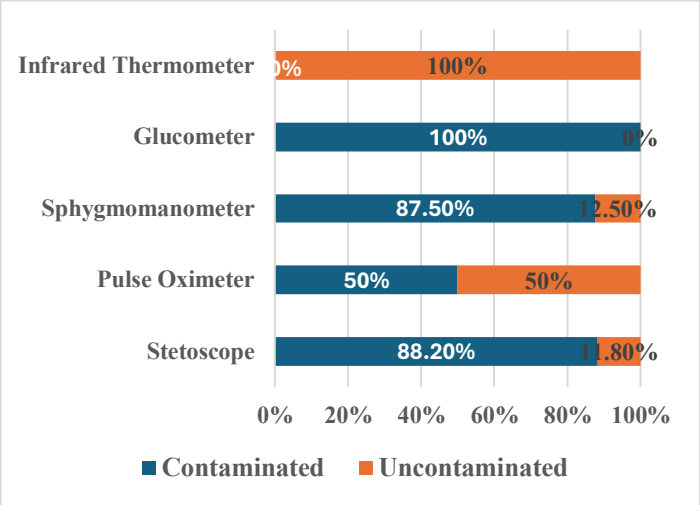

Figure 2: Contaminated Versus Uncontaminated Medical Equipment

More than one microorganism was isolated from some of the items.

Most of the medical devices swabbed were contaminated with either bacteria or fungi. The number of microorganisms isolated from the cuff were three microorganisms on 1 cuff (12.5%), two microorganisms on 2 cuffs (25%) and one microorganism on 5(62.5%). For the inflatable bulbs, two microorganisms were isolated on 3(37.5%) while only one microorganism was isolated on the remaining.

Table 3a: Isolated micro-organisms

S/N	Microorganism	Number of equipment isolated from	%
	Fungi		
1.	*Candida albicans*	10	58.8
2.	*Penicillum species*	4	23.5
4.	*Aspergillus niger*	3	17.6
	Total	17	
	Bacteria	**Number of equipment isolated from**	**%**
1.	*Bacillus species*	21	45.7
2.	*Klebsiella oxytoca*	1	2.2
3.	*Staphylococcus species*	12	26.1
4.	*Escherichia coli*	2	4.3
5.	*Staphylococcus aureus*	8	17.4
6.	*Klebsiella species*	2	4.3
	Total	46	100

Table 3b: Micro-organisms isolated from each non-critical medical device

S/N	Microorganisms isolated per Device	Portion of device and number of organisms	
I.	**Glucometer**	**Test strip port**	
	Candida albicans	1	
II.	**Infrared Thermometer**	**Handle**	
	No growth		
III.	**Pulse Oximeter**	**Probe**	**Monitor/ Surface**
1.	No growth	1	1
2.	*Bacillus species*	1	1
IV	**Sphygmomanometer**	**Cuff**	**Inflatable Bulb**
1.	*Bacillus species*	2	2
2.	*Klebsiella oxytoca*	1	-
3.	*Klebsiella species*	1	1
4.	*Candida albicans*	2	2
5.	*Staphylococcus species*	5	1
6.	*Staphylococcus aureus*	1	1
7.	No growth	-	1
8.	*Aspergillus niger*	-	1
9.	*Penicillium species*	-	1

Table 4: Microorganisms isolated from the stethoscopes

S/N	Microorganism	Part of the Stethoscope Swabbed		
		Earpiece	Tubing	Diaphragm
1.	*Bacillus species*	7	4	3
2.	*No growth*	7	5	6
3.	*Penicillium species*	1	1	2
4.	*Staphylococcus aureus*	2	3	1
5.	*Candida albicans*	2	2	2
6.	*Staphylococcus species*	-	2	1
7.	*Escherichia coli*	-	-	*1*
8.	*Aspergillus niger*		1	*2*

Table 5: Antimicrobial Sensitivity pattern of isolates

S/N	Bacteria	AST pattern and number of isolates															Total Isolates
		Gentamycin			Vancomycin			Ceftriaxone			Moxifloxacin			Cefixime			
		S	R	I	S	R	I	S	R	I	S	R	I	S	R	I	
1.	*Bacillus species*	20	1	0	19	2	0	7	14	1	11	10	1	16	5	0	21
2.	*Klebsiella oxytoca*	1	0	0				1	-	-	-	-	1	0	1	-	1
3.	*Staphylococcus species*	12	0	0	12	-	-	7	4	1	8	4	-	9	1	2	12
4.	*Escherichia coli*	2	0	0				2	0	0	2	-	-	2	-	-	2
5.	*Staphylococcus aureus*	8	0	0	8	-	-	2	6	-	4	4	-	5	3	-	8
6.	*Klebsiella oxytoca*	2	0	0				0	2	0	2	-	-	2	-	-	2

S: Sensitive; R: Resistant; I: Intermediate

DISCUSSION

One entity that threatens public health globally is antimicrobial resistance (AMR). This is because of the negative effects it imposes on the lives of both well and unwell persons. It also has a financial impact as patients will have to spend more money on medications.[6] The ED is one of the parts of a hospital is more likely to be contaminated. This could be because of the increased workload, chaotic nature of the ED, and increased traffic of patients, their caregivers and healthcare workers in the ED.[3,13,26] Some devices were contaminated with more than one microorganism and some of the isolates were multidrug-resistant.[12]

In this study, some of the microorganisms isolated from the medical equipment are resistant to more than one antibiotic used for the susceptibility test. The handle of the infrared thermometer was not contaminated. This may be because it is handled only by the healthcare workers, and it does not come in direct contact with the patient. The glucometer was contaminated with *Candida albicans*. The pulse Oximeter can be a source of infection to a patient. One of the probes and monitors of the pulse Oximeter was contaminated. Hence, the health worker needs to be careful not to contract the bacteria and infect themselves and their household. The pulse Oximeter that grew no microorganism was privately owned by a nurse. Hence, it is not surprising that she may be disinfecting and cleaning it after use. *Staphylococcus species* was the commonest contaminant of the sphygmomanometer. Other bacteria contaminating the cuff are the *Bacillus species, Klebsiella oxytoca*. This is a potential problem as *Klebsiella species* can be transmitted from person to person. The bacteria contaminating the bulb of the sphygmomanometer are *Bacillus species, Klebsiella species, Staphylococcus aureus* and Staphylococcus species. The fungi that contaminated the cuff are Candida albicans. The inflatable of the sphygmomanometer was contaminated with *Aspergillus niger, Penicillium species* and C*andida albicans*.

Stethoscope

Various parts of the stethoscope were contaminated with bacteria and fungi. Only 2(11.8%) of stethoscopes were free of contaminants. The diaphragm was the least contaminated. This may be because most physicians will clean the diaphragm of the stethoscope after examining a patient with it but forget to disinfect other parts. The stethoscope is a commonly used and cheap non-critical equipment in the ED whose surfaces make direct contact with the patient; hence it is commonly contaminated.[17,29] The different surfaces of the stethoscope can be infected. The stethoscope can be contaminated by both normal flora and infectious microorganisms from the hands of the health workers and the bodies of the patients it comes in contact with.[3] In this study, the diaphragm tubing and earpiece were contaminated with different microorganisms. Even each particular stethoscope had different parts contaminated by different microorganisms. In this study, the isolated bacteria comprised *Staphylococcus aureus* and other species of *Staphylococcus*, *Klebsiella* and *Escherichia coli*. This is similar to the study conducted in Edo State, Nigeria, where some bacteria were isolated from the ED and outpatient departments[26] and in Ethiopia.[18] The stethoscope is a source of nosocomial infection.[26] The swabbed stethoscopes in this study were contaminated except for a few. This is similar to other studies.[12,29] Sphygmomanometers are another set of medical devices that are commonly contaminated with pathogenic microorganisms[12,18] as seen in this study. Isolation of pathogenic bacteria from the stethoscope indicates that it is a potential source of infection.[17] This is why various aspects of the stethoscope surfaces of inanimate objects in the ED can be contaminated with different microorganisms, which sometimes may be multidrug-resistant[10]. In this study, some of the isolates were resistant to more than one antibiotic. Physicians in the ED must be aware of the high risk of cross-infection from contaminated medical devices to establish infection prevention and control strategies that are appropriate.[10,22]

Some of the isolates in this study were resistant to the antimicrobial used for the sensitivity test. This is similar to two studies conducted in Ethiopia and Cameroon.[12,21,30] A preventive strategy to reduce the morbidity and mortality in the ED among patients and health workers in the reduction of nosocomial infections,[22] strict adherence to infection prevention and control strategies[11] and proper cleaning and disinfection of medical devices will help reduce the contamination of these devices. Continuous training and education are necessary to update the knowledge of the physicians concerning infection prevention and control[12,18,29] to minimise nosocomial infection.

Stethoscopes and sphygmomanometers should be disinfected before and after use on each patient. Health facilities must develop infection prevention and control strategies for the protection of both patients and healthcare workers against contracting nosocomial infections.[26] Poor cleaning of the stethoscope can convert it to an infection-carrying agent, and when it is not controlled, nosocomial infection is eminent.[17]

Conclusion

Medical devices used to aid diagnosis, and treatment can be a source of infection. This study reveals that some of the non-critical medical devices used in the ED are contaminated with pathogenic microorganisms (bacteria and fungi), some of which are also resistant to some antimicrobials. Some devices were contaminated with more than one microorganism.

Recommendation

There is a need to imbibe good infection prevention and control strategies and practices. This includes proper decontamination and disinfection. Good hand-washing techniques are also necessary to prevent the transmission of microorganisms from one medical device to another. It is also important to conduct an audit of the antimicrobial prescribing pattern, which may have affected the results, resulting in high resistance to ceftriaxone, moxifloxacin and cefixime.

REFERENCES

1. Rudhart SA, Gunther F, Dapper LI, Gelirt F, Stuck BA, Hoch SI. Analysis of bacterial contamination and the effectiveness of ultraviolet light-based reprocessing of everyday medical devices. PLOS One. 2022, 17(11): e0268863. https://doi.org/10.1371/journal.pone.0268863
2. Blazquez-Garrido RM, Cuchi-Burgos E, Martin-Sallas C, Ruiz-Garbajosa P. Microbiological monitoring of medical devices after cleaning, disinfection and sterilization. Emerg Infect Microbial Clin. 2018, 36(10), 657-661.
3. Datta P, Kaur M, Rawat S, Gupta V, Chander J. Stethoscope "the friendly foe - a study to evaluate bacterial contamination of stethoscopes and disinfection practices. J Infect Developing Countries. 2018, 12(10): 887-893. Doi:10.3855/jidc.10128
4. Alrawi SK, Assi MS, Younus ZY, Hayyawi AH, Abdullah AW, Lateef BN et al. Medical devices, tools and equipment surfaces were contaminated in three departments at a tertiary hospital in Baghdad. Ann Trop Med Public. 2020, 23(s11): s1231130. doi: http://doi.org.org/10.36295/ASPO.2020.231130
5. Ndu IK, Asinobi IN, Ekwochi U, Nduagubam OC, Amadi OF, Okeke IB et al. 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. Med Sci Dis. 2019, 6(9), 192-7.
6. Luna D, Sanchez JT, Peguero M, Garcia W, Liciaga S, Brito F et al. Antimicrobial resistance profiles of microorganisms isolated from hospitalised patients in the Dominican Republic. Rev Panam Salud Publica. 2020, 44.
7. Liang SY, Rietham M, Fox J. Infection prevention for the emergency department out of reach or standard of care? Emerg Med Clin North Am. 2018, 36, 873-887
8. Bielawska-Drozd A, Wlizlo-Skowronek B, Cieslike P, Winuicka I, Skopinska-Rozewska E, Kubia KL, Zakowska D et al. Evaluation of the levels and quality of microbial contamination in medical emergency departments in comparison to other workplaces. Polish J Microb. 2016, 65 (4), 465-479.
9. Kiraly A, Stedford A, Awad E, Adam G, Bosserer F. Evaluation of portable ultrasound machine contamination in a community emergency department. Med Res Innov. 2020, 4 (1-4). Doi. 10.15761/MRI.1000173
10. Russotto V, Cortegiani A, Maiheri SM, Giarratono A. Bacterial contamination of inanimate surfaces and equipment in the intensive care unit. J Intensive Care. 2015, 3:54. Doi: 10.1186/s40560-015-0120-5
11. Etiz P, Yuzbasioglu - Ariyurek S. Assessment of knowledge about nosocomial infections among Cukurova University Vocational School of Health Services studies. Turk Hij Den Biyol Derg. 2020, 77(1), 69-78.
12. Birru M, Mengistu M, Siraj M, Aklilu A, Boru K, Woldemariam M, Biresaw G et al. Magnitude, diversity and antibiograms of bacteria isolated from patient care equipment and inanimate objects of selected wards in Arba Minch General Hospital, Southern Ethiopia. Res Reports Trop Med. 2021, 12, 39-49.
13. Adesanya OA, Nwadike VU, Adesanya OO, Lamina AB. Bacterial contamination of stethoscopes at a tertiary care hospital in southwestern Nigeria. Afr J Clin Experiment Microb. 2017, 18(2), 59-63.
14. Obenza A, Cruz P, Buttner M, Woodard D. Microbial contamination on ambulance surfaces: a systematic literature review. J Hosp Infect. 2022, 122, 44-59.
15. Awange AM, Amrasawe B. Microbiological assessment of environmental surfaces in a healthcare facility. GCS Boil Pharm Sci. 2020, 12(02), 046-055.
16. Ssekitoleko RT, Oshabaheebwa B, Munabi IG, Tusabe MS, Namayega C, Ngabirano BA et al. The role of medical equipment in the spread of nosocomial infections: a cross-sectional study in four tertiary public health facilities in Uganda. BMC Public Health. 2020, 20:1561.
17. Ndu IK, Chinawa JM, Emeka CK, Asinobi IN, Ekwochi U, Nduagubam OC et al. Bacterial contamination of medical equipment and surfaces in the main operating theatre of Enugu State University. Inter J Med Health Dev. 2022, 27, 164-8.
18. Ebongue CO, Nguatcheussi CM, Mefolo JN, Bollanga JB, Adiogo D et al. Microbial ecology and antibiotic susceptibility profile of germs isolated from hospital surfaces and medical devices in a reference hospital in Doula, Cameroon. Adv Microb. 2018, 8, 125-137. http://www.scirp.org/journal/aim.
19. Ssekitoleko, R.T., Oshabaheebwa, S., Munabi, I.G., Tusabe,MS., Namayega, C., Ngabirano, Matovu, B., et al. The role of medical equipment in the spread of nosocomial infections: a cross sectional study in four tertiary public health facilities in Uganda. BMC Public Health (2020) 20:1561 https://doi.org/10.1186/s12889-020-09662-w. 1-11.
20. Shahida, S.M., Islam, A., Dey, B.R., Islam, F., Venkatesh, K., Goodman, A. Hospital Acquired Infections in Low and Middle Income Countries: Root Cause Analysis and the Development of Infection Control Practices in Bangladesh. Open J Obstet Gynec, 6, 28-39. http://dx.doi.org/10.4236/ojog.2016.61004

21. Obasi, C., Agwu, A., Akinpelu, W., Hammons, R., Clark, C., Etienne-cummings, R., et al. Contamination of equipment in emergency settings: An exploratory study with a targeted automated intervention. Ann of Surg Innov Res. 2009, 3:8 doi:10.1186/1750-1164-3-8. http://www.asir-journal.com/content/3/1/8
22. Adam VY, Olajie OH. A study of the potentially harmful pathogens on environmental surfaces in healthcare facilities in Edo State, Nigeria. J Comm Med Prim Healthcare. 2013, 25(2), 1-10.
23. Muthoni MS. Antibiotic susceptibility patterns of bacteria isolated from hospital surfaces and environment in Kenya. Microbio Res J Inter. 2021, 3(5), 44-55.
24. Lalami AEO, Touijer H, El-Akhai F, Ettayebi M, Benchemsi N, Maniar S et al. Microbiological monitoring of environmental surfaces in a hospital in Fez City, Morocco. J Mater Environ Sci. 2016, 7(1), 123-130.
25. Pandar PK, Kumar R, Raj P, Khusio P. Bacteriological profile and antimicrobial susceptibility patterns of bacteria isolated from surgical site infections of patients attending a tertiary care hospital. Inter J Contemp Med Res. 2020, 7(2), 5-9
26. Nunez S, Moreno A, Green K, Villar K. The stethoscope in the emergency department: a vector of infection? Epidemiol Infect. 2000, 124, 233-237.
27. Lee R, Choi S, Jo SJ, Han S, Park YJ, Choi MA et al. A quasi-experimental study on stethoscope contamination with multi-drug resistant bacteria: its role as a vehicle of transmission. PLOS ONE, 2021, 16 (4):e0250455. https://doi.org/10.1371/journal.pone.0250455
28. Weldegebret F, Admasi D, Meazu D, Asfew M. Non-Critical healthcare tools as a potential source of healthcare-acquired bacterial infections in eastern Ethiopia: a hospital-based cross-sectional study. SAGE Open Med. 2019, 7: 1-10.
29. Al-Rubeaan, K.A, Saeb, A.T.M., AlNaqeb, D. M., AlQumaidi, H.M., AlMogbel., T.M. The bacterial contamination rate of glucose meter test strips in the hospital setting. Saudi Med J 2016; Vol. 37 (9), 985-995.
30. Darge, A., Kahsay, A.G., Hailekiros, H., Niguse, S., Abdulkader, M. Bacterial contamination and anti-microbial susceptibility patterns of intensive care units medical equipment and inanimate surfaces at Ayder Comprehensive Specialized Hospital, Mekelle, and northern Ethiopia. BMC Research Notes. 2019: 12,621. https://doi.org/10.1186/s13104-019-4658-5