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High Prevalence and Antibiotic Resistance of MRSA and *Acinetobacter* spp. among Healthcare Personnel and Neonatal Units: Implications for Infection Control and Hygiene Protocols

Oluwadamilare Afolabi Obe [a], Adewunmi Akingbola [a,b*], Bamidele Mutiu [a], Margaret Nnakwue [c] and Ibrahim Oladipupo Odulate [a]

[a] Department of Medical Microbiology and Parasitology, Lagos State University College of Medicine, Ikeja, Lagos, Nigeria.
[b] Department of Public Health, University of Cambridge, The Old Schools, Trinity Ln, Cambridge, United Kingdom.
[c] Department of Nursing, Lagos State University College of Medicine Ikeja, Lagos, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author OAO designed the concept of the research and wrote the results. Author AA wrote the methodology, discussion and analysed the data. Author BM wrote the results, and did the editing of the manuscript. Author IOO wrote the Discussion. Author MN wrote the Introduction. All authors read and approved the final manuscript.

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**Corresponding author: E-mail: akingbolaadewunmi@gmail.com;*

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ABSTRACT

Objective: To assess the efficacy of current hygiene practices at the tertiary center through comprehensive microbiological surveillance, and to provide targeted recommendations for enhancing hospital hygiene to mitigate infection risks.
Methodology: A cross-sectional study employing microbiological surveillance to evaluate microbial contamination across various hospital settings in a tertiary healthcare facility in Lagos, Nigeria, focusing on high-risk areas such as personnel body parts, operating theaters, specialized care units, and staff areas. The study involved collecting microbial samples from the hospital environment, including surfaces in operating theaters, neonatal units, and healthcare personnel.
Microbial samples were collected from 38 different locations and personnel within the hospital. Culturing was conducted on appropriate media. Antibiotic susceptibility was tested using the disc diffusion method. Statistical analyses included ANOVA and logistic regression to determine the prevalence and distribution of microbial contaminants and to assess the effectiveness of current hygiene practices.
Results: The surveillance detected microbial growth in 33.33% of samples, with significant pathogens like MRSA and Acinetobacter species present. ANOVA showed significant differences in microbial contamination among different hospital locations ($F(3,32) = 4.267$, $p = 0.0121$). Logistic regression analysis didn't find statistically significant predictors for microbial presence but highlighted higher odds of contamination in personnel areas (OR = 2.78, p = 0.406).
Conclusion: The study highlights the need for continuous microbiological surveillance to identify and mitigate infection risks in hospital settings. Despite effective sterilization practices in some areas, the presence of pathogens like MRSA indicates the necessity for enhanced hygiene protocols, particularly in personnel areas.

Keywords: Antibiotic; acinetobacter; infection control; hospital hygiene.

1. INTRODUCTION

Hospitals, as vital institutions dedicated to treating various illnesses and safeguarding patient health, inherently harbor numerous infectious agents within their environments. Unfortunately, this poses a significant risk to individuals seeking healthcare within their confines, including patients, healthcare workers, and visitors. The continual exposure to common microbial agents prevalent in healthcare settings increases the risk for infection development among these groups. Mitigating this risk thus requires meticulous adherence to hygiene practices within healthcare facilities [1]. Throughout the years, hospital hygiene has been managed through various strategies, among which active microbial surveillance in healthcare facilities stands as a pivotal approach. Such surveillance endeavors play a crucial role in providing insights into local challenges and needs pertinent to hygiene maintenance [2,3,4].

The purpose of this paper is to explore the insights gained from tertiary Medical Centre microbial surveillance and provide practical recommendations for enhancing hospital hygiene. Through the analysis of surveillance data and identification of key areas for improvement, this study endeavors to contribute to the ongoing efforts aimed at bolstering hygiene practices and reducing nosocomial infections.

The concept of hygiene in healthcare facilities is a development stemming from Florence Nightingale's observations and interventions during the Crimean War. Nightingale observed that soldiers of the war were being treated in poor conditions and advocated for sanitary measures that significantly reduced the mortality rate [5]. This is an evidence-based indicator of the essentiality of hospital hygiene in nosocomial infection prevention and control. Amongst the numerous definitions of hospital hygiene that have been established, this paper will contextualize hospital hygiene as "every activity carried out to efficiently and scientifically assure that healthcare structures, equipment, and procedures contribute to the health of patients, hospital visitors, and healthcare workers in a secure and acceptable environment" [6]. Eliminating nosocomial infections through hospital hygiene takes on different forms of cleanliness and sanitary activities such as standardized hand washing, disinfection and sterilization of surfaces, proper management of medical wastes, the use of personal protective

equipment and microbial surveillance, all of which are most effective when done in combination [7].

The CDC defines surveillance as the continuous, methodical gathering and evaluation of disease-related data, followed by the sharing of findings with relevant parties [8]. Therefore, microbiological surveillance is the methodical gathering of data regarding the kinds and amounts of microbial flora present in hospital environments, including equipment, personnel, and surfaces [9].

As a vital component of infection control programs, active microbial surveillance provides information on the local disease-causing microorganisms. Microbiological surveillance is also relevant to monitor infection trends, giving professionals the ability to recognize infection problems [10]. In the event of an infection problem such as a disease outbreak, microbiological surveillance will be useful in isolating causative organisms, identifying them up to the species and type level, and then tracing the source of the infection [11]. Isolating causative organisms involves giving a name to the fast-growing, spreading microbial flora. It is finding out whether it is the common causative organisms of hospital-acquired infections (HAIs) like methicillin-resistant Staphylococcus aureus (MRSA) and Escherichia coli or uncommon organisms like proteus species. Identifying these causative organisms up to the species and type level involves differentiating strains of the same microorganism by determining their distinct characteristics. This is important to ensure that the people affected by the infection outbreak are connected. Tracing the source of infection entails utilizing information obtained from microbial identity and its connection to an outbreak to determine the origin of the spread.

Despite the established importance of maintaining optimal hygiene in hospitals, healthcare facilities still face some challenges that hinder standardized hygiene practices, giving room for nosocomial infections to persist.

One of the challenges hospitals face is the issue of diverse variations of hospital hygiene practices [12]. This challenge may be a result of the variable hospital hygiene training to which health professionals are exposed. Additionally, several standards of hygiene may exist in different departments within the same healthcare facility, creating a disparity in which protocols to adhere to. Healthcare professionals and visitors can disregard standard procedures due to unawareness or negligence. A practical recommendation to address this challenge would be regular training and retraining of personnel to ensure uniformity and keep them updated with the best practices.

In hospitals where workers are well aware of hygiene standards, limitation of resources such as time, equipment and personnel may prevent the optimal implementation of these standards [13]. Friction in logistics can make it difficult to obtain personal protective equipment and sterile equipment for use. Research has also shown that within establishments where staff responsible for environmental hygiene lack adequate training, motivation, and compensation, they may experience feelings of undervaluation, consequently leading to subpar performance in their duties [14].

In the context of Nigerian medical facilities, there is a paucity of academic literature on medical surveillance and its pivotal contribution to hospital hygiene—one of the key strategies necessary for eliminating nosocomial infections. Most literature related to medical surveillance, hospital hygiene, hospital-acquired infections, and antimicrobial resistance is obtained from existing research, predominantly from developed countries. The purpose of this research study is to address this gap by providing reliable information about enhancing hospital hygiene through microbial surveillance from a Nigerian health institution's perspective. Additionally, the paper seeks to document progressive efforts to optimize hygiene in healthcare facilities.

2. METHODOLOGY

This study employed comprehensive microbiological surveillance to assess the prevalence of microbial contamination within the Lagos tertiary center, focusing on the operating theatre, specialized care units, and personnel. The objective was to evaluate the effectiveness of current cleaning protocols, hand hygiene practices, and antibiotic susceptibility patterns among isolated microbes. This section outlines the methodologies used for sample collection, microbial culture, identification, and statistical analysis.

2.1 Sample Collection and Distribution

A total of thirty-eight (38) samples were collected from various sections of the hospital and

selected staff members. The breakdown of sample sources included the theatre (9 samples), neonatal unit (6 samples), postnatal unit (4 samples), cleaning solutions (3 samples), water source (1 sample), personnel (14 samples), and an air quality assessment. The selection criteria for these samples were based on their potential risk of contributing to hospital-acquired infections (HAIs).

Samples were cultured on appropriate media and incubated under optimal conditions for bacterial growth. The microbial growth was identified using standard microbiological techniques, including Gram staining, biochemical tests, and molecular methods when necessary. The percentage distribution of microbial growth types was calculated and documented to determine the prevalence of various pathogens within the hospital environment.

Isolated bacteria were subjected to antibiotic susceptibility testing using the disc diffusion method. The test evaluated the efficacy of various antibiotics against the pathogens, including Clindamycin, Levofloxacin, Amikacin, Piperacillin/Tazobactam, Meropenem, and others. The patterns of resistance and sensitivity were recorded to guide antibiotic stewardship within the facility.

2.2 Statistical Analysis

An Analysis of Variance (ANOVA) was used to compare mean growth rates between different location types within the hospital. Pearson's Chi-squared test assessed the association between location type and microbial growth. Logistic regression analysis investigated the likelihood of microbial growth based on location types, with odds ratios calculated to determine the risk factors for microbial presence. Statistical significance was set at a p-value of less than 0.05.

2.3 Environmental Controls Evaluation

Environmental controls within the operating theatre, including air quality, cleaning solution efficacy, and water safety, were evaluated. The settle plate method assessed pre-operative air quality, while sterility checks confirmed the effectiveness of cleaning agents. Water safety assessments checked for the presence of fecal coliforms and other gram-negative bacilli, with the absence of these pathogens affirming the safety of the hospital's water supply.

3. RESULTS

As detailed in Table 1 below, the percentage distribution of microbial growth types shows a significant proportion of samples (66.67%) demonstrating no microbial growth, which provides some insight into the efficacy of the center's sterilization processes. Notably, however, there remains a presence of microbial growth, with CONS and MRSA each identified in 8.33% of the samples, and acinetobacter spp. having a combined 8.34% as visualized in Fig. 1, representing a persisting challenge in hospital hygiene management.

A focused analysis of personnel hygiene uncovered a 43% incidence of MRSA nasal carriage among staff and this emphasizes the critical need for enhanced hand hygiene and decontamination protocols among the staff. This finding, coupled with the frequency distribution of identified microbial contaminants, suggests targeted areas for intervention, particularly in hand hygiene practices, as depicted in Fig. 2.

Table 1. Percentage distribution of microbial growth types identified in the tertiary medical centre

Growth Type	Percentage (%)
Acinetobacter baumannii	2.78
Acinetobacter iwoffin	5.56
CONS	8.33
CONS; Staphylococcus aureus	2.78
MRCONS	2.78
MRSA	8.33
No growth	66.67
Staphylococcus aureus	2.78

CoNS: coagulase-negative staphylococci
MRCoNS: Methicillin-resistant coagulase-negative staphylococci
MRSA: Methicillin-resistant Staphylococcus aureus

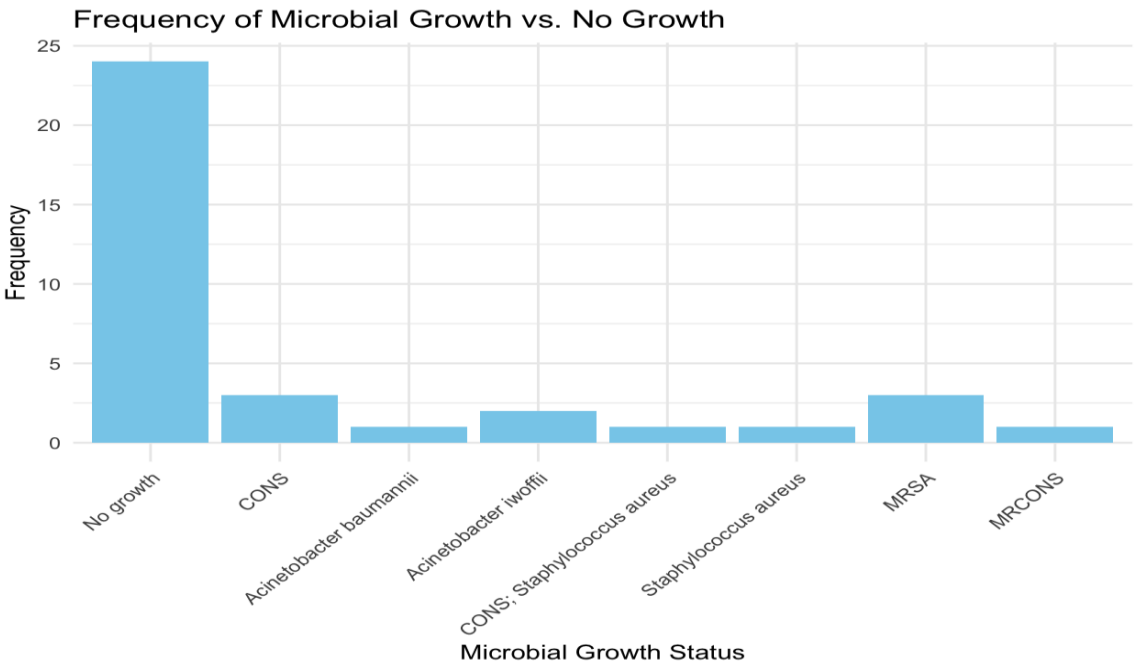

Fig. 1. Frequency of microbial growth status identified in the tertiary medical centre

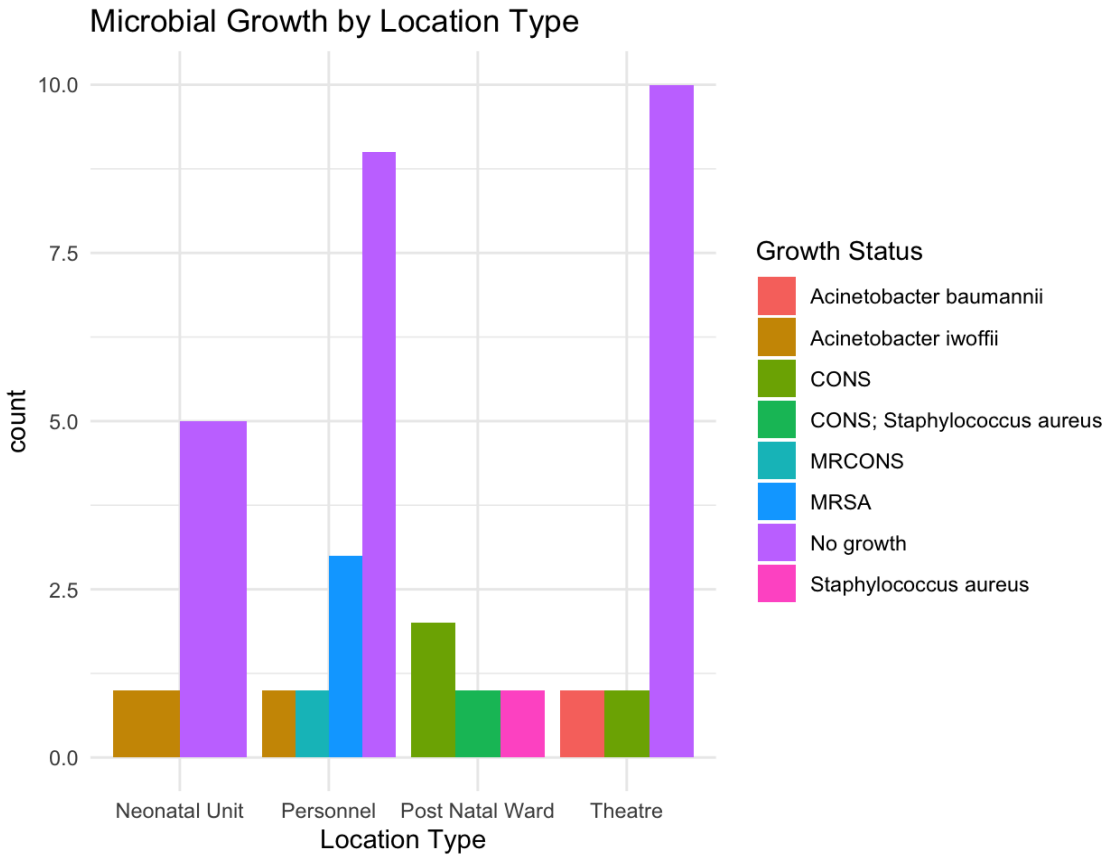

Fig. 2. Count of Microbial growth status across the different types of locations in the tertiary Medical Centre

Further statistical analyses were employed to understand the data more deeply. The ANOVA to compare the mean growth rates between different location types, coded numerically with "No growth" as 0 and "Growth" as 1 revealed significant differences in microbial contamination across various locations within the center ($F(3, 32) = 4.267$, $p = 0.0121$), suggesting that certain areas are more prone to microbial presence. With a p-value less than the conventional alpha level of 0.05, we reject the null hypothesis, indicating that not all location types exhibit the same mean microbial growth. Pearson's Chi-squared test also established this pattern, highlighting a statistically significant association between location type and microbial growth ($X^2(21) = 40$, $p = 0.0074$). In our logistic regression analysis investigating the likelihood of microbial growth based on location types, the model did not identify statistically significant predictors of growth occurrence however the odds ratios suggest that Personnel locations are associated with 2.78 times the odds of growth compared to the theatres but coefficient for Personnel was estimated at 1.022 ($z = 0.831$, $p = 0.406$), also indicating that location of personnel does not significantly increase the odds. Similarly, the Post Natal Ward, with an extreme coefficient estimate of 19.18 and a very large standard error, resulted in a p-value of 0.992, indicating no significant difference from the Theatre. The Theatre location type itself (coefficient effectively zero, $p = 1.000$) served as the reference category and showed no difference within itself as expected.

Susceptibility patterns of the isolates revealed that Staphylococcus aureus exhibited sensitivity to Clindamycin, Levofloxacin, Amikacin, Piperacillin/Tazobactam, and Meropenem, suggesting these antibiotics as effective therapeutic options against this pathogen. However, resistance was noted against Doxycycline, Erythromycin, Ciprofloxacin, and Gentamycin, highlighting a concern for antibiotic stewardship.

Coagulase-negative staphylococci (CONS), often considered less pathogenic but a significant cause of nosocomial infections shared a similar susceptibility pattern with Staphylococcus aureus for Clindamycin and Levofloxacin while indicating intermediate resistance to Ceftriaxone and Gentamycin.

Acinetobacter spp., recognized for their resilience and propensity for antimicrobial resistance, particularly in healthcare settings, showed resistance to Ciprofloxacin and Gentamycin, with intermediate sensitivity to Levofloxacin, Cefotaxime, Ceftazidime, and Ceftriaxone. Such a pattern mandates caution for treatment options and further emphasizes the necessity for judicious use of antibiotics.

In the evaluation of environmental controls within the center's operating theatre, comprehensive microbiological surveillance was conducted, encompassing air quality, cleaning solution efficacy, and water safety assessments. Pre-operative air quality, assessed via the settle plate method, remained within acceptable contamination levels, indicating adequate air hygiene practices before surgical activities. The sterility of cleaning agents - alcohol, savlon, and iodine - was confirmed through rigorous testing, with no microbial agents detected, underscoring their effectiveness in maintaining a sterile surgical environment. Additionally, water safety assessments revealed the absence of fecal coliforms and other routinely monitored gram-negative bacilli, affirming the potability and safety of the hospital's water supply for medical and surgical use. However, comprehensive testing for Legionella and other waterborne pathogens associated with hospital-acquired infections was not performed, highlighting an area for future scrutiny.

4. DISCUSSION

Hospitals and medical centers surfaces are very prone to being reservoirs of significant microbial population as they are commonly contacted by healthcare workers, patients relatives patients, and their bodily fluids including blood, urine, and excreta which often results in infection [15]. The prevalence of MRSA (8.33%) as revealed in this present study is mostly from samples taken from three personnel's noses thus, representing a 43% incidence of MRSA amongst the personnel, which is contrasting with a similar study whose recorded MRSA personnel prevalence was 23.6. [16]. Acinetobacter species (8.34%) were cultured from samples obtained from a personnel’s hands (A. iwoffi), and resuscitaire in the Neonatal Unit (A. iwoffi) which suggests that an exchange must have occurred between the personnel and the resuscitaire as a result of usage. Interestingly, Vishal B Shete et al. reported that out of 240 neonatal septicemia cases in their blood-based study, Acinetobacter species were found in 26 instances, accounting for 10.8% of the cases. Among these, the

majority, 84.6% were classified as Acb complex strains, while the remaining 15.4% were identified as Acinetobacter lwoffi. This establishes the fact that Acinebacter is a cause of severe neonatal sepsis and the finding of this pathogen in the Neonatal unit, specifically the Resuscitaire raises serious concerns about the safety of neonates in the center.

Acinetobacter baumannii was also cultured from a sample from the suction machine hose in the theatre, which points to either a sub-optimal personal hygiene practice of the medical doctors and nurses and/or personnel generally, a deficient institution-wide standard hygiene protocol for staff and equipment and/or refusal of personnel to adhere to already existing hygiene protocols. Similar to these findings, another study [17] conducted in a tertiary care hospital in Pokhara, Nepal, reported a significant contamination rate of frequently touched objects, including door handles and biometric attendance devices, with MRSA and Acinetobacter species, further establishing their role as commonly spread pathogens in the hospitals and medical centers, indicating poor hygienic practices and brings to light the fact that these institutions can be a source and transmission route of these pathogens and resistance.

Regarding sensitivity and resistance of these pathogens to some antibiotics, our findings demonstrated MRSA's resistance against Doxycycline, Erythromycin, Ciprofloxacin, and Gentamycin, while S. aureus showed sensitivity to Clindamycin, Levofloxacin, Amikacin, Piperacillin/Tazobactam, and Meropenem. Similarly, the study from Addis Ababa reported high resistance levels of Gram-positive bacteria to penicillin and erythromycin but showed low-level resistance to Gentamicin and vancomycin which contrasts with our finding. Additionally, our revealed acinetobacter spp resistance to gentamicin and ciprofloxacin which is also corroborated by a similar resistance pattern by acinetobacter spp in the Addis Ababa study [18].

5. CONCLUSION

This study highlights the high prevalence and antibiotic resistance of MRSA and Acinetobacter spp. among healthcare personnel and neonatal units in a tertiary medical center. The findings indicate significant microbial contamination, particularly in personnel and neonatal areas, emphasizing the critical need for improved hygiene protocols. Despite some effective sterilization practices, the persistent presence of these pathogens underscores gaps in infection control measures. The association between personnel hygiene and pathogen carriage rates points to areas requiring targeted interventions. Comprehensive and continuous microbiological surveillance is essential to monitor and mitigate infection risks, ensuring safer healthcare environments.

6. RECOMMENDATIONS

To address the challenges identified in this study, it is crucial to implement targeted and practical recommendations that can significantly improve infection control measures and hygiene protocols within healthcare facilities.

6.1 Enhancing Hygiene Protocols Among Healthcare Personnel

Improving hygiene protocols, particularly among healthcare personnel, is of paramount importance. Healthcare workers are at the frontline of patient care and often come in contact with various pathogens. Therefore, mandatory regular training sessions on proper hand hygiene techniques and the consistent use of personal protective equipment (PPE) should be established. These training sessions should provide detailed instruction on the critical role of hand hygiene in preventing the spread of infections, focusing on the correct handwashing procedures, the use of alcohol-based hand sanitizers, and the proper techniques for donning and doffing PPE to minimize contamination risks. Incorporating practical demonstrations, compliance monitoring, and feedback mechanisms into these sessions can reinforce the importance of these practices and ensure adherence. By ensuring that all healthcare workers are well-informed and consistently practicing these protocols, the risk of pathogen transmission can be significantly reduced, leading to a safer healthcare environment for both patients and staff.

6.2 Strengthening Environmental Controls within the Hospital

Effective environmental controls are essential to reduce the risk of healthcare-associated infections. This involves enhancing sterilization practices in high-risk areas such as neonatal units and operating theatres. Implementing systematic and standardized protocols for

cleaning and disinfection is crucial. Routine assessments of these protocols should be conducted to ensure their efficacy, which includes regular testing of disinfectants to confirm their ability to eliminate microbial contaminants on surfaces and equipment. Additionally, employing advanced cleaning technologies, such as ultraviolet (UV) light disinfection or vaporized hydrogen peroxide systems, can further enhance the decontamination process. Training cleaning staff on the latest techniques and ensuring they have access to appropriate protective gear and cleaning supplies can also improve outcomes. By addressing these aspects, hospitals can significantly reduce the microbial load in critical areas, thereby lowering the risk of infection transmission.

6.3 Developing and Enforcing Antibiotic Stewardship Programs

The rational use of antibiotics is crucial in combating the rise of antibiotic-resistant pathogens. Developing and enforcing antibiotic stewardship programs within the hospital can help monitor and regulate antibiotic use. These programs should involve a multidisciplinary approach, including input from infectious disease specialists, pharmacists, and microbiologists, to oversee antibiotic prescribing practices. Regular reviews of antibiotic prescriptions should be conducted to ensure that antibiotics are used appropriately based on current clinical guidelines and local susceptibility patterns. Implementing protocols for de-escalation of therapy and duration of treatment can prevent overuse and misuse of antibiotics. Additionally, educating healthcare providers on the principles of antibiotic stewardship and resistance patterns can foster more judicious use of these medications. By promoting the rational use of antibiotics, healthcare facilities can preserve the effectiveness of existing treatments and curb the development of resistant strains.

6.4 Establishing Regular Microbiological Surveillance

Implementing ongoing microbiological surveillance is vital for identifying and tracking microbial contamination trends within the hospital. Regular sampling from various hospital sections, including personnel, equipment, and surfaces, should be performed. This surveillance should be systematic and comprehensive, covering all areas of the hospital, with a particular focus on high-risk zones such as intensive care units, operating theatres, and neonatal wards. Data collected from these samples should be analyzed to identify trends in contamination and resistance patterns. Establishing a central database to record and monitor these findings can facilitate early detection of potential outbreaks and guide targeted interventions. Sharing surveillance data with relevant healthcare teams can help in formulating effective infection control strategies, adjusting cleaning protocols, and modifying treatment approaches as necessary. Continuous surveillance provides valuable data that can inform infection control strategies, enhance response measures, and ultimately improve overall healthcare safety.

By focusing on these key areas, healthcare facilities can develop a robust framework for infection control, ultimately reducing the prevalence of healthcare-associated infections and improving patient outcomes.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ETHICAL APPROVAL AND CONSENT

As per international standards or university standards written ethical approval has been collected and preserved by the author(s). Informed consent was obtained from all participating staff members, and the study's purpose and procedures were transparently communicated to all stakeholders involved.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Somengil. Hospital hygiene: 5 good practices that promote patient health. Blog - Somengil: Soluções Para Lavagem Industrial De Alta Performance; 2023, June 9.
Available:https://blog.somengil.com/hospitalhygiene/#:~:text=Hospital%20hygiene%2

0refers%20to%20the,patients%2C%20healthcare%20workers%20and%20visitors
2. Maki DG, Crnich C, Safdar N. Nosocomial infection in the intensive care unit. In Elsevier eBooks. 2008;1003–1069. Available:https://doi.org/10.1016/b978-032304841-5.50053-4
3. Ibe C, Onyeagba RA, Ugochukwu SC. Antibiotic resistance patterns and plasmid profiles of methicillin resistant staphylococcus aureus Isolates from Human Samples. Microbiol. Res. J. Int. 2013 Oct. 23 [cited 2024 May 28];4(2):185-94. Available:https://journalmrji.com/index.php/MRJI/article/view/801
4. Cascioferro S, Carbone D, Parrino B, Pecoraro C, Giovannetti E, Cirrincione G, Diana P. Therapeutic strategies to counteract antibiotic resistance in MRSA biofilm-associated infections. Chem Med Chem. 2021 Jan 8;16(1):65-80.
5. Bencko V, Schejbalová M. From Ignaz Semmelweis to the present: Crucial problems of hospital hygiene. Indoor and Built Environment. 2006;15(1):3–7. Available:https://doi.org/10.1177/1420326x06062362
6. Mahmoodi H, Shaghaghi A, Sarbakhsh P, Janati A. Hospital hygiene and infection prevention and control in Italy: State of the art and perspectives. PubMed. 2018;30(5 Supple 2):1–6. Available:https://doi.org/10.7416/ai.2018.2245
7. Rampling A, Wiseman SW, Davis L, Hyett AP, Walbridge A, Payne G, Cornaby A. Evidence that hospital hygiene is important in the control of methicillin-resistant Staphylococcus aureus. Journal of Hospital Infection. 2001;49(2):109–116. Available:https://doi.org/10.1053/jhin.2001.1013
8. Bax R, Bywater R, Cornaglia G, Goossens H, Hunter P, Isham V, Jarlier V, Jones RN, Phillips I, Sahm DF, Senn S, Struelens M, Taylor DR, White AR. Surveillance of antimicrobial resistance — what, how, and whither? Clinical Microbiology and Infection. 2001;7(6):316–325. Available:https://doi.org/10.1046/j.1198-743x.2001.00239.x
9. Najotra DK, Malhotra AS, Slathia P, Raina S, Dhar A. Microbiological surveillance of operation theatres: Five-year retrospective analysis from a Tertiary Care Hospital in North India. International Journal of Applied & Basic Medical Research. 2017 Jan 1;7(3):165. Available:https://doi.org/10.4103/ijabmr.ijabmr_281_16
10. Emori TG, Gaynes RP. An overview of nosocomial infections, including the role of the microbiology laboratory. Clinical Microbiology Reviews. 1993 Oct 1;6(4):428–42. Available:https://doi.org/10.1128/cmr.6.4.428
11. Kalenić S, Budimir A. The role of microbiology laboratory in healthcare-associated infection prevention. International Journal of Infection Control. 2009 Aug 5;5(2). Available:https://doi.org/10.3396/ijic.v5i2.014.09
12. Holmen IC, Niyokwizerwa D, Nyiranzayisaba B, Singer T, Safdar N. Challenges to the sustainability of hand hygiene at a rural hospital in Rwanda. American Journal of Infection Control. 2017 Aug 1;45(8):855–9. Available:https://doi.org/10.1016/j.ajic.2017.04.006
13. Mohamed M, Ali A. Hospital hygiene challenges: An overview of issues and solutions. Journal of analytical sciences and applied biotechnology. 2023;5(1):46–52.
14. Peters A, Otter JA, Moldovan A, Parneix P, Voß A, Pittet D. Keeping hospitals clean and safe without breaking the bank; summary of the Healthcare Cleaning Forum 2018. Antimicrobial Resistance and Infection Control. 2018 Nov 8;7(1). Available:https://doi.org/10.1186/s13756-018-0420-3
15. Mann EE, Manna D, Mettetal MR, May RM, Dannemiller EM, Chung KK, et al. Surface micropattern limits bacterial contamination. Antimicrob Resist Infect Control. 2014;3:28.
16. Citak S. Nasal carriage and methicillin resistance of Staphylococcus aureus in patients and hospital staff in a tertiary referral center setting. Afr J Microbiol Res. 2011;5(13):1618. Available:https://academicjournals.org/article/article1380102787_Citak%20et%20al.pdf
17. 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. 2018;7(1). Available from: http://dx.doi.org/10.1186/s13756-018-0385-2

18. Sebre S, Abegaz WE, Seman A, Awoke T, Desalegn Z, Mihret W, et al. Bacterial profiles and antimicrobial susceptibility pattern of isolates from inanimate hospital environments at Tikur Anbessa Specialized Teaching Hospital, Addis Ababa, Ethiopia. Infect Drug Resist. 2020;13:4439–48. Available:https://www.dovepress.com/terms.php

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