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Methicillin Resistant *Staphylococcus aureus* nasal carriage among apparently healthy University Students

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Abstract

Medical and paramedical students are often exposed to MRSA colonization and infection during clinical postings. They may serve as reservoirs or vector and occasionally as victims of MRSA cross-contamination. This study was designed to determine the rate of MRSA nasal carriage among apparently healthy undergraduate medical students of Usmanu Danfodiyo University Sokoto. A questionnaire was administered to collect demographic data and health history of the recruited participants. Swab sticks pre-moistened with sterile physiological saline was used to collect samples from the nasal cavities of the participants. The collected samples were processed using standard microbiological techniques. The presence of MRSA was determined using the Oxacillin resistance screening agar base test (ORSAB). The susceptibility of the MRSA isolates to commonly prescribed antibiotics was carried out using the disc diffusion method. A total of 200 participants were recruited from medical and allied faculties. The participants comprised of 120 clinical students and 80 pre-clinical students. The mean age of the study participants was 23.32±1.76 years. Majority of the participants were males 119 (59.5 %). Overall, 77 (38.5 %) of the study participant were found to be nasally colonised with MRSA. The carrier rate was higher among the male (61.0 %) and participants aged less than 20 years (79.2 %). Equally, higher MRSA colonisation rate was observed among the students of faculties of medicine (27.3 %) and nursing (22.1 %) and predominantly among the clinical students (53.2 %). Clinical students and students who visited

the hospital more than four time in a month were 0.72 (95% CI, 0.394-1.328) and 0.61 (95% CI, 0.325-1.136) times more likely to carry MRSA, respectively. The MRSA isolates were highly resistant to all the tested antibiotics (72-100 %). The MRSA nasal carriage rate among medical and paramedical students of Usmanu Danfodiyo University Sokoto is high. The finding of this study has important implication on public health. Thus, urgent steps should be taken to improve infection control practices in the study area.

Keywords: MRSA, Nasal colonisation, *Staphylococcus aureus*, Nigeria

Introduction

Staphylococcus aureus (*S. aureus*) is one of the pathogens of great concern due to its inherent virulence, its ability to cause various life-threatening infections and its capacity to adapt to different environmental conditions. It is a Gram-positive, facultative anaerobic bacterium, usually part of human body's microflora. The bacterium is highly versatile and infectious opportunistic pathogen for humans and animals, responsible for a variety of infections, such as superficial lesions, toxic shock syndrome, systemic and a number of life-threatening diseases. More worrisome is the methicillin resistant *S. aureus* (MRSA) because of its propensity for antibiotic resistance, exhibiting resistance to multiple classes of antimicrobial agent . This has been classified as high priority pathogens requiring urgent global attention and action by the World Health Organization . The total hospital cost among inpatients with MRSA was 1.12-6.25 times higher than that for patients with methicillin susceptible strains .

Without prejudice to other routes of transmission, transmission of MRSA is mainly via person-to-person contact. The in-patients and hospital staff are the main reservoirs of *S. aureus* with squamous epithelium of anterior nares as the main ecological niche and most colonized site in human body . Of the general population, 1.5% are asymptomatic nasal carriers of MRSA and the prevalence among health care workers is about 3 times higher . A 1.8% MRSA nasal colonization rate has been reported among healthcare workers in the United States and Europe . Similarly, among healthcare workers in India, a 7.5% MRSA nasal carriage rate has been documented particularly among the nursing staff . In Nigeria, a 13.6% rate of MRSA has been documented among healthcare workers with higher preponderance among clinical staff than the non-clinical staff.

Students are often neglected component of healthcare workforce worldwide, undergoing training and rendering non-essential services during clinical posting. They are at the interface between healthcare facilities and communities . These students are exposed to patients and other healthcare workers during their clinical rotation thus predisposing them to colonization and infection with MRSA. Because of their limited knowledge and consciousness of infection control practices, they may serve as reservoirs or vector and occasionally as victims of MRSA cross-contamination . Moreover, they can be one of the major sources of transmission during contact with non-medical students and other members of the public in the community, if infection control measures are not complied.

The MRSA colonization predisposes the carriers to higher risk of subsequent infections . Additionally, colonized individuals have been demonstrated to be essential link in the transmission chain of MRSA in hospitals. Thus, understanding and control of the spread of MRSA is an important strategy for reduction of inter-patient MRSA transmission and horizontal transmission between the hospitals and communities. While the rate of colonization among hospital personnel has been extensively studied in Nigeria . In Sokoto Nigeria, the rate of nasal carriage of MRSA among students

studying medical and allied courses in Sokoto is currently unknown. In the present study, we investigated the rate of MRSA nasal carriage among undergraduate students of medical and allied faculties in Usmanu Danfodiyo University Sokoto, Nigeria.

Materials and methods

Population Study

This study was conducted among undergraduate medical and paramedical students of Usmanu Danfodiyo University Sokoto (UDUS), Nigeria. The University has three campuses with medical and paramedical students sharing hostel facilities within the Usman Danfodiyo University Teaching Hospital (UDUTH) complex. The students are routinely posted on clinical posting from the third year of their study to observe and learn basic clinical skills within the teaching hospital. These students are often exposed to patients and other healthcare workers during their clinical rotation thus predisposing them to colonization and infection with MRSA.

Ethical approval and consent to participate

The approval to conduct this study was granted by the Sokoto State Ministry of Health (Reference number: SMH/2019/1280/V). Written informed consent was also sought from the study participants after carefully briefing them on the objective of the study. Student who declined consent to participate were excluded from the study.

Study design and participant recruitment

This comparative study was carried out among medical and paramedical students (Pharmacy, Nursing, Medical Laboratory Science and Radiography) of Usmanu Danfodiyo University, Sokoto. Eligible participants were pre-clinical (Undergraduates, UG 1-3) and clinical (UG 4 to 5). Eligible participants were recruited after briefing them on the objectives of the study and assuring them that the procedure for sample collection does not pose any hazard to their health.

Data collection

A questionnaire was administered to collect demographic data and health history of the participants. Data collected include age, year of study, gender, any underlying disease condition,

hospitalization in the past one year, skin infections, antibiotic use in the past four weeks prior to sample collection, habitual behaviour such as nose-picking, more than four times a month visit to the hospital.

Selection criteria

Students from the five medical and allied faculties with no apparent respiratory diseases who consented to participate in this study were included. Students that do not give consent and also those having apparent respiratory diseases such as running nose, bronchitis, etc. were excluded from the study.

Sampling and sample collection

Convenient sampling technique was employed. Commercially available swab sticks pre-moistened with sterile physiological saline was used to collect samples from the anterior nares of nasal cavities of the participants. The collected samples were transported within an hour of collection in an ice pack to the Microbiology Laboratory of the Faculty of Pharmaceutical Sciences for culturing and further analysis.

Culturing, Isolation and identification

Each swab collected from nasal cavities was inoculated into Petri-dishes containing mannitol salt agar (Oxoid Limited, UK) and incubated at 37°C for 24 hours. Bacterial isolates that grew on the mannitol salt agar were subjected to Gram staining, catalase and coagulase tests as described. The identity of the isolates was confirmed by Microgen™ Staph-ID System kit (Microgen, Surrey, UK). The *S. aureus* isolates were inoculated onto Oxacillin resistant screening agar (ORSAB) plate (Oxoid, UK) and the resultant isolates after overnight culture were regarded as MRSA and the cultures were preserved in agar slant for further characterisation.

Antibiotic susceptibility test

The isolates were subjected to antibiotic susceptibility using the disc diffusion method according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. The disc of antibiotics used includes those recommended by the CLSI and/or those most commonly used locally for empirical treatment of *S. aureus* infections. This includes amoxicillin-

clavulanate (30µg), ciprofloxacin (5µg), gentamycin (30µg), chloramphenicol (30µg), azithromycin (15µg), trimethoprim/sulphamethoxazole (25µg). Interpretation of results as susceptible, intermediate or resistant was carried out according to the criteria recommended by the CLSI guideline.

Statistical analyses

Statistical analysis was performed using SPSS version 20 (IBM Corporation). Pearson's χ^2 test or Fisher's exact test was used for data comparison. Multivariable logistic regression was performed to estimate risk of MRSA carriage. Independent variables with p-value > 0.2 in the bivariate analysis were included in a multivariable model. At 95% confidence interval, $p < 0.05$ was considered as statistically significant.

Result

Socio-demographic characteristics of the study participants

A total number of 200 students participated in this study (Table 1). Forty participants each (20.0 %) were sourced from each of the five medical related faculties. The participants included 120 (60.0 %) clinical students carrying out clinical rotation at various departments in the hospital and 80 (40.0 %) pre-clinical students who have not yet been exposed to clinical posting. The mean age of the study participants was 23.32 ± 1.76 years (Range, 19-30 years). Majority of the participants were males 119 (59.5 %) with a male to female ratio of 1.47 to 1. Out of the 200 participants recruited for this study, 9 (4.5 %) were hospitalized within the last six months, 46 (23.0 %) have used antibiotics in the last four weeks and 79 (39.5 %) have visited hospitals more than four times for various reasons within the last one month. A total of 54 (27.0 %) participants admitted to having habitual behaviour such as nose-picking.

MRSA Carriage Among Study Participants

Overall, 77 (38.5 %) of the 200-study participants were found to be colonised with MRSA. The carrier rate was higher among the male (61.0 %) than the female (39.0 %) participants (Table 2). Equally, higher MRSA colonisation rate was observed among the participants aged less than 20 years (79.2 %).

Comparison of nasal carriage rates across different faculties showed that medical (27.3 %) and nursing (22.1 %) students had the highest colonisation rate. Also, the colonisation rate was higher among the clinical students (53.2 %) compared to their pre-clinical counterparts (46.8). However, statistical comparison revealed that no significant difference ($p>0.05$) was observed between the colonisation rates and the various stratified parameters, despite different prevalence percentages.

Predictors of MRSA carriage among study population

In bivariate analysis, no significant difference ($p>0.05$) was found between MRSA carriage and the various stratified parameters. In multivariate analysis, clinical students and students who visited the hospital more than four time in a month were 0.72 (95% CI, 0.394-1.328) and 0.61 (95% CI, 0.325-1.136) times more likely to carry MRSA. However, no significant difference ($p>0.05$) was observed between the colonisation rates and other parameters (Table 2).

Table 1: Demographic and Clinical Characteristics of Participants

Variable	Number of participants
<i>Gender</i>	
Female	81
Male	119
<i>Age (years)</i>	
20-24	159
25-29	40
>30	1
<i>Faculties/Departments</i>	
Medicine	40
Med. Lab. Science	40
Nursing	40
Pharmacy	40
Radiography	40
<i>Level of study</i>	
Clinical	120
Pre-clinical	80
<i>Any underlying disease conditions</i>	
No	196
Yes	4
<i>Hospitalization in the past one year</i>	
No	191
Yes	9
<i>Antibiotic use for the past four weeks</i>	
No	154
Yes	46
<i>Visit to hospital more than four times in a month</i>	
No	121
Yes	79
<i>Habitual behaviour (nose-picking)</i>	
No	146
Yes	54

Table 2: Predictors of MRSA carriage among study population

Variables	MRSA carriage (n, %)		OR (95% IC)	p-value*	aOR(95% CI)	p value
	NO	YES				
Gender				0.7258		NA
Female	51(41.5)	30(39.0)	1			
Male	72(58.5)	47(61.0)	1.10(0.620 - 1.985)			
Age				0.2548		NA
(19,25]	111(90.2)	73(94.8)	1			
(25,30]	12(09.8)	4(05.2)	0.50(0.157-1.632)			
Visit to hospital more than four time in a month				0.0577		0.1232
No	68(55.3)	53(68.8)	1		1	
Yes	55(44.7)	24(31.2)	0.559(0.307-1.019)		0.61(0.325-1.136)	
Hospitalization in the past one year				0.98387		NA
No	114(92.7)	77(100.0)	1			
Yes	9(07.3)	0	9.4e-08(0)			
Antibiotics use in the past four weeks				0.42976		NA
No	97(78.9)	57(74.0)	1			
YES	26(21.1)	20(26.0)	1.30(0.670-2.554)			
Level of study				0.124		0.2956
Preclinical	44(35.8)	36(46.8)	1		1	
Clinical	79(64.2)	41(53.2)	0.63(0.355-1.132)		0.72(0.394-1.328)	

Variables with p < 0.2 were included in the saturated multivariable regression model. p-values are only shown for variables included in the multivariable regression model. For variables not included we show p = NA (Not Applicable). OR: odds ratio; aOR: adjusted odds ratio; 95% CI:

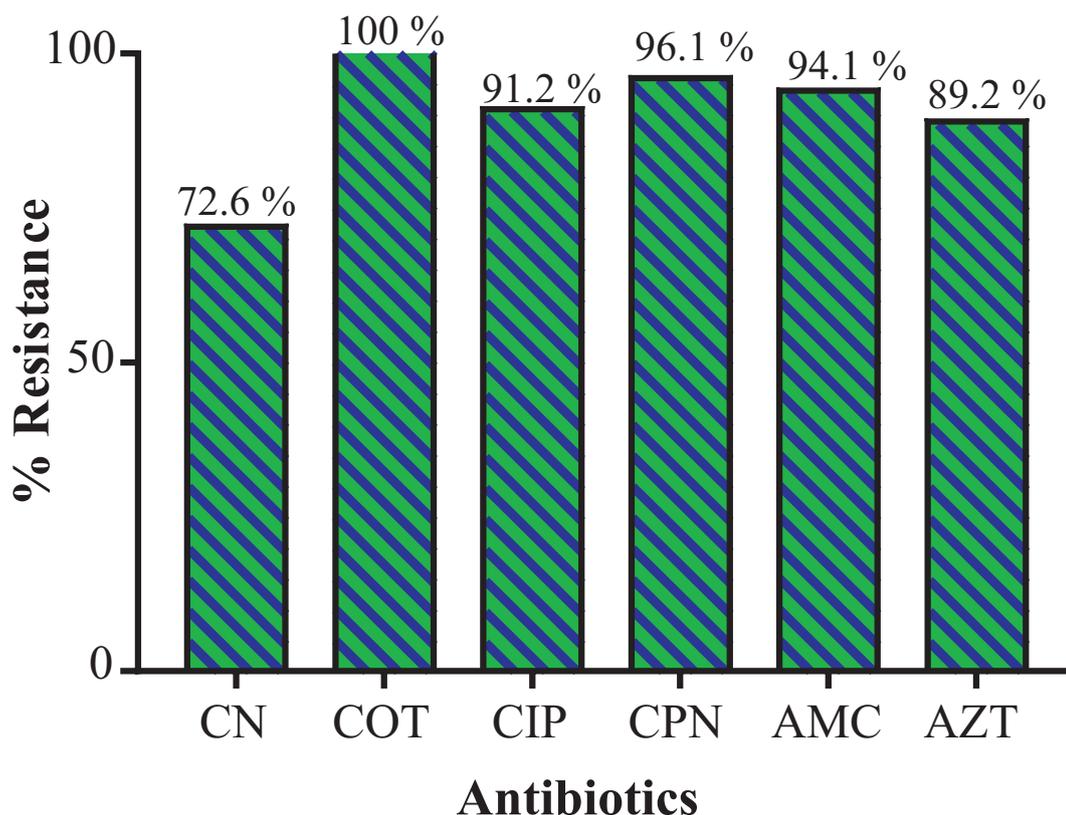


Figure 1: Antibiotics susceptibility profile of the MRSA isolates

Key: CN, Gentamicin; COT, cotrimoxazole; CIP, ciprofloxacin; CPN, chloramphenicol; AMC, amoxicillin-clavulanate; AZT, azithromycin.

Antimicrobial Susceptibility Pattern of MRSA isolates

The MRSA isolates were highly resistant to all the tested antibiotics (Figure 1). Highest resistance rate was observed against trimethoprim/sulphamethoxazole (100 %), chloramphenicol (96.8 %) and amoxicillin/ clavulanic acid (94.1 %). The least resistance rate was observed against gentamicin.

Discussion

Methicillin resistant *S. aureus* is an important pathogen in both community and hospital settings. Individuals nasally colonised with MRSA are more prone to self-contamination and eventually infections due to MRSA than un-colonised individuals . This study investigated MRSA nasal colonization rate among undergraduate students of medical and allied faculties in a tertiary education institution in Sokoto, Nigeria.

Results from this study showed that the overall nasal carriage rate of MRSA in the study area

was 38.5 %. Our finding is comparable to the 18.3% to 42.3% MRSA prevalence reported in a systematic review of MRSA in Nigeria . Different carriage rates have been reported by other researchers. For example, 45.9% in Ecuador, 31.0% in Malaysia , 18.7 % in Saudi Arabia and 3.1 % in South Korea . In another study, none of the medical students investigated were found to be nasally colonised with MRSA . Comparatively, a lower rate has been reported among non-medical students. The varying prevalence rate reported in various studies could be attributed to differences in hygiene practices and infection control and prevention policies in the various study centres. The higher MRSA colonisation rate reported in this study may be as a result of vertical transmission in over-crowded student's hostels. Students in Nigeria mostly reside in overcrowded hostels . Crowded environment has been linked with higher MRSA colonisation, vertical transmission and infections.

In this study, we found no significant difference between colonization rate and gender ($p > 0.05$). A higher MRSA carriage rate was however observed among the males than the females. Our results are in agreement with many previous works. The higher colonisation rate reported among the males may be due to low hand hygiene behaviour prevalent among the males. A more positive attitude and compliance with hand hygiene has been documented among the females than the males. Males are thus more susceptible to MRSA colonisation than the female. Contact sport and other outdoor games may further facilitate the transmission of the infections among the males than the females.

Among the studied groups, higher prevalence rate was observed among the clinical students. This result was comparable with finding in a previous report. The higher prevalence observed among the clinical students may be due to higher exposure of the clinical students to nasal colonisation during clinical posting. Similarly, this could account for higher colonisation rate observed among the medical and nursing students compared to their pharmacy and laboratory science counterparts, since these students visit hospital more frequently during clinical posting, have longer stay in the hospital environment and have more contact time with the patients and other healthcare professionals. An association has been established between the exposure to healthcare settings and colonization with MRSA among medical students. Although, no significant statistical association was found between more than four visit to hospital a month and MRSA colonisation rate, frequent hospital visit has been shown to be significantly associated with MRSA colonisation rate.

In this study, significant statistical association was not found between the nasal MRSA carriage rate and recent hospitalization and antibiotic use. In another centre in Nigeria, strong correlation has been established between these factors.

The high resistance (72-100 %) of the isolates to commonly prescribed anti-staphylococci antibiotics is not surprising. MRSA isolates are known to be highly resistant to several important antibiotics. A systematic review has reported that

Nigerian MRSA isolates are highly resistant to commonly prescribed orally available antibiotics. Antibiotics overuse, often inappropriately and without prescription, is a common drug use problem in Nigeria. This overuse drives selection pressure which often results in antibiotic induced gene expression, and emergence of multidrug resistant bacteria. Genomic analysis of a MRSA strain revealed that it contains about 29 genes associated with antibiotic resistance.

This study is limited by a number of factors. Majorly, the investigations are mainly phenotypic. This is common to studies in resource-limited settings such as Africa. Investigation of molecular basis of the observed resistance is the focus of our future studies. Also, for the same reason as above, the resistance of the MRSA strains was tested against a limited number of antibiotics.

Conclusion

The MRSA nasal carriage rate among medical and paramedical students of Usmanu Danfodiyo University Sokoto is high. The finding of this study has important implication on public health. Thus, urgent steps should be taken to improve infection control practices in the study area.

Data availability

All relevant raw data are available on: <https://doi.org/10.6084/m9.figshare.13394231.v1>

Competing interests

No competing interests were disclosed.

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Reference

- Abubakar, U. and Sulaiman, S.A.S. (2018). Prevalence, trend and antimicrobial susceptibility of Methicillin Resistant Staphylococcus aureus in Nigeria: A systematic review. *Journal of Infection and Public Health*; 11(6): 763 -770.
- Akerele, J., Obasuyi, O. and Omede, D. (2015).

- Prevalence of Methicillin-Resistant *Staphylococcus aureus* among Healthy Residents of Ekosodin Community in Benin-City, Nigeria. *Tropical Journal of Pharmaceutical Research*; 14: 1495 -1499.
- Albrich, W.C., Harbarth, S. and Bern, H. (2008). Health-care workers: Source, vector, or victim of MRSA? *Lancet Infectious Diseases*; 8: 289 -301.
- Ali, M.S., Isa, N.M., Abdelrhman, F.M., Alyas, T.B., Mohammed, S.E., Ahmed, A.E., Ahmed, Z.S.A., Lau, N., Garbi, M.I., Amirul, A.A., Seed, A.O., Omer, R.A. and Mohamed, S.B. (2019). Genomic analysis of methicillin-resistant *Staphylococcus aureus* strain SO-1977 from Sudan. *BMC Microbiology*; 19(126): 1 -9.
- Aluko, O.E. (2011). The Assessment of Housing Situation among Students in the University of Lagos. *Arica Research Review*; 5(20): 104 -118.
- Arachchige, J., Sampath, A., Pilapitiya, S. and Kumbukgolla, W. (2020). The relationship between the exposure to healthcare settings and colonization with methicillin-resistant *Staphylococcus aureus* among medical students. *GERMS*; 10(1): 34 -43.
- Ayepola, O.O., Taiwo, S.O., Anifowose, A. and Onile-ere, O. (2018). Nasal Carriage of *Staphylococcus aureus* and Associated Risk Factors among Students in a Nigerian University. *Acta Scientific Microbiology*; 1(2): 6 -8.
- Badger-emeka, L.I. and Emeka, P.M. (2018). Evaluation of the extent and reasons for increased non-prescription antibiotics use in a University town, Nsukka Nigeria. *International Journal of Health Sciences*; 12(4): 11-17.
- Baek, Y.S., Dds, S.B. and Dds, Y.Y. (2016). Higher nasal carriage rate of methicillin-resistant *Staphylococcus aureus* among dental students who have clinical experience. *The Journal of the American Dental Association*; 12: 1 -6.
- Beltrán, M.A., García, H., Couso, M., Gallo, M.D., Lettieri, A. and Barna, P.V. (2018). Relationship between Overcrowding, Other Markers of Poverty and Community Acquired Methicillin Resistant *Staphylococcus aureus*. *Journal of Infectious Diseases and Therapy*; 6(2): <https://doi.org/10.4172/2332-0877.1000359>
- M100S Performance Standards for Antimicrobial Susceptibility Testing, (2019) (testimony of CLSI).
- Cowan, T. and Steel, K. (1993). *Cowan and Steel manual for the identification of medically important bacteria* (Barrow, G.I. and Feltham, R.K.A. Éds.; 3rd éd.). Cambridge University Press.
- Dulon, M., Peters, C., Schablon, A. and Nienhaus, A. (2014). MRSA carriage among healthcare workers in non-outbreak settings in Europe and the United States: A systematic review. *BMC Infectious Diseases*; 14: 363. <https://doi.org/10.1186/1471-2334-14-363>
- Egwuatu, T.O. and Oduyebo, O.O. (2013). Prevalence and Risk Factors for Carriage of Methicillin-Resistant *Staphylococcus aureus* (MRSA) among Healthcare workers in a tertiary Prevalence and Risk Factors for Carriage of Methicillin-Resistant *Staphylococcus aureus* (MRSA) among Healthcare worke. *IOSR Journal of Dental and Medical Sciences*; 8(4): 9 -13.
- Fadeyi, A., Bolaji, B., Oyedepo, O.O. and Adesiyun, O.O. (2010). Methicilin Resistant *Staphylococcus aureus* Carriage amongst Healthcare Workers of the Critical Care Units in a Nigerian Hospital Methicilin Resistant *Staphylococcus aureus* Carriage amongst Healthcare Workers of the Critical Care Units in a Nigerian Hospit. *American Journal of Infectious Diseases*; 6(1): 18 -23.
- Graber, C. J. (2017). Route of transmission of *Staphylococcus aureus*. *The Lancet Infectious Diseases*; 17(2): 124 - 125. [https://doi.org/10.1016/S1473-3099\(16\)30512-6](https://doi.org/10.1016/S1473-3099(16)30512-6).
- Hodges, N.A. (2004). *Hugo and Russell's Pharmaceutical Microbiology* (Denyer, S., Hodges, N.A. and Sean P. Gorman, Éds.; 7th éd.). Blackwell Publishing Company.
- Hogan, B., Rakotozandrindrainy, R., Al-emran, H., Dekker, D., Hahn, A., Jaeger, A., Poppert, S., Frickmann, H., Hagen, R. M., Micheel, V., Crusius, S., Heriniaina, J. N., Rakotondrainiarivelo, J. P., Razafindrabe, T., May, J. and Schwarz, N. G. (2016). Prevalence of nasal colonisation by resistant *Staphylococcus aureus* among healthcare workers and students in Madagascar. *BMC Infectious Diseases*; 16(420): 1 - 9. <https://doi.org/10.1186/s12879-016-1733-6>.

- Humphreys, H., Fitzpatrick, F. and Harvey, B.J. (2015). Gender differences in rates of carriage and bloodstream infection caused by methicillin-resistant *Staphylococcus aureus*. Are they real, do they matter and why? *Clinical Infectious Diseases*; 61(11): 1708 -1714.
- Ike, B., Ugwu, M.C., Ikegbunam, M.N., Nwobodo, D., Ejikeugwu, C., Gugu, T. and Esimone, C. O. (2016). Prevalence, Antibio gram and Molecular Characterization of Comunity-Acquired Methicillin-Resistant *Staphylococcus aureus* in in Awka, Anambra Nigeria Blessing. *The Open Microbiology Journal*; 10: 211 - 221. <https://doi.org/10.2174/1874285801610010211>
- Irfan, N., Mohd, B., Hlaing, S.S., Myint, T., Emran, N.A., Lin, Z., Thein, T.T., Masandid, H., and Aung, T.S. (2016). Nasal Carriage of. *Asian Journal of Pharmaceutics*; 2016(4): 10 -11.
- Jimoh, F.O., Adovi, A.V., Olugbenga, O.O., Akeem, B.O. and Oluseyi, A.E. (2018). Off-Campus Living Among Ekiti State University Students in Southwestern Nigeria: Health and Policy Implications. *Journal of Health and Environmental Research*; 4(2): 77 - 83. <https://doi.org/10.11648/j.jher.20180402.15>.
- Olowo-Okere, A., Atata, R.F., Abass, A., Adeiza Suleiman Shuaibu, U.H.Y. and Nuhu Tanko. (2017). Incidence and Antibiotic Susceptibility Profile of *Staphylococcus aureus* Isolates from Wounds of Patients at Specialist Hospital, Sokoto, Nigeria. *Journal of Medical Bacteriology*; 6(3): 44 -50.
- Shuaibu, S.A. and Onalapo, Josiah Ademola Olayinka, B.O. (2018). Nasal Colonization as a Risk Factor for Staphylococcal Infection: A Systematic Review and Meta-Analysis. *Nigerian Journal of Microbiology*; 32(1): 4220 -4235.
- Singh, N., Mohanty, S., Panda, S. S., Sahoo, S., Pattnaik, D. and Jena, J. (2018). Methicillin resistant *Staphylococcus aureus* (MRSA) carriage among health care workers in a tertiary care hospital in Bhubaneswar. *International Journal of Community Medicine and Public Health*; 5(8): 3276 -3282.
- Stenehjem, E. and Rimland, D. (2013). MRSA nasal colonization burden and risk of MRSA infection. *American Journal of Infection Control*; 41(5): 405 - 410. <https://doi.org/10.1016/j.ajic.2012.07.017.MRSA>
- Ventola, C.L. (2015). The Antibiotic Resistance Crisis Part 1: Causes and Threats. *Pharmacy and Therapeutics*; 40(4): 277 -283.
- Villacrés-granda, I., Coral-almeida, M. and Cifuentes, S.G. (2019). Antibiotic susceptibility profile and prevalence of mec A and lukS-PV/lukF-PV genes in *Staphylococcus aureus* isolated from nasal and pharyngeal sources of medical students in Ecuador. *Infection and Drug Resistance*; 12: 2553 -2560.
- WHO (2017). Global priority list of antibiotic-resistant bacteria to guide research, discovery, and development of new antibiotics.
- Wong, J.L., Siti-Azrin, A.H., Mohd-Fadhli, K. and Siti-Asma, H. (2018). Low prevalence of *Staphylococcus aureus* colonization among dental students in a teaching hospital in Malaysia. *Tropical Biomedicine*; 35(1): 246 -251.
- World Bank. (2016). Drug-Resistant Infections: A Threat to Our Economic Future (Discussion Draft). *World Bank Report*; 2: 1 - 132. <https://doi.org/10.1007/s11947-009-0181-3>
- Zakai, S.A. (2015). Prevalence of methicillin-resistant *Staphylococcus aureus* nasal colonization among medical students in Jeddah, Saudi Arabia. *Saudi Medical Journal*; 36(7): 807 -812.
- Zhen, X., Lundborg, C.S., Sun, X., Hu, X. and Dong, H. (2019). Economic burden of antibiotic resistance in ESKAPE organisms: A systematic review. *Antimicrobial Resistance and Infection Control*; 8(137): 1 -23.

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