PREVALENCE AND ANTIBIOGRAM OF MRSA ISOLATED FROM VARIOUS CLINICAL SPECIMENS IN A TERTIARY CARE HOSPITAL IN PESHAWAR

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ABSTRACT

Methicillin-resistant Staphylococcus aureus (MRSA) is a major hospital-acquired infection, yet its current epidemiology in Pakistan remains unknown. This study aimed to determine MRSA prevalence across wards in Peshawar's Rehman Medical Institute. Microbiologic culture and susceptibility testing were performed on 160 total samples. S. aureus was isolated from 18 samples (11.3%), of which 17 (94.4%) were MRSA. Other pathogens like Enterococcus, Pseudomonas, Klebsiella, and Escherichia coli were also detected at lower frequencies. No bacterial growth occurred in 60% of tested samples. The extremely high MRSA positivity rate among isolated S. aureus demonstrates this multidrug-resistant strain is flourishing in the hospital and underscores the need for improved infection control. Continued surveillance of antibiotic resistance rates is vital to guide interventions against nosocomial MRSA transmission as a public health threat in Pakistan. Further studies should explore genetic and phenotypic bases of local MRSA strains to elucidate antibiotic evasion mechanisms and virulence traits. The study revealed a substantial 94.4% prevalence of MRSA in S. aureus positive samples from hospital patients, indicating antibiotic resistant strains now overwhelmingly dominate in this setting. Such extensive resistance has dire implications for treatment options and underscores how deeply entrenched MRSA has become within the hospital ecosystem, necessitating more aggressive infection control to protect public health.

Key Words: Clinical and Laboratory Standards Institute (CLSI), European centre for disease control (ECDC), Methicillin-resistant Staphylococcus aureus (MRSA).

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INTRODUCTION

Staphylococcus aureus is a coagulase positive, non-motile gram-positive *S. aureus* is certainly the most clinically significant bacteria. *Staphylococcus aureus* is most commonly present in the nasal mucosa. When the body's cutaneous and mucosal barriers are compromised, such as due to chronic skin diseases, chronic wounds, or surgical procedures then *Staphylococcus aureus* can penetrate the body and invade the underlying tissues or the circulation and spread infection. *S. aureus* infection is more likely to affect people with weakened immune system or hospitalized patients with chronic diseases. *MRSA* was initially identified in the United Kingdom in 1961, not long after methicillin was first used in clinical settings. Methicillin was once widely used as an antibiotic, but due to its toxicity, it is no longer available. Instead, related, more stable penicillin-like antibiotics for example oxacillin, and flucloxacillin are used as antibiotics. However, the phrase *"Methicillin-resistant Staphylococcus Aureus*" is still used. *MRSA* has been shown to cause diseases in livestock. Numerous cases were found since the beginning of the 21st century. A number of *S. aureus* clones have evolved into *MRSA* through the horizontal gene transfer of the staphylococcal cassette chromosome mec (SCCmec), a mobile genetic element that encodes the genes mecA or mecC, which give resistance to methicillin and, consequently, to the majority of -lactam antibiotics. *MRSA* frequently exhibits resistance to multiple other antibiotic groups. The amazing ability of *S. aureus* to show resistance to any antibiotic has important effects on both the current and future treatments available for this microorganism (1).

MRSA infections are not restricted to humans but they can also cause infection in domestic and farm animals. *MRSA* is distributed globally but its frequency is different in various regions. The prevalence of *MRSA* is quite high in Pakistan as compared to European countries. It has been reported that the prevalence of *MRSA* in Pakistan is 42 to 51 % (2).

The nasal carriage of *S. aureus* is known to increase the likelihood of developing future endogenous infections and to act as a pathogen transmission vector in medical facilities. In this regard, healthcare professionals, who serve as the link between the hospital and the community, have the potential to make it more difficult to control *S. aureus* in healthcare settings. They might act as reservoirs, victims, or perhaps as vectors of *MRSA* cross-transmission in the healthcare setting. *S. aureus* was susceptible to practically every type of antibiotic created at the beginning of the antibiotic era. But as time went on, many *S. aureus* strains developed a greater level of antibiotic resistance. The appearance of *MRSA* clones in the 1960s marked a turning point in the development of *S. aureus* resistance. *MRSA* is now widespread in many medical setups and hospitals all over the world. (3)

S. aureus can quickly develop resistance to broad-spectrum antibiotics, including quinolones, aminoglycosides, and lactam antibiotics, used in clinical practice to treat severe infections. The majority of *S. aureus* clones in circulation are unsusceptible to methicillin and several other antibiotics. In hospitals and other healthcare settings, as well as in healthy populations who have never been hospitalized, invasive *methicillin-resistant Staphylococcus aureus (MRSA)* infections are a huge challenge. Mec genes (mecA, mecC) on the mobile genetic element known as staphylococcal cassette chromosome mec are linked to methicillin resistance in staphylococci (SCCmec). *MRSA* makes up a sizable fraction of nosocomial infections in Pakistan, and numerous medical kinds of research have shown the growing clinical importance of *MRSA* (4).

S. aureus infections can range from minor to serious skin and soft tissue infections to invasive, even fatal systemic infections. The risk of spreading the disease to other patients and medical personnel increases when individuals who are carrying *MRSA* are admitted. Particularly if there are several strains of antibiotic-resistant bacteria present, such diseases may have grave complications and lethal outcomes. Additional identified risk factors for *MRSA* acquisition include extended hospital stays, outpatient clinic visits, skin or soft tissue infections in patients, employment in healthcare settings, and a history of antibiotic usage. (5).

MRSA is a global problem causing nosocomial infections. According to WHO *MRSA* infections affect 150,000 patients annually in European countries. *MRSA* infection puts an additional economic burden of 380 million euros per year on European countries (6).

It has been investigated that the *MRSA* mortality rate is 20,000 in the USA. *MRSA* mortality rates are higher than AIDS and tuberculosis combined. In the past 10 years, very high increase in the prevalence of *MRSA* has been found. (7).

MRSA infection risk is higher in children, aged individuals, sportsmen, military service members, drug abusers, people living in undeveloped backward urban areas, people with HIV AIDS or cystic fibrosis, and people who are healthcare providers or frequently interact with healthcare

providers, and those living in prison. *MRSA* infection rates spiked from the 1990s to the 2000s. Before the emergence of *Community-acquired MRSA*, it was assumed that only hospitalized populations are infected by *MRSA*, but in the early 1980s cases were reported in those people who have never been hospitalized. (8)

Phenotypic methods: The disk-diffusion method can be used to test for methicillin resistance in pure Staphylococcus aureus cultures that were produced by plating clinical samples on suitable culture media. This procedure comprises either adding a cefoxitin disc to Mueller-Hinton agar or, as advised by the Clinical and Laboratory Standards Institute (CLSI), supplementing MHA with 4 % NaCl and 6 micrograms per millilitre of oxacillin. Oxacillin was first used as the marker antibiotic to find *MRSA*, however, CLSI now advises cefoxitin. To avoid misleading negative results, the disk-diffusion method must strictly adhere to incubating samples at 37° degrees centigrade for 24 hours.

Non-phenotypic methods: RT PCRs tests are used to identify *S. aureus* and the presence of the mecA gene is being used for direct *MRSA* identification from clinical samples. These assays have received widespread validation. In around 1.5 hours, results are obtained (1).

Broad-spectrum antibiotics should not be used indiscriminately to treat *MRSA* infections; instead, the best course of action should be determined by the conclusive findings of an antibiotic sensitivity test. Telavancin and tedizolid, are two new antibiotics that are considered to be more effective against *MRSA* infections. Moreover, a different strategy would be to find compounds that can obstruct the efflux process (9).

2. MATERIAL AND METHODS

The study design was an observational cross-sectional study, conducted at Rehman medical institute (RMI) Peshawar. The duration of our research studies was 3 months from August 2022 to October 2022. Samples were collected only from different wards of RMI hospital, Peshawar. Other than wards for example pharmacy, OPD, Radiology, and Laboratory were excluded. The sample size was collected through the formula $\mathbf{n= \underline{z^2x\ p\ (1-\ p)}\ /\ e^2}$ and our sample size was 160. The age distribution of patients comprised from 1 to 76 years. All samples were collected by non-probability convenient sampling in sterile containers by clinicians using an aseptic technique and transported to the laboratory without delay. All samples were processed according to CLSI guidelines.

2.9 Culture and bacterial identification

Collected samples were inoculated into Chocolate agar (CHA) blood agar (BA), and MacConkey media (MA), Selective media for *S. aureus* was not used. *S. aureus* was identified by standard microbiological techniques.

2.10 Antibiotic susceptibility testing

Antibiotic susceptibility tests of the *S. aureus* isolates were performed by the Kirby-Bauer disk diffusion method in compliance with Clinical and Laboratory Standards Institute (CLSI) guidelines using Mueller-Hinton agar (MHA) standard media. The inhibition zone standards for antimicrobial susceptibility were considered from tables for interpretative zone diameters of CLSI.

2.11 Identification of methicillin-resistant *Staphylococcus aureus* (MRSA) strains

MRSA was identified by using cefoxitin (30 µg) discs Muller Hinton agar. Plates were inoculated with test organisms and cefoxitin (30µg) discs were inserted in the plate and incubated at 37°C. Plates containing cefoxitin discs were read following a 24-hour incubation period. The diameter of the zone of inhibition (ZOI) of growth was recorded and interpreted as susceptible or resistant according to the criteria of CLSI. *S. aureus* isolates were deemed methicillin-resistant when the Zone of inhibition was ≤21 mm with the cefoxitin disc.

2.12 Ethical Consideration

Institutional consent was taken from the department of microbiology at Rehman Medical Institute (RMI) Peshawar, Pakistan. Data is kept confidential and only used for academic purposes.

2.13 Data Analysis

The Statistical Package for Social Sciences software (SPSS) was used to analyse all of the data. Quantitative data were presented in the form of a Pie Chart. A histogram is used for the presentation of Data.

3. RESULTS

The present study showed that prevalence of MRSA in different wards of RMI hospital Peshawar. Out of 160 patients, 74 (46.25 %) were males' patient, and 86(53.75) were female patients. The age distribution of patients comprised from 1 to 76 years. We divided our study population into different age groups. The age group 1 to 15 years comprises 22.5 % of the whole study population while the age groups 16 to 30 years, 31 to 45 years, 46 to 60 years, and 61 to 75 years encompasses 15

%, 15.6 %, 21.3 %, and 18.1 % of our study population respectively.

Out of 160 samples collected, 18 (11.25 %) samples were found *Staphylococcus aureus* positive. Out of 18 *S.aureus* specimens, 17 (94.44 %) were found *MRSA* positive. By using clindamycin disk, moxifloxacin disk, cloxacillin, and erythromycin disks the isolates were detected as MRSA

Other bacteria found were *Enterococcus* (1.9 %), *Pseudomonas aeruginosa* (5.6 %), *Klebsiella pneumonia* (5.6 %), *Enterobacter aerogenes* (3.8 %), *Escherichia Coli* (7.5 %), *Acinetobacter baumannii* (1.9 %), *Citrobacter braakii* (0.6 %), *Proteus mirabilis* (1.3 %) while no growth was reported in 60 % of samples.

Table 1: Gender distribution of the Study population

Serial No.	Patient	Frequency	Percent	Valid Percent	Cumulative Percent
1	Male	73	45.6	45.6	45.6
2	Female	86	53.8	53.8	99.4
3	Gender	1	.6	.6	100.0
4	Total	160	100.0	100.0	100.0

Table 2: Age distribution of the study population

Serial No.	Patients age (Years)	Frequency	Percent	Valid Percent	Cumulative Percent
1	1 to 15	36	22.5	22.5	22.5
2	16 to 30	24	15.0	15.0	37.5
3	31 to 45	25	15.6	15.6	53.1
4	46 to 60	34	21.3	21.3	74.4
5	61 to 75	29	18.1	18.1	92.5
6	above 76	11	6.9	6.9	99.4
7	Age	1	.6	.6	100.0
8	Total	160	100.0	100.0	100.0

Table 3: Sample nature of samples collected

Serial No.	Patients reports	Frequency	Percent	Valid Percent	Cumulative Percent
1	Bile Culture report	1	0.6	0.6	0.6
2	Bronchial Wash Culture Report	1	0.6	0.6	1.3
3	Catheter Tip Culture Report	7	4.4	4.4	5.6
4	CSF Culture Report	9	5.6	5.6	11.3
5	End bronchial Secretion Culture Report	1	0.6	0.6	11.9
6	Fluid Culture Report	5	3.1	3.1	15
7	Fluid Culture sensitivity report	1	0.6	0.6	15.6
8	High Vaginal Swab Culture Report	3	1.9	1.9	17.5
9	Pleural Fluid Culture report	1	0.6	0.6	18.1
10	Pus Culture	2	1.3	1.3	19.4
11	Pus Culture Report	9	5.6	5.6	25
12	Pus Swab Culture	1	0.6	0.6	25.6
13	Pus Swab Culture Report	15	9.4	9.4	35
14	pus swab Culture sensitivity report	2	1.3	1.3	36.3
15	Sample nature	1	0.6	0.6	36.9
16	Sputum Culture Report	8	5	5	41.9
17	Stool Culture Report	11	6.9	6.9	48.8
18	Stool Culture sensitivity report	2	1.3	1.3	50
19	Tissue Culture	1	0.6	0.6	50.6
20	Tissue Culture Report	4	2.5	2.5	53.1
21	Tissue Culture sensitivity report	1	0.6	0.6	53.8
22	Tracheal Secretion Culture Report	4	2.5	2.5	56.3
23	Urine Culture Report	61	38.1	38.1	94.4
24	Urine Culture sensitivity Report	9	5.6	5.6	100
24	Total	160	100	100	100

Table 4: Different bacterial species identified

Serial No.	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
1	*Enterococcus species*	3	1.9	1.9	1.9
2	*Staphylococcus aureus*	18	11.3	11.3	13.1
3	*Pseudomonas aeruginosa*	9	5.6	5.6	18.8
4	*Klebsiella pneumonia*	9	5.6	5.6	24.4
5	*Enterobacter aerogenes*	6	3.8	3.8	28.1
6	*Escherichia coli*	12	7.5	7.5	35.6
7	No growth	96	60.0	60.0	95.6
8	*Acinetobacter baumannii*	3	1.9	1.9	97.5
9	*Citrobacter braakii*	1	.6	.6	98.1
10	*Proteus mirabilis*	2	1.3	1.3	99.4
11	*species identification*	1	.6	.6	100.0
12	Total	160	100.0	100.0	100.0

4. DISCUSSION AND RECOMMENDATION

Methicillin-resistant *S. aureus* also called superbug or bad bug has created a serious concern for healthcare planners as a limited options available to treat *MRSA.* Problems with *MRSA* are not only confined to industrialized countries an alarmingly high rate of *MRSA* infections was also observed in Pakistan in the past decade. Early *MRSA* incidence was reported in Pakistan in 1989 and then its prevalence has been observed to be increasing. Different studies have depicted variations in the prevalence rates of *MRSA* in different countries. Differences in the length of the study period, number of study sites, sample size, sample type, and the laboratory procedures employed may be factors that could contribute to variations in the prevalence rate of *MRSA.* The rate of *MRSA* obtained in this study, however, was nearly the same as the *MRSA* prevalence rate recorded in different research studies in different countries.

In the present study, we found a 94.44 % frequency of *MRSA* among *S. aureus* isolates. In comparison with another study performed by Tekalign Kejela et al in 2022 about the prevalence of *MRSA* among patients of a hospital in Ethiopia. The point prevalence of *MRSA* was investigated by a cross-sectional investigation. 384 patients in total, of which 201 were men and 183 were women, were admitted to the different wards of the Mettu Karl Hospital in Ethiopia. The study's sample size was 384 samples, including 166 swabs from wounds and 218 swabs from the nasal cavities. Based on visual and biochemical characteristics, *Staphylococcus aureus* was separated, characterized, and identified. Its identity was then confirmed using Polymerase Chain Reaction amplification of the nuc gene. The isolates were tested against 12 different antibiotics, and *MRSA* was recognized by cefoxitin (30 g) disc, which was then verified by the amplification of the mecA gene. Staphylococcus aureus was found in 126 out of 384 Samples (32 %). *MRSA* was present in clinical specimens at a point prevalence of 18.8 % (72/384). *MRSA* was present in 72 out of the 126 *Staphylococcus aureus* samples (57.1). *MRSA* was isolated from 35 out of the collected 166 samples taken from patients in the surgical unit. Patients admitted to surgical wards had a higher rate of *MRSA* isolation than those to medical and paediatric wards. (10).

Ahmad Nikpey 2021 investigated the rate of *MRSA* in different wards of a hospital in Iran. This was a cross-sectional study. Samples were collected from 12 different wards of hospitals. Each hospital has 255 and 230 patient beds, and they are both in the north of the Iranian city of Qazvin. Gram-negative bacteria and *S. aureus* were found in 59.6 and 80 % of the samples, respectively. The most contaminated ward was the intensive care unit, which had a 7.5 % prevalence of *MRSA. MRSA* was recovered from 16.7 % of the surface samples, whereas *S. aureus* was found in 20 % of them. (11).

Zainol Abidin et al 2020 conducted a research study about *MRSA* Infections in a tertiary care hospital in Malaysia. In this research experiment, he determined the prevalence of *MRSA* infection in the only a surgical ward. Out of the 598 patients who were *staphylococcus aureus* positive, 51 patients were found to have *MRSA* infection, making the frequency of *MRSA* in surgical wards 8.53 %. (12).

Raut S et al 2017 conducted a research study about the prevalence of *MRSA* in a hospital in Nepal. A total of 1981 samples were taken from patients attending the hospital for treatment. From the total of 1981 samples, 133 were confirmed as *S. aureus*. *MRSA* was detected by the disk diffusion method. Cefoxitin was used as an antibiotic disk for *MRSA* detection. Among 133 *Staphylococcus aureus* samples, 58 (43.6 %) samples were *MRSA.* (13).

Pus (118, 55.4%) had the greatest rate of *S. aureus* isolation among clinical specimens.

CSF and urethral discharge did not contain any *S. aureus*. 194 *S. aureus* isolates were discovered; 34

(17.5 %) were *MRSA* and the remainder 160 (82.5 %) were *MSSA*. A total of 98 (50.5 %) *S. aureus* isolates tested positive for several drugs, with penicillin resistance at its greatest (187, 96.4 %) and clindamycin and vancomycin resistance at its lowest (23, 11.9 %, and 10.1 %, respectively). *MRSA* strains were completely resistant to penicillin G, erythromycin, trimethoprim-sulfamethoxazole, and vancomycin (10, 29.4 %), with the latter being the least resistant. 153, or 79.0 %, of the 194 *S. aureus* isolates were beta-lactamase producers. (14).

Shilpa Arora et al 2020 studied about the prevalence of *MRSA* in a tertiary care hospital in India. This research study included 250 coagulase-positive staphylococci isolated from a total of 6743 specimens (like blood, pus, urine, sputum, etc.). Using the oxacillin and cefoxitin disc diffusion method, the oxacillin screen agar method, and the minimum inhibitory concentration method with broth macro dilution, methicillin resistance was found. *MRSA* was discovered in 115 strains overall (46 %) 73 % of *MRSA* strains had multidrug resistance. (15).

In 2018 Tarequl Islam et al. investigated about the prevalence of *MRSA* in Hospitals in Chittagong, Bangladesh. The sample size of this research study was 100. Out of the 100 samples in total, 66 *Staphylococcus aureus* isolates were identified. Out of 66, 53 of them (80.3 %) tested positive for oxacillin but to prevent any false results the 53 oxacillin-positive isolates were then tested again for cefoxitin resistance. 43 (65.15 %) were confirmed to be *MRSA*, while the remaining 23 isolates (34.85 %) were determined to be methicillin-sensitive. (16).

The research was conducted in 2017 by Tuba Siddiqui et al. on the prevalence of *MRSA* and its susceptibility profile in healthcare facilities in Karachi, Pakistan. The frequency of *MRSA* was 52 % out of a total of 346 *S. aureus strains*. *MRSA* infection was shown to be more prevalent in people aged 21 to 30 (i.e. 30 %), followed by people aged 31 to 40 (i.e. 20 %). Male and female *MRSA* prevalence rates were 70 % and 30 %, respectively. *MRSA* was found in blood 20 % more frequently. *MRSA* exhibited strong resistance to Cefoxitin and Oxacillin and reported isolates with 25 % Teicoplanin resistance and 100 % Vancomycin-resistant *S. aureus* (VRSA) resistance. Minocycline resistance in *MRSA* was 16 %. (17)

5. CONCLUSIONS

According to our research studies the occurrence of *MRSA* in *Staphylococcus aureus* specimens was high which is a significant threat to public health in hospitals**.** This high prevalence of *MRSA* highlights the need for periodic assessments to understand and characterize *MRSA* infections. In addition, the maintenance of proper hygiene by hospitalized patients and staff and avoidance of irrational use of broad-spectrum antibiotics could effectively reduce the rate and dissemination of multi-drug resistant strains .

REFERENCES: -

1. Lee AS, De Lencastre H, Garau J, Kluytmans J, Malhotra-Kumar S, Peschel A, Harbarth S. Methicillin-resistant Staphylococcus aureus. Nature reviews Disease primers. 2018 May 31;4(1):1-23.
2. Ullah A, Qasim M, Rahman H, Khan J, Haroon M, Muhammad N, Khan A, Muhammad N. High frequency of methicillin-resistant Staphylococcus aureus in Peshawar Region of Pakistan. Springerplus. 2016 Dec;5(1):1-6.
3. Choubdar M, Mousavi S, Pakbin B, Naghdali Z, Rahmani B, Nikpey A. Methicillin-resistant Staphylococcus aureus in air and surfaces of hospital wards: a comparison between new and old buildings. Electronic Physician. 2021 Jan 1;13(1).
4. Khan AA, Ali A, Tharmalingam N, Mylonakis E, Zahra R. First report of mecC gene in clinical methicillin-resistant *S. aureus* (MRSA) from tertiary care hospital Islamabad, Pakistan. Journal of Infection and Public Health. 2020 Oct 1;13(10):1501-7.
5. Moyo SJ, Nkinda L, Majigo M, Mmbaga E, Mbembati N, Aboud S, Lyamuya EF. Prevalence of methicillin-resistant Staphylococcus aureus carriage on admission among patients attending regional hospitals in Dar es Salaam, Tanzania. BMC research notes. 2017 Dec;10(1):1-7.
6. Tsige Y, Tadesse S, Tefera MM, Amsalu A, Menberu MA, Gelaw B. Prevalence of methicillin-resistant Staphylococcus aureus and associated risk factors among patients with wound infection at the referral hospital, northeast Ethiopia. Journal of Pathogens. 2020 May 24;2020.
7. Dadashi M, Nasiri MJ, Fallah F, Owlia P, Hajikhani B, Mancini M, Mirpour M. Methicillin-resistant Staphylococcus aureus (MRSA) in Iran: a systematic review and meta-analysis. Journal of global antimicrobial resistance. 2018 Mar 1;12:96-103.
8. Turner NA, Sharma-Kuinkel BK, Maskarinec SA, Eichenberger EM, Shah PP, Carugati M, Holland TL, Fowler VG. Methicillin-resistant Staphylococcus aureus: an overview of basic

and clinical research. Nature Reviews Microbiology. 2019 Apr;17(4):203-18.
9. Algammal AM, Hetta HF, Elkelish A, Alkhalifah DH, Hozzein WN, Batiha GE, El Nahhas N, Mabrok MA. Methicillin-Resistant Staphylococcus aureus (MRSA): one health perspective approach to the bacterium epidemiology, virulence factors, antibiotic-resistance, and zoonotic impact. Infection and Drug Resistance. 2020; 13:3255.
10. Kejela T, Dekosa F. High prevalence of MRSA and VRSA among inpatients of Mettu Karl referral hospital, southwest Ethiopia. Tropical Medicine & International Health. 2022 Aug;27(8):735-41.
11. Nikpey A. Methicillin-resistant Staphylococcus aureus in air and surfaces of hospital wards. Electronic Physician. 2021 Dec 7;13(1):7803-1.
12. Zainol Abidin NZ, Voon LC, Yu WZ, Zakaria M, Lim M, Rosli NK. MRSA infection in general surgical wards in a Malaysian tertiary hospital: a retrospective study. Ann Clin Surg. 2020; 1 (2). 2020;1008.
13. Raut S, Bajracharya K, Adhikari J, Pant SS, Adhikari B. Prevalence of methicillin resistant Staphylococcus aureus in lumbini medical college and teaching hospital, palpa, western Nepal. BMC research notes. 2017 Dec;10(1):1-7.
14. Dilnessa T, Bitew A. Prevalence and antimicrobial susceptibility pattern of methicillin resistant Staphylococcus aureus isolated from clinical samples at Yekatit 12 Hospital Medical College, Addis Ababa, Ethiopia. BMC infectious diseases. 2016 Dec;16(1):1-9.
15. Arora S, Devi P, Arora U, Devi B. Prevalence of methicillin-resistant Staphylococcus aureus (MRSA) in a tertiary care hospital in Northern India. Journal of laboratory physicians. 2010 Jul;2(02):078-81.
16. Islam T, Kubra K, Chowdhury MM. Prevalence of methicillin-resistant Staphylococcus aureus in hospitals in Chittagong, Bangladesh: A threat of nosocomial infection. Journal of microscopy and ultrastructure. 2018 Oct;6(4):188.
17. Siddiqui T, Muhammad IN, Khan MN, Naz S, Bashir L, Sarosh N, Masood R, Ali A, Fatima S, Naqvi T. MRSA: Prevalence and susceptibility pattern in health care setups of Karachi. Pak J Pharm Sci. 2017 Nov 1;30(6):2417-1.