Aljeldah et al. | J Pure Appl Microbiol | 16(2):1192-1199 | June 2022
Article 6838 | https://doi.org/10.22207/JPAM.16.2.48
Published Online May 31, 2022
Print ISSN: 0973-7510; E-ISSN: 2581-690X

RESEARCH ARTICLE OPEN ACCESS

Prevalence of Multidrug-Resistant Methicillin-Resistant *Staphylococcus aureus* in Northeastern Saudi Hospitals

Mohammed Aljeldah[1], Basim Al Shammari[1], Eman S. Farrag[1], Ehab M. Taha[2] and Sabry Y. Mahmoud[2]*

[1]Department of Clinical Laboratory Science, College of Applied Medical Sciences, University of Hafr Al Batin, Hafr Al Batin, Saudi Arabia.
[2]Biology Department, College of Science, Hafr Al Batin University, Hafr Al Batin, Saudi Arabia.

Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) is responsible for serious threats to human health, causing various syndromes worldwide. Here, our purpose was to estimate the prevalence of nosocomial MRSA among isolates from King Khalid Hospital (KKH) and Maternity and Children Hospital (MCH) at Hafar Al Batin Governorate, Saudi Arabia, and to determine the resistance of these isolates to common antibiotics used for treatment. One-hundred clinical specimens were collected from admitted patients during a six month period, and subjected to MRSA screening using traditional microbiological techniques. Antimicrobial susceptibility testing (AST) was also performed and confirmed by the VITEK2 automated system. Among the 37 *S. aureus* strains isolated from KKH, 23 (62.16%) were identified as MRSA. In MCH, 38 (60.31%) out 63 isolated strains were identified as MRSA. According to AST, few MRSA strains were resistant to teicoplanin, fosfomycin, linezolid, and mupirocin in both hospitals. Vancomycin resistance was not detected in any of the MRSA strains. Twelve MRSA strains from KKH and 17 strains from MCH were considered multidrug resistant (MDR). In conclusion, prevention is critical to reduce the high prevalence of MRSA.

Keywords: *Staphylococcus aureus*, MRSA, multidrug-resistant, prevalence, Saudi Arabia

***Correspondence:** symohamed@uhb.edu.sa

(Received: January 4, 2021; accepted: April 12, 2022)

Citation: Aljeldah M, Al Shammari B, Farrag ES, Taha EM, Mahmoud SY. Prevalence of Multidrug-Resistant Methicillin-Resistant *Staphylococcus aureus* in Northeastern Saudi Hospitals. *J Pure Appl Microbiol.* 2022;16(2):1192-1199. doi: 10.22207/JPAM.16.2.48

INTRODUCTION

S. aureus is one of the most important nosocomial pathogenic agents worldwide. It can cause a wide range of infections, especially meningitis, endocarditis, and bloodstream infections, which are often fatal in nature.[1] *S. aureus* infections are particularly difficult to treat due to increased resistance to antimicrobial drugs. Methicillin-resistant *S. aureus* (MRSA) has become the world's leading source of antimicrobial-resistant health care-associated infections (European Centre for Disease Prevention and Control).[2]

Many MRSA isolates become multidrug-resistant (MDR), which are only susceptible to glycopeptide antibiotics such as vancomycin.[3] Possible risk factors involved in the acquisition of MDR-MRSA emergence include the use of antibiotics, lack of knowledge, being on antibiotics before arriving to the hospital, prolonged hospitalization, and indiscriminate.[4] MRSA infections are now widespread and epidemic in hospitals and long-term health facilities worldwide, and the distribution of these isolates allows further transmission.[5,6] This emphasizes the need to consider the prevalence of MRSA and its antimicrobial profile to select effective empirical treatments and control measures.

In Saudi Arabia, the prevalence of MRSA among *S. aureus* isolates varies widely across regions and has shown temporal increases. Low MRSA prevalence (5–7.5%) was regularly observed in the early 1990s, rising dramatically to 91% after 1995.[7] The average prevalence of MRSA in Saudi Arabia was 29.9% from January 1990 to April 2011.[8] Recently, the overall Saudi MRSA prevalence rate was 35.6% from a pooled estimate of 22,793 *S. aureus* strains collected between 2002 and 2012.[9]

The present study was conducted to estimate the preva¬lence of MRSA isolates from Hafar Al-Batin hospitals and determine their antimicrobial resistance profiles.

MATERIALS AND METHODS

A total of 100 non-replicate clinical strains of *S. aureus* were isolated from various specimens of patients admitted to the King Khalid Hospital (KKH) and Maternity and Children Hospital (MCH), Hafar Al-Batin, Eastern Region, Saudi Arabia between July 2019 and December 2019. The sources of the strains were pus, blood, urine wound swab, purulent discharge, sputum, ear swab, nasal swab, throat swap, abscesses, catheter tip, and suction tip, which were obtained from patients who had been hospitalized for more than 48 h. Ethical approval was obtained from the Institutional Review Board (IRB) committee of Hafar Al-Batin (approval Number: 67) and the committee registration with King Abdulaziz City for Science and Technology (KACST), Kingdom of Saudi Arabia (No. H-05-FT-083).

All clinical specimens were cultured on blood agar and mannitol salt agar plates and incubated at 35°C for 24 to 48 h. Isolated bacteria were identified according to colonial and microscopic morphology, Gram staining, as well as catalase, coagulase (using rabbit plasma), Slidex Staph plus (SSP) latex reagent (bioMerieux France), DNase, and Mannitol fermentation tests.[10] All isolates positive for these tests were identified as *S. aureus*.

Based on the Clinical Laboratory Standards Institute guidelines,[11] all *S. aureus* isolates were tested for methicillin resistance using oxacillin screen agar and cefoxitin disc diffusion tests. Furthermore, the Kirby Bauer Disc Diffusion test has been introduced for routine antimicrobial susceptibility testing (AST) of traditional and

Table 1. Distribution of MRSA among clinical specimens (n= 100) collected from King Khalid (KKH) and Maternity and children hospital (MCH)

Specimen (n)	KKH		MCH	
	No.	MRSA	No.	MRSA
Pus (10)	1	1	9	5
Blood (10)	10	6	-	-
Urine (1)	-	-	1	0
Wound (46)	14	8	32	22
Purulent discharge (3)	3	1	-	-
Sputum (1)	1	1	-	-
Ear (1)	1	1	-	-
Nasal (6)	-	-	6	3
Throat (2)	-	-	2	1
Abscesses (10)	-	-	10	7
Suction and Catheter (10)	7	5	3	0
Total	37	23	63	38

Table 2. Antibiotics resistance pattern of MRSA (n=23) and MSSA (n=14) isolates from King Khalid hospital

Antibiotics		Sensitivity (%)	CI	Resistance (%)	CI
Cefoxitin	MRSA	0 (0.0)	0.00-0.14	23 (100)	0.86-1.00
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Clindamycin	MRSA	10 (43.5)	0.26- 0.63	13 (56.5)	0.37-0.74
	MSSA	10 (71.4)	0.45-0.88	4 (28.6)	0.12-0.55
Erythromycin	MRSA	9 (39.1)	0.22- 0.59	14 (60.9)	0.41-0.78
	MSSA	10 (71.4)	0.45-0.88	4 (28.6)	0.12-0.55
Fosfomycin	MRSA	22 (95.7)	0.76- 0.99	1 (4.3)	0.01-0.21
	MSSA	13 (92.9)	0.69-0.99	1 (7.1)	0.013-0.31
Fusidic Acid	MRSA	12 (52.2)	0.33-0.71	11 (47.8)	0.27-0.67
	MSSA	11 (78.6)	0.52-0.92	3 (21.4)	0.08-0.48
Gentamicin	MRSA	18 (78.3)	0.58- 0.90	5 (21.7)	0.09-0.42
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Levofloxacin	MRSA	18 (78.3)	0.58- 0.90	5 (21.7)	0.09-0.42
	MSSA	10 (71.4)	0.45-0.88	4 (28.6)	0.12-0.55
Linezolid	MRSA	20 (87)	0.68-0.95	3 (13.0)	0.05-0.32
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Moxifloxacin	MRSA	16 (69.6)	0.49-0.84	7 (30.4)	0.16-0.51
	MSSA	10 (71.4)	0.45-0.88	4 (28.6)	0.12-0.55
Mupirocin	MRSA	20 (87)	0.68-0.95	3 (13.0)	0.05-0.32
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Oxacillin	MRSA	0 (0.0)	0.00-0.14	23 (100)	0.86-1.00
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Penicillin	MRSA	0 (0.0)	0.00-0.14	23 (100)	0.86-1.00
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Rifampin	MRSA	21 (91.3)	0.73-0.98	2 (8.7)	0.02-0.27
	MSSA	13 (92.9)	0.69-0.99	1 (7.1)	0.01-0.31
Teicoplanin	MRSA	22 (95.7)	0.79-0.99	1 (4.3)	0.01-0.21
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Tetracycline	MRSA	15 (65.2)	0.45-0.81	8 (34.8)	0.19-0.55
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Trimeth/Sulfa	MRSA	20 (87)	0.68-0.95	3 (13.0)	0.05-0.32
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22
Vancomycin	MRSA	23 (100)	0.86-1.00	0 (0.0)	0.00-0.14
	MSSA	14 (100)	0.78-1.00	0 (0.0)	0.00-0.22

CI = Confidence Interval.

recently introduced antibiotics based on CLSI recommendations (2012 and 2014). The VITEK 2 automated system was used to confirm the results of strain identification and AST according to the instructions of the manufacturer (bioMerieux France).

MRSA incidence was calculated as: total number of intermediate and resistant isolates/ total number of isolates. Isolates resistant to penicillin, oxacillin, and cefoxitin plus three or more classes of the antibiotics used in this study were considered MDR.[12] Antimicrobial susceptibility rates are presented with 95% confidence interval values.

All data were examined using iBM SPSS version 21.0. Frequencies were calculated for categorical variables. The Chi-square test was used to analyze significant differences at a 95% confidence level. Statistical significance was set at $p < 0.01$, unless otherwise noted.

Table 3. Antibiotics resistance pattern of MRSA (n=38) and MSSA (n=25) isolates from Maternity and children hospital

Antibiotics		Sensitivity (%)	CI	Resistance (%)	CI
Cefoxitin	MRSA	0 (0.0)	0.00-0.09	38 (100)	0.91-1.00
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Clindamycin	MRSA	29 (76.3)	0.61-0.87	9 (23.7)	0.13-0.39
	MSSA	24 (96.0)	0.80-0.99	1 (4.0)	0.01-0.19
Erythromycin	MRSA	29 (76.3)	0.61-0.87	9 (23.7)	0.13-0.39
	MSSA	18 (72.0)	0.52-0.86	7 (28.0)	0.14-0.48
Fosfomycin	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Fusidic Acid	MRSA	13 (34.2)	0.21-0.50	25 (65.8)	0.49-0.79
	MSSA	21 (84.0)	0.65-0.94	4 (16.0)	0.06-0.35
Gentamicin	MRSA	35 (92.1)	0.79-0.97	3 (7.9)	0.03-0.21
	MSSA	24 (96.0)	0.80-0.99	1 (4.0)	0.01-0.19
Levofloxacin	MRSA	36 (94.7)	0.83-0.99	2 (5.3)	0.01-0.17
	MSSA	23 (92.0)	0.75-0.98	2 (8.0)	0.02-0.25
Linezolid	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Moxifloxacin	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	24 (96.0)	0.80-0.99	1 (4.0)	0.01-0.19
Mupirocin	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Oxacillin	MRSA	0 (0.0)	0.00-0.09	38 (100)	0.91-1.00
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Penicillin	MRSA	0 (0.0)	0.00-0.09	38 (100)	0.91-1.00
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Rifampin	MRSA	3 (7.9)	0.03-0.21	35 (92.1)	0.79-0.97
	MSSA	0 (0.0)	0.00-0.13	25 (100)	0.87-1.00
Teicoplanin	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13
Tetracycline	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	23 (92.0)	0.75-0.98	2 (8.0)	0.02-0.25
Trimeth/Sulfa	MRSA	36 (94.7)	0.83-0.99	2 (5.3)	0.01-0.17
	MSSA	22 (88.0)	0.70-0.96	3 (12.0)	0.04-0.29
Vancomycin	MRSA	38 (100)	0.91-1.00	0 (0.0)	0.00-0.09
	MSSA	25 (100)	0.87-1.00	0 (0.0)	0.00-0.13

CI = Confidence Interval.

RESULTS AND DISCUSSION

The regular surveillance of hospital-acquired MRSA infection is a very effective procedure in assisting the monitoring of antibiotic policies. In this study, wounds were the most common site of infection (46 specimens). In 30 of them, MRSA was the causative agent. This finding confirmed that skin and soft tissue infections are the main reservoir of MRSA. Previous studies have shown a higher prevalence in skin infections inside and outside the hospital than in other sites of infection.[13]

Of the 100 clinical *S. aureus* isolates reported in the present study, 63 were isolated from MCH, while 37 were recovered from KKH. Different clinical specimens were collected from both hospitals (Table 1). Wound swabs represented most of the collected specimens (46), followed by abscesses, blood, pus, as well as suction and catheter tips (10). Low numbers of specimens

Table 4. MRSA Resistant patterns and multidrug-resistant from King Khalid Hospital (n=12) and Maternity and children hospital (n=17)

Location	Antibiotic resistance pattern (n)	Antibiotics which are resistant	No. of MRSA
KKH	R1 (6)	CE, OX, PE, CL, ER, MO	1
	R2 (6)	CE, OX, PE, CL, ER, LI	1
	R3 (6)	CE, OX, PE, CL, ER, FU	1
	R4 (7)	CE, OX, PE, CL, ER, GM, LI	1
	R5 (7)	CE, OX, PE, ER, LE, MO, TE	1
	R6 (7)	CE, OX, PE, ER, LE, MO, FU	1
	R7 (8)	CE, OX, PE, CL, ER, FU, MU, TE	1
	R8 (9)	CE, OX, PE, ER, GM, LE, MO, TE, TR	1
	R9 (10)	CE, OX, PE, CL, ER, FU, GM, LE, MO, RA	1
	R10 (10)	CE, OX, PE, CL, ER, FU, GM, RA, TE, TR	1
	R11 (11)	CE, OX, PE, CL, ER, FU, LE, MO, MU, TE, TR	1
	R12 (12)	CE, OX, PE, CL, ER, FO, FU, GM, LI, MU, TE, TE	1
MCH	R1 (6)	CE, OX, PE, RA, MO, LE	1
	R2 (6)	CE, OX, PE, RA, FU, TE	4
	R3 (6)	CE, OX, PE, RA, CL, ER	2
	R4 (6)	CE, OX, PE, RA, FU, GM	3
	R5 (7)	CE, OX, PE, RA, FU, CL, ER	6
	R6 (9)	CE, OX, PE, RA, FU, CL, ER, LE, TR	1

CE- Cefoxitin, CL- Clindamycin, ER- Erythromycin, FO- Fosfomycin, FU- Fusidic Acid, GM- Gentamicin, LE- Levofloxacin, LI- Linezolid, MO- Moxifloxacin, MU- Mupirocin, OX- Oxacillin, PE- Penicillin, RA-Rifampin, T- Teicoplanin, TE-Tetracycline, TR- Trimeth/Sulfa, VA- Vancomycin. King Khalid Hospital, KKH; Maternity and children hospital, MCH.

were obtained from purulent discharge (3) as well as urine, sputum, and ear, nasal, and throat swabs (1). In a recent European study, the most common species in skin and soft tissue infections was *S. aureus* (71% of cases), with 22.5% being MRSA.[14] In Saudi Arabia, *S. aureus* was shown to be the most common cause of infection in wounds, skin, and soft tissue, and these sites also showed the highest prevalence of MRSA.[15,16] Al-Hamad et al. found that the vast majority of MRSA isolates collected in Qatif from 2006 to 2015 were obtained from wound and pus specimens.[17]

Of the 100 clinical *S. aureus* isolates from both hospitals, 61 were identified as MRSA (23 out of 37 (62.16%) from KKH, and 38 out of 63 (60.31%) from MCH. Thirty MRSA isolates (49.1%) were isolated from wound swabs, while 6 (9.8%) were isolated from pus and blood specimens.

The antibiotic susceptibility data for MRSA and methicillin-susceptible *S. aureus* (MSSA) are summarized in Table 2. MRSA isolates had higher resistance rates to various antibiotics than MSSA isolates. Resistance to cefoxitin (30 µg-1), oxacillin (8 µg-1), and penicillin (10 µg-1) was found in all MRSA isolates (100%). In contrast, no MRSA strains resistant to vancomycin were isolated from either of the hospitals.

MRSA has become an enormous problem because it is hardly treated and develops resistance.[18] During the six months examined in this study, the prevalence of MRSA was 62.2% in KKH and 60.31% in MCH. These values are very high compared with those of previous reports from other hospitals in Saudi Arabia.[18] This could be attributed to the special environmental and host factors at Hafar Al-Batin, which is a border town near Iraq, Kuwait, and Jordan. MRSA incidence varies across Saudi Aria and is therefore not uniform. Low MRSA occurrence (5–7.5%) was regularly found in the early 1990s, rising drastically to 91% after 19957. In Saudi Arabia, the mean prevalence of MRSA was 29.9% from January 1990 to April 20118. A study conducted in 2013 compiled information on MRSA in Saudi Arabia between 2002 and 2012, covering five regions (Makkah, Dahran, Riyadh, Assir, and Al-Gouf)

and including 26 published research articles. This study concluded that 35.6% of the 22,793 strains of *S. aureus* were MRSA (95% CI, 0.28–0.42; P < 0.01).[9] In Saudi Arabia's Eastern Zone (Al-Sharqia), the prevalence of MRSA has continued to vary. MRSA prevalence was reported to be 2.3% in Al-Hasa,[18] 5.9% in Daharan,[19] and 38.4–47.2 % in Al-Khobar.[20,21] Nevertheless, the proportion of MRSA was 22.1% and 24% in Daharan and Al-Ahsa, respectively.[22,23] In contrast, other studies from regional countries have shown higher MRSA prevalence (>50% in Jordan, Egypt, and Cyprus).[24] MRSA prevalence was shown to be 13.2% in Qatar and 32% in Kuwait.[25,26] At an international scale, MRSA incidence also varies greatly between countries (e.g., 54.6% in Portugal versus 38.2% in Italy and 1.2% Denmark) (European Centre for Disease Prevention and Control)[2].

In this study, resistance to other antibiotics greatly varied between the two hospitals (Tables 2 and 3). In KKH, MRSA showed lower resistance rates to fosfomycin and teicoplanin (one isolate; 4.3%), rifampin (two isolates; 8.7%) as well as linezolid, mupirocin, and trimethoprim/sulfamethoxazole (3 isolates each; 13%). Resistance to other antibiotics differed, and greater resistance to erythromycin, clindamycin, fusidic acid, tetracycline, and moxifloxacin was found. All MRSA strains in MCH were susceptible to fosfomycin, linezolid, moxifloxacin, mupirocin, teicoplanin, and tetracycline, while most isolates showed resistance to rifampicin and fusidic acid (35 (92.1%) and 25 (65.8%), respectively).

This study demonstrated that approximately half of the MRSA strains isolated from KKH and MCH were MDR (52.2 and 44.7%, respectively), with considerable variation in the antibiotics to which they were resistant. Vancomycin was the most effective agent, followed by teicoplanin, fosfomycin, linezolid, and mupirocin, in both hospitals (Tables 2–4). Resistance to β-lactam and closely related antibiotics may be caused by the production of beta-lactamase (an enzyme that inactivates the β-lactam ring).[27] The most common reason for the development of multi-drug resistant MRSA is the indiscriminate use of antibiotics without drug sensitivity testing.[28] Many studies conducted in Saudi Arabia have reported similar data, with MDR-MRSA rates of 85.2%,[29] 55%,[30] and 32.14%.[31] The first-line prescription for MRSA treatment has been vancomycin.[32,33] However, vancomycin use should be limited to MRSA infections for which other medications are not suitable.

Antibiotic susceptibility patterns and MDR are summarized in Table 4. Twelve MRSA strains (52.2%) from KKH and 17 (44.7%) from MCH harbored resistance to three or more antimicrobials as well as penicillin, oxacillin, and cefoxitin. There was considerable variation in antibiotic resistance patterns between the two hospitals. Twelve different patterns were shown from KKH, with a high number of antibiotics to which the isolates were resistant (6–12 antibiotics). MCH showed only 6 patterns, with a lower number of antibiotics to which they were resistant (6–9 antibiotics).

CONCLUSIONS

In conclusion, our findings demonstrate that MRSA is a serious problem in Saudi Arabia. Compared with MSSA isolates, MRSA isolates showed a higher prevalence of multidrug resistance. Vancomycin remains the mainstay treatment for MRSA infections. The rise in MDR-MRSA prevalence emphasizes the importance of sound infection treatment in hospitals.

ACKNOWLEDGMENTS

The authors extend their appreciation to the Deanship of Scientific Research at the University of Hafr Al-Batin for funding this work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors designed the experiments. ESF, EMT and SYM performed the experiments. MA, ESF and BA analyzed the data. EMT and SYM wrote the manuscript. All authors read and approved the manuscript for final publication.

FUNDING

This research was funded by the Deanship of Scientific Research, Hafr Al-Batin University, Saudi Arabia under grant no. RGP-S-0012-1443.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

This study was approved by the Institutional Ethics Committee, King Khalid Hospital (KKH), and Maternity and Children Hospital (MCH), Hafr Al-Batin, Saudi Arabia with reference number: KACST No. H-05-FT-083.

REFERENCES

1. Nejad ASM, Shabani S, Bayat M, Hosseini SE. Antibacterial Effect of Garlic Aqueous Extract on *Staphylococcus aureus* in Hamburger. *Jundishapur J Microbiol.* 2014;7(11):e13134. doi: 10.5812/jjm.13134
2. European Centre for Disease Prevention and Control. Antimicrobial resistance surveillance in Europe 2011. 2012. http://www.ecdc.europa.eu/en/publications/publications/antimicrobial-resistance-surveillance-europe-2011.pdf.Last accessed on 24. February 2014.
3. Mehta AP, Rodrigues C, Sheth K, Jani S, Hakimiyan A, Fazalbhoy N. Control of methicillin resistant *Staphylococcus aureus* in a tertiary care Centre-A five-year study. *J Med Microbiol.* 1998;16:31-34.
4. Lee AS, Huttner B, Harbarth S. Control of Methicillin-resistant *Staphylococcus aureus*. *Infect Dis Clin North Am*. 2011;25(1):155-179. doi: 10.1016/j.idc.2010.11.002
5. Strausbaugh LJ, Crossley KB, Nurse BA, Thrupp LD. Antimicrobial resistance in long-term-care facilities. *Infect Control Hosp Epidemiol*. 1996;17(2):129-140. doi: 10.2307/30141013
6. McDonald M. The epidemiology of methicillin resistant *Staphylococcus aureus*: Surgical relevance 20 years on. *ANZ journal of surgery.* 1997;67(10):682-685. doi: 10.1111/j.1445-2197.1997.tb07108.x
7. Yezli S, Shibl AM, Livermore DM, Memish ZA. Antimicrobial resistance among gram-positive pathogens in Saudi Arabia. *J Chemother.* 2012; 24(3):125-136. doi: 10.1179/1973947812y.0000000010
8. Aly M, Balkhy HH. The prevalence of antimicrobial resistance in clinical isolates from gulf corporation council countries. *Antimicrob Resist Infect Control.* 2012;1(1):26. doi: 10.1186/2047-2994-1-26
9. AL-Yousef SA, Mahmoud SY, Taha EM. Prevalence of methicillin-resistant *Staphylococcus aureus* in Saudi Arabia: systemic review and meta-analysis. *Afr J Cln Exper Microbiol.* 2013;14(3):146-154. doi: 10.4314/ajcem.v14i3.5
10. Murray RR, Baron EJ, Jorgenson J H, Pfaller M A, Yolken RH. Manual of Clinical Microbiology. 2003; ASM Press, Washington, DC, USA, 8th edition, 2113 pages.
11. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing. 2014; CLSI Supplement M100-S24. Wayne, 34 (1), PA, USA.
12. Bell JM, Turnidge JD. High prevalence of oxacillin-resistant *Staphylococcus aureus* isolates from hospitalized patients in Asia-Pacific and South Africa: results from SENTRY antimicrobial surveillance program, 1998-1999. *Antimicrob Agents Chemother.* 2002;46(3):879-881. doi: 10.1128/aac.46.3.880-882.2002
13. Ellis Simonsen SM, van Orman ER, Hatch BE, et al. Cellulitis incidence in a defined population. *Epidemiol Infect.* 2006;134(2):293-299. doi: 10.1017/S095026880500484X
14. Sader HS, Farrell DJ, Jones RN. Antimicrobial susceptibility of Gram-positive cocci isolated from skin and skin-structure infections in European medical centres. *Int J Antimicrob Agents.* 2010;36(1):28-32. doi: 10.1016/j.ijantimicag.2010.03.016
15. Asghar AH, Momenah AM. Methicillin Resistance among *Staphylococcus aureus* isolates from Saudi Hospitals. *Med Princ Pract.* 2006;15(1):52-55. doi: 10.1159/000089386
16. Asghar AH. Frequency and antibiotic susceptibility of gram-positive bacteria in Makkah hospitals. *Ann Saudi Med.* 2011;31(5):462-468. doi: 10.4103/0256-4947.84622
17. Al-Hamad AM, Alfaraj AA, Altowaileb J, et al. Incidence and antibiotic susceptibility of MRSA infections in a Saudi Arabian Hospital: a 10-year surveillance study. *J Infect Dev Ctries.* 2018;12(6):454-461. doi: 10.3855/jidc.9778
18. Panhotra BR, Saxena AK, Al-Mulhim AS. Chloramphenicol susceptible methicillin resistant *Staphylococcus aureus* in eastern region of Saudi Arabia. *Saudi Med J.* 2005;26(7):1149-1151
19. Al-Tawfiq JA. Incidence and epidemiology of methecillin-resistant *Staphylococcus aureus* infection in a Saudi Arabian hospital, 1999-2003. *Infect Control Hospit Epidemiol.* 2006;27(10):1137-1139. doi: 10.1086/507971
20. Bukharie HA. Increasing threat of community-acquired methicillin-resistant *Staphylococcus aureus*. *Am J Med Sci.* 2010;340(5):378-381. doi: 10.1097/maj.0b013e3181e95fdc
21. Akhtar N, Alzahrani A, Obeid O, Dassal D. *In vitro* ciprofloxacin resistance patterns of gram positive bacteria isolated from clinical specimens in a teaching hospital in Saudi Arabia. *J Ayub Med Coll Abbottabad.* 2009;21(3):54-56.
22. Al-Tawfiq JA, Abed MS. Prevalence and antimicrobial resistance of health care associated bloodstream infections at a general hospital in Saudi Arabia. *Saudi Med. J.* 2009;30(9): 1213–1218.
23. Ahmad S, Alenzi FQ, Al-Juaid NF, Ahmed S. Prevalence and antibiotic susceptibility pattern of Methicillin Resistant *Staphylococcus aureus* at Armed Forces Hospital in Saudi Arabia. *Bangladesh Med. Res. Counc. Bull.* 2009; 35(1): 28-30.
24. Borg MA, de Kraker M, Scicluna E, et al. Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in invasive isolates from southern and eastern Mediterranean countries. *J Antimicrob Chemother.* 2007;60(6):1310-1315. doi: 10.1093/jac/dkm365
25. Kha FY, Elshafie SS, Almaslamani M, et al. Epidemiology of bacteraemia in Hamad general hospital, Qatar: a one-year hospital-based study. *Travel Medicine and*

Infectious Disease. 2010;8(6):377-387. doi: 10.1016/j.tmaid.2010.10.004

26. Udo EE, Al-Sweih N, Dhar R, et al. Surveillance of antibacterial resistance in *Staphylococcus aureus* isolated in Kuwaiti hospitals. *Med Princ Pract.* 2008;17(1):71-75. doi: 10.1159/000109594
27. Adesoji AT, Onuh JP, Bagu J, Itohan SA. Prevalence and antibiogram study of *Staphylococcus aureus* isolated from clinical and selected drinking water of Dutsin-Ma, Katsina state, Nigeria. *Afr Health Sci.* 2019;19(1):1385-1392. doi: 10.4314/ahs.v19i1.11
28. Llor C, Bjerrum L. Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. *Therapeutic Advances in Drug Safety.* 2014;5(6):229-241. doi: 10.1177/2042098614554919
29. Hamid ME. Resistance pattern of coagulase positive *Staphylococcus aureus* clinical isolates from Asir region, kingdom of Saudi Arabia. *J Microbiol Antimicrob.* 2011;3(4):102-108. http://www.academicjournals.org/JMA
30. Khadri H, Alzohairy M. Prevalence and antibiotic susceptibility pattern of methicillin-resistant and coagulase-negative staphylococci in a tertiary care hospital in India. *Int J Med Med Sci.* 2010;2(4):116-120. doi: 10.5897/IJMMS.9000181
31. Masoud EA, Mahdy ME, Esmat AM. Bacterial Prevalence and Resistance to Antimicrobial Agents in Southwest, Saudi Arabia. *Egypt Acad J Biolog Sci.* 2011;3(1):105-111. doi: 10.21608/eajbsg.2011.16700
32. Freidlin J, Acharya N, Lietman TM, Cevallos V, Whitcher JP, Margolis TP. Spectrum of eye disease caused by methicillin-resistant *Staphylococcus aureus*. 2007; *Am. J. Ophthalmol*. 144:313-315. doi: 10.1016/j.ajo.2007.03.032
33. Liu C, Bayer A, Cosgrove SE, Daum RS, Fridkin SK, Gorwitz RJ, Kaplan SL, Karchmer AW, Levine DP, Murray BE, Rybak MJ, Talan DA, Chambers HF. Clinical Practice Guidelines by the Infectious Diseases Society of America for the Treatment of Methicillin-Resistant Staphylococcus aureus Infections in Adults and Children. *Clinical Infectious Diseases*, 2011; 52(3): e18–e55. doi: 10.1093/cid/ciq146