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Original Article

Epidemiology of Methicillin-Resistant Staphylococcus Aureus in Arab Countries of the Middle East and North African (MENA) Region

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Abstract. Available data suggest a high burden of methicillin-resistant *staphylococcus aureus* (MRSA) in Arab countries of the Middle East and North Africa (MENA). To review the MRSA rates and molecular epidemiology in this region, we used PubMed search engine to identify relative articles published from January 2005 to December 2019. Great heterogeneity in reported rates was expectedly seen. Nasal MRSA colonization ranged from 2%-16% in Gulf Cooperation Council (GCC), 1-9% in the Levant, and 0.2%-9% in North African Arab states. Infective MRSA rates ranged from 9%-38% in GCC, 28%-67% in the Levant, and 28%-57% in North African states. Studies demonstrated a wide clonal diversity in the MENA. The most common molecular types belonged to 5 clonal complexes (CC) known to spread worldwide: CC5, CC8, CC22, CC30, and CC80. The most prevalent strains had genotypes related to the European community-acquired MRSA (CA-MRSA), Brazilian/Hungarian hospital-acquired MRSA (HA-MRSA), UK-EMRSA-15 HA-MRSA, and USA300 CA-MRSA. Finally, significant antimicrobial resistance was seen in the region with variation in patterns depending on location and clonal type. For a more accurate assessment of MRSA epidemiology and burden, the Arab countries need to implement national surveillance systems.

Keywords: MRSA; Methicillin-Resistant *Staphylococcus aureus*; Arab countries; Middle East; North African.

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Introduction. The last few decades have witnessed an increasing interest in the molecular epidemiology of methicillin-resistant Staphylococcus aureus (MRSA). Various techniques have been utilized to decipher the MRSA genotype, which could provide insight into a strain's resistance capacity and virulence. It also provides insight into their origin of spread and helps implement proper infection control measures.[1]

To date, MRSA is the most frequently identified antibiotic-resistant microbe in many regions, including East Asia, the Middle East, North Africa, Europe, and the Americas.[2] Available data suggest a high burden of MRSA in Arab countries of the Middle East and North Africa (MENA).[3,4] However, the Arab world lacks both regional and national surveillance systems. Instead, the current literature is derived from fragmented single-centered research. Moreover, no review summarizing such findings is yet available. Therefore, the purpose of

our paper is to examine the current literature on the epidemiology of MRSA in Arab countries of the MENA region.

Definitions.

The Middle East and North African Region: According to the World Bank, the MENA region comprises 21 member states. The Arab member states include the Kingdom of Saudi Arabia (KSA), Unites Arab Emirates (UAE), Kuwait, Qatar, Bahrain, Oman, Yemen, Syria, Lebanon, Jordan, Palestine (west bank and Gaza strip), Iraq, Egypt, Tunisia, Algeria, Morocco, Yemen, and Libya.[5]

MRSA molecular typing techniques: Currently, there are four molecular typing techniques, including pulsed-field gel electrophoresis (PFGE), Multilocus sequence typing (MLST), staphylococcal cassette chromosome mec (SCCmec) typing, and *S. aureus* protein A gene (spa) typing.

Pulsed-field gel electrophoresis: It is considered the reference standard for MRSA typing. Uses restriction enzyme SmaI to digest purified chromosomal DNA followed by agarose gel electrophoresis. A unique pattern is created and analyzed using the Dice coefficient and unweighted pari-group matching analysis (UPGMA). Thus, it is the most discriminative method and the best for investigating hospital outbreaks. Nonetheless, efforts to harmonize PFGE protocols have failed, which hinders inter-laboratory comparability.[1] Therefore, it is not useful when comparing isolates from different centers.[6]

Multilocus sequence: It is based on sequence analysis of 7 housekeeping genes (arcC, aroE, glpF, gmk, pta, tpi, yqiL). Each unique sequence within a gene is designated as an allele. When combined, the 7-allele pattern behaves as an allelic profile or sequence type (ST) that defines the MRSA isolate. For example, all isolates with the allelic profile 7-6-1-5-8-8-6 are clones and this sequence is identified as ST5. However, this method is laborious and time-consuming.[1]

A database for MLST typed isolates identified and reported globally exists through http://www.pubmlst.org.

Staphylococcal Cassette Chromosome mec: SCCmec is a mobile genetic element that harbors mecA gene. Different typing methods exist, utilizing polymerase chain reaction (PCR) technology. There are five main types, SCCmec I to V,[1] but overall, 13 types have been reported (type I-XIII), some of which have subvariants.[7]

Staphylococcus aureus Protein A Gene Typing: This is a single-locus DNA sequence typing of the polymorphic region X of spa gene. The typing reveals a specific pattern of repeats which is then used to deduce the spa type. It is simpler than the tedious MLST typing. It has good discriminatory power that lies between PFGE and MLST. Although individual laboratories use "in-house" sequencing platforms, a dedicated software (Ridom StaphType software) that analyzes sequencing patterns from different laboratories exists and is accessible to the public. This software helps ensure interlaboratory comparability. A laboratory's typing data can be uploaded and synchronized into the database via a central server available at http://www.spaserver.ridom.de. The database currently has 20,056 spa types reported, representing 444,798 total strains from 146 countries.[1]

Clonal Complex: The primary method of determining clonal complex (CC) is based on MLST. Individual isolates with an identical sequence in at least 5 out of 7 housekeeping genes are grouped into a CC. The ancestor of a CC is the ST with the highest single-locus variants. Therefore, each ST will belong to a single CC, but each CC can have several STs with five identical housekeeping genes. For example, ST228 and ST5 both belong to CC5.[1]

Due to a higher discriminatory power, several spa types can belong to the same ST. A unique spa-type can be shared among several STs but can belong to only 1 CC. Therefore, clustering analysis based on spa typing is also feasible (i.e., spa-CC). **Supplementary Table 1** reports the relative global frequencies of common spa types.

MRSA Clone Nomenclature: The nomenclature of MRSA strains is determined by the combination of ST and SCCmec type. For example, ST239-SCCmec-III is colloquially known as Brazilian/Hungarian clone. **Table 1** lists some of the major clones identified globally. Some clones can have more than 1 colloquial name.

For a more detailed description of MRSA molecular typing, we refer our readers to a publication by Deurenberg et al..[1] Additionally, a comprehensive guide describing the different MRSA clones is available.[8] Finally, **Supplementary Figure 1** illustrates the interconnection of different typing methods.

Panton-valentine leucocidin (PVL) and toxic shock syndrome-toxin 1 (Tst1): The lukF/S-PV and TST genes encode *PVL* and *Tst1*,, respectively, which are virulence factors found in MRSA.[9] More specifically, [*PVL*+] strains can cause leukocyte destruction and tissue necrosis and are frequently associated with skin and soft tissue infections and necrotizing pneumonia.[10] *PVL* is commonly found in CA-MRSA strains and rarely present in HA-MRSA strains.[8]

Community-acquired MRSA (CA-MRSA) vs. Hospital-acquired MRSA (HA-MRSA): Distinguishing between CA-MRSA and HA-MRSA has traditionally been based on genetic makeup.[1] CA-MRSA is typically associated with SCCmec types IV/V while HA-MRSA is associated with types I/II/III. However, CA-MRSA carrying SCCmec type I, II, and III and HA-MRSA carrying type IV have been identified questioning the distinction based on SCCmec alone.[1]

Table 1. Major MRSA Clones Encountered Globally.

Clone	MLST	ST	CC	*SCCmec*	*Spa*	Geographic areas
UK-EMRSA-3	1-4-1-4-12-1-10	5	5	I	**t003**, **t002**, t001, t010, **t045**, t053, t062, t105, t178, t179, t187, t214, t311, t319, t389, t443	Af, Arg, Aus, Au, Bel, Bra, Can, Chi, China, Cro, Cyp, Cze, Den, Det, Es, Fin, Fr, Ga, Ger, Gr, HK, Hun, Ice, Iran, Ire, Isr, It, Jap, Ma, Mal, Mart, Min, Nets, NZ, Nor, Pol, Por, Ro, SA, Slo, Sp, Swe, Swit, Tai, UK, USA
New York/Japan	1-4-1-4-12-1-10	5	5	II	**t003, t002,** t001, t010, **t045**, t053, t062, t105, t178, t179, t187, t214, t311, t319, t389, t443	Aus, Aust, Belg, Can, Cro, Den, Fin, Fra, Ger, HK, Hun, Ire, Jap, Kor, Mex, Por, Sin, Swe, Tai, Uru, UK, USA
Paediatric	1-4-1-4-12-1-10	5	5	IV	**t001**, **t002**, **t003**, t010, **t045**, t053, t062, t105, t178, t179, t187, t214, t311, t319, t389, t443	Alg, Arg, Aust, Bra, Col, Den, Fr, Kor, Nor, Pol, Por, Sp, Swe, Uru, UK, USA
South German	1-4-1-4-12-24-29	228	5	I	t041, t023, t201, t188, t001	Aust, Aus, Cro, Ger, Hun, Isr, It, Malta, Par, Slo, Swit
Brazilian/Hungarian HA-MRSA	2-3-1-1-4-4-3	239	8	III	**t037**, t030, t234, t387, t388	Arg, Aust, Aus, Bel, Bul, Can, Chi, China, Cro, Cze, Den, Egy, Fr, Ger, Gr, Ice, In, Iran, Ire, Isr, It, Latvia, Ma, Mal, Min, Nets, NZ, Nor, Pol, Ro, SA, Sp, Swe, Swit, Tai, Tur, Ug, UK, USA, China
Iberian	3-3-1-12-4-4-16	247	8	I	**t008,** t051, t052, t054, t200, t064	Aust, Bel, Cro, Cze, Den, Fin, Fr, Ger, It, Nets, Pol, Por, Slo, Sp, Swe, Swit, UK, USA
USA 300 CA-MRSA [C]	3-3-1-1-4-4-3-8	8	8	IV	**t008**	Aust, Ger, Iraq, Ire, Sp, Swit, UK, USA, Jap, HK
UK-EMRSA-15 HA-MRSA [B]	7-6-1-5-8-8-6	22	22	IV	**t032**, **t022**, **t005**, **t223**, t309, t310, t417, t420	Aus, Bel, Cro, Can, Den, Det, Ger, Ice, Ire, It, In, Mal, Malta, Min, Nets, NZ, Nor, Por, SA, Sp, Swe, UK,
Southwest pacific CA-MRSA	2-2-2-2-6-3-2	30	30	IV	**t012**, **t021**, t019, **t018**, t318, t338, t138, t276, t268, t391	Aust, Ger, HK, Ire, Ku, La, NZ, Sca, Swit, Tai, UK, USA
European CA-MRSA [A]	1-3-1-14-11-51-10	80	80	IV	**t044**, t416	Alg, Aus, Au, Bel, Bul, Chi, Cro, Cyp, Cze, Den, Det, Egy, Fin, Fr, Ger, Gr, Hun, Ice, Iran, Ire, It, Isr, Ku, Malta, Nets, Nor, Ro, Sp, Swe, Swit, Tur, UK, Nets, Cam, Moz

Data adopted from Deurenberg et al (5), Monecke et al (6), http://www.spaserver.ridom.de, and http://www.pubmlst.org. Bolded *spa* types are the most commonly reported types globally (refer to **supplementary table 1**).
Arg: Argentina; Af: Afghanistan; Alg: Algeria; Aust: Australia; Au: Autre; Bel: Belgium; Bra: Brazil; Bul: Bulgaria; Cam: Cameroon; Can: Canada; CC: Clonal complex; Chi: Chile; Col: Colombia; Cro: Croatia; Cyp: Cyprus; Cze: Czech Republic; Den: Denmark; Det: Detmold; Egy: Egypt; Es: Estonia; Fin: Finland; Fr: Franc; Ga: Gabon; Ger: Germany; Gr: Greece; HK: Hong Kong; Hun: Hungary; Ice: Iceland; In: India; Ire: Ireland; Isr: Israel; It: Italy; Jap: Japan; Kor: Korea; Ku: Kuwait; La: Lativa; Ma: Macedonia; Mal: Malaysia; Mart: Martinique; Mex: Mexico; Min: Minden; MLST: Multilocus sequence; Moz: Mozambique; Net: Netherland; Nor: Norway; NZ: New Zealand; Par: Paraguay; Pol: Poland; Por: Portugal; Ro: Romania; SA: South Africa; Sca: Scandinavia; Sin: Singapore; Slo: Slovenia; Spa: *s. aureus* protein A; Sp: Spain; ST: Sequence type; Swe: Sweden; Swit: Switzerland; Tai: Taiwan; Tur: Turkey; Ug: Uganda; UK: United Kingdom; Uru: Uruguay; USA: United States of America
[A] Widely disseminated in Europe and Middle East, accounts for considerable percent of isolates in Greece, [B] When present, it tends to be abundant; accounts for 54% isolates in Por, 66% in Malta, 80% in Ire and Azores; This clone is also increasingly detected in UK; This clone is [*PVL*-], [*Tst1*-] but a [*PVL*+] variant and a [*Tst1*+] variant exist; the [*Tst1*+] variant occurs in some parts of the Middle East; the [*PVL*+] variant occurs in some European countries, Middle east, and Aust, [C] spread extensively across USA.

Alternatively, MRSA can be classified by epidemiological criteria. The epidemiologic definition of CA-MRSA is any strain isolated in an outpatient setting or within 48 hours of admission in a patient with no prior history of MRSA infection or colonization, no permanent invasive medical devices, and none of the following risk factors within the past year: hemodialysis, surgery, hospitalization, residence in a long-term care facility.[1,11] Strains not fitting this definition are considered HA-MRSA. Nonetheless, we now know that both genotypes can be acquired regardless of risk factors.[1] Therefore, the better practice would be to use epidemiological criteria to label isolates as community-onset (CO-MRSA) versus hospital-onset (HO-MRSA).

For the sake of our review, we use the genetic makeup to identify CA-MRSA or HA-MRSA and, when provided, the epidemiological criteria to distinguish CO-MRSA from HO-MRSA.

Antimicrobial Susceptibilities: We reviewed reported susceptibility rates against rifampin, fusidic acid, clindamycin, trimethoprim-sulfamethoxazole (TMP-SMX), ciprofloxacin, tetracycline, erythromycin, vancomycin, linezolid, teicoplanin, daptomycin, mupirocin, and gentamicin.

Methodology. We used the PubMed search engine to identify articles published from January 2005 to June 2019. We selected 13 out of the 18 Arab countries listed in section the Middle East and North African Region, geographically spread across the MENA region. The area was subdivided into the Gulf Cooperation Council (GCC), which includes KSA, Kuwait, UAE, Qatar, Bahrain and Oman; the Levant region, which includes Lebanon, Palestine, Jordan, and Iraq; and the North African region, which includes Egypt, Algeria, and Tunisia. For our search we used the following terms: "Methicillin-Resistant Staphylococcus aureus", "Saudi Arabia", "Kuwait", "United Arab Emirates", "Oman", "Qatar", "Bahrain", "Iraq", "Lebanon", "Palestine", "Gaza strip", "West bank", "Jordan", "Syria", "Egypt", "Algeria," "Tunisia." Our search retrieved 134 articles. We excluded articles that lacked clear methodology and articles written in languages other than Arabic and English. We also disregarded articles that were not accessible unless all relevant information was clearly provided in the abstract. Finally, we included 20 articles from KSA, 8 from Kuwait, 5 from UAE, 2 from Qatar, 1 from Bahrain, 7 from Lebanon, 5 from Jordan, 3 from Gaza, 1 from West Bank, 10 from Algeria, 5 from Tunisia, and 7 from Egypt.

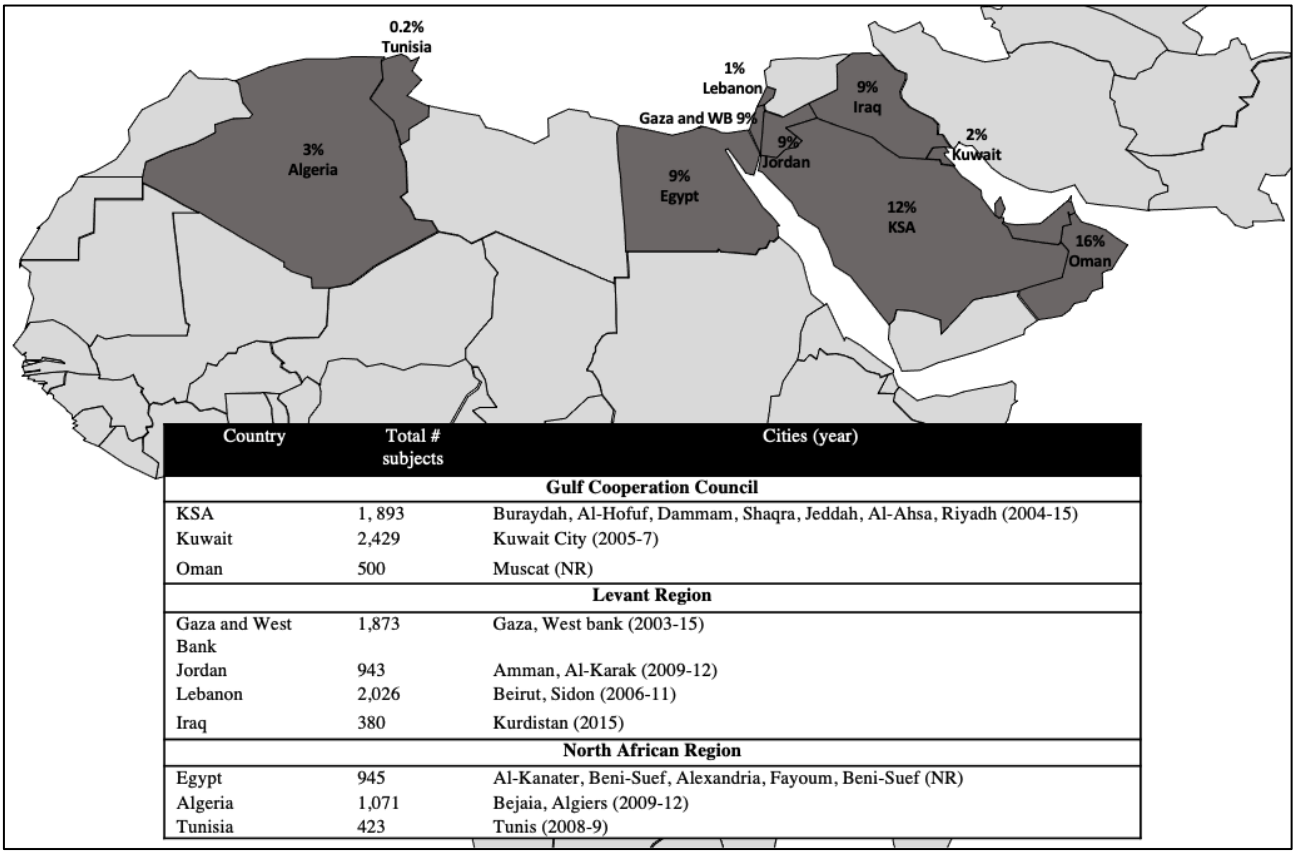
Results.

MRSA colonization in the MENA region:

MRSA Nasal Carriage: Subjects with MRSA isolated from nasal/pharyngeal swabs without symptoms attributed to MRSA infection are considered colonized. We report MRSA carriage rate as a percent of total nasal/pharyngeal swabs growing MRSA (i.e., total MRSA/total swabs). **Figure 1** provides the MRSA carriage rate of total subjects combined from all studies per country. **Table 2** lists rates stratified according to four cohorts (outpatients, inpatients, healthy volunteers, and HCWs).

When combining all subjects reported per country, the colonization rates ranged from 2%-16% in GCC,[12-22] 1-9% in Levant,[23-30] and 0.2%-9% in North African Arab states.[12,31-36] In the GCC, reported rates were overall higher in KSA and Oman compared to Kuwait. In the Levant and North Africa, Lebanon and Tunisia had very low rates.

Several factors may account for the difference in reported rates between studies. These include the difference in study cohorts (i.e., high risk vs. low risk for colonization), the difference in the study period, and the difference in local factors of the study site (i.e., resource-limited vs. resource-rich city or center). It is



Country	Total # subjects	Cities (year)
Gulf Cooperation Council		
KSA	1, 893	Buraydah, Al-Hofuf, Dammam, Shaqra, Jeddah, Al-Ahsa, Riyadh (2004-15)
Kuwait	2,429	Kuwait City (2005-7)
Oman	500	Muscat (NR)
Levant Region		
Gaza and West Bank	1,873	Gaza, West bank (2003-15)
Jordan	943	Amman, Al-Karak (2009-12)
Lebanon	2,026	Beirut, Sidon (2006-11)
Iraq	380	Kurdistan (2015)
North African Region		
Egypt	945	Al-Kanater, Beni-Suef, Alexandria, Fayoum, Beni-Suef (NR)
Algeria	1,071	Bejaia, Algiers (2009-12)
Tunisia	423	Tunis (2008-9)

Figure 1. Reported Rates of MRSA Colonization in the MENA Region. MRSA carriage rate reported as % of total nasal/pharyngeal swabs growing MRSA (i.e., total MRSA/total swabs). The reported rates in the figure are for the total number of subjects from all cited studies per country.
KSA [12-19]; Kuwait [20]; Oman [21, 22]; Gaza and West Bank [23-25]; Jordan [26, 27]; Lebanon [28, 29]; Iraq [30]; Egypt [12, 31-33]; Algeria [34, 35]; Tunisia [36].

Table 2. Reported Rates of MRSA Colonization in the MENA Region Stratified based on Cohorts.

Ref	Total # subjects	% Subjects with risk factors for MRSA	# MRSA(%)	City (year)	Site
KSA [12-19]					
[12]	**103 OP**	**0%**	**26 (25%)**	Buraydah (2011)	Multiple hospitals (n=NS)
	1,048 IP[A]	**31%**	**76 (7%)**		
[13]	· 600		7 (1%)	Al-Hofuf (2004)	King Fahad Hospital
[18]	· 228[B]		21 (9%)	Dammam (2011)	King Fahad Specialist Hospital
[14]	· 220		48 (22%)	Shaqra (2014-15)	Shaqra General Hospital
	152 CV	**0%**	**1 (1%)**		
[15]	· 50		0 (0%)	Jeddah (NR)	King Abdulaziz University
[16]	· 70		1 (1%)	Al-Ahsa (NR)	NS
[17]	· 32[C]		0 (0%)	Jeddah (2014-15)	King Abdulaziz University
	590 HCWs	**100%**	**128 (22%)**		
[19]	· 200		36 (18%)	Riyadh (2012-13)	King Khaled University Hospital
[15]	· 100		73 (73%)	Jeddah (NR)	Multiple hospitals (n=NS)
[16]	· 68[D]		3 (4%)	Al-Ahsa (NR)	Multiple hospitals (n=6)
[16]	· 72		6 (8%)	Al-Ahsa (NR)	Multiple hospitals (n=6)
[17]	· 150[D]		10 (7%)	Jeddah (2014-15)	King Abdulaziz University
Kuwait [20]					
[20]	**2,429 IP[E]**	**100%**	**42 (2%)**	Kuwait City (2005-7)	Farwania Hospital
Oman [21, 22]					
	312 CV	**2%**	**48 (15%)**		
[21]	· 189		34 (18%)	Muscat (NR)	Oman Medical College and Sultan Qaboos University Hospital
[22]	· 123[C]		14 (11%)	Muscat (NR)	Oman Medical College
	188 HCWs	**100%**	**31 (17%)**		
[21]	· 116		16 (14%)	Muscat (NR)	Oman Medical College and Sultan Qaboos University Hospital
[22]	· 72[D]		15 (21%)	Muscat (NR)	Oman Medical College
Gaza and West Bank [23-25]					
[24]	**843 IP[A]**	**0%**	**17 (2%)**	West bank (2003)	Ramallah Government hospital
[23]	**758 CV**	**3%**	**94 (12%)**	Gaza (2009)	Multiple Gaza neighborhoods (n=12)
	272 HCWs	**100%**	**61 (22%)**		
[25]	· 200		51 (26%)	Gaza (2015)	Al Shifa Hospital
[24]	· 72		10 (14%)	West Bank (2003)	Ramallah Government hospital
Jordan [26, 27]					
	646 CV	**4%**	**43 (7%)**		
[26]	· 227		17 (8%)	Amman (2009)	University of Jordan
[27]	· 419		26 (6%)	Alkarak (2011-12)	Al-Karak Hospital
[27]	**297 HCWs**	**100%**	**30 (10%)**	Al-Karak (2011-12)	Al-Karak Hospital
Lebanon [28, 29]					
[28]	**1, 526 OP**	**17%**	**2 (0.1%)**	Beirut (2010-11)	Rizk Hospital, Beirut
[29]	**500 CV[C]**	**12%**	**8 (2%)**	Beirut, Sidon (2006-7)	NS
Iraq [30]					
[30]	**198 CV**	**0%**	**8 (4%)**	Kurdistan (2015)	NS

[30]	**182 HCWs**	**100%**	**25 (14%)**	Kurdistan (2015)	NS
Egypt [12, 31-33]					
	130 OP[F]	**0%**	**36 (28%)**		
[31]	· 27		3 (11%)	Beni-Suef (NR)	Beni-Suef University
[12]	· 103		33 (32%)	Al Kheireya (2011)	-
[32]	**360 IP[G]**	**NS**	**29 (8%)**	Alexandria (NR)	Alexandria University
[32]	**470 CV[G]**	**NS**	**32 (7%)**	Alexandria (NR)	Alexandria University
	475 HCWs	**100%**	**56 (12%)**		
[33]	· 223		30 (14%)	Fayoum (NR)	Fayoum University Hospital
[32]	· 191		21 (11%)	Alexandria (NR)	Alexandria University
[31]	· 61		5 (8%)	Beni-Suef (NR)	Beni-Suef University
Algeria [34, 35]					
[34]	**612 IP**	**33%**	**9 (2%)**	Bejaia (2010-12)	Frantz-fanon nephrology department and Amizour Hospital
[35]	**459 CV[G]**	**NS**	**23 (5%)**	Algiers (2009-11)	Centre Hospitalo-Universitaire Mustapha Bacha
Tunisia [36]					
[36]	**423 CV**	**23%**	**1 (0.2%)**	Tunis (2008-9)	Université Tunis El Manar

MRSA carriage rate reported as % of total nasal/pharyngeal swabs growing MRSA (i.e., total MRSA/total swabs). Bolded rows represent entire cohort. Risk factors for MRSA: isolate recovered > 48 hours of hospitalization, invasive medical devices, healthcare workers (including medical/pharmaceutical students with clinical exposure) and the following within the preceding year: hemodialysis, surgery, hospitalization, residence in a long-term care facility.

CV: community volunteer(s); HCWs: healthcare worker(s); IP: inpatient(s); NS: not specified; OP: outpatient(s). [A] Screened <48 hours of admission, [B] Cancer patients, [C] Students without clinical exposure (considered community volunteers), [D] Students with clinical exposure (considered HCWs), [E] ICU patients [screened on admission and weekly thereafter; hence, all considered at risk for MRSA colonization], [F] 27 subjects were dental clinic outpatients whose risk factors were not specified, [G] access to abstract only.

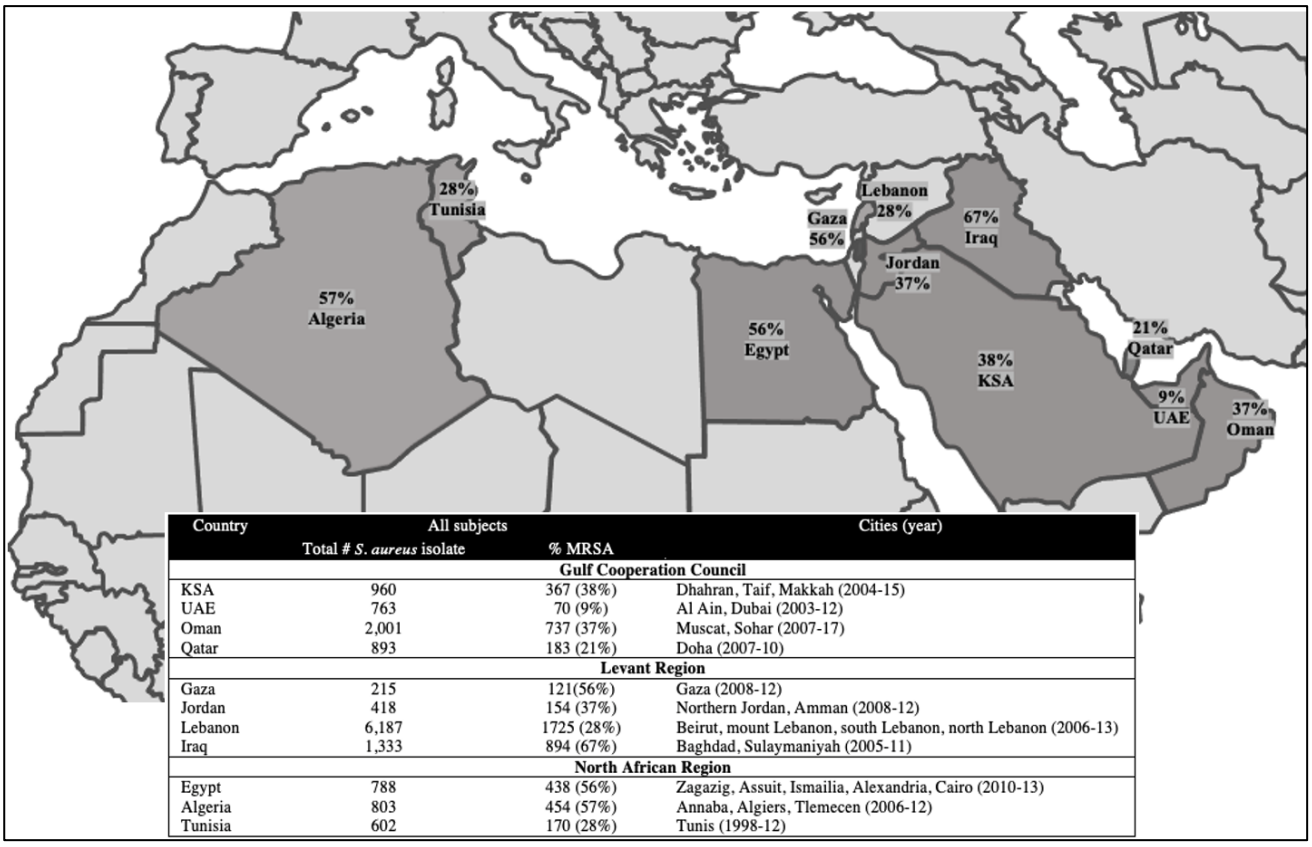
difficult through our review to determine which factors explain the observed difference in rates. The cited studies from Lebanon were limited to outpatients and community volunteers only as opposed to Gaza, Jordan, and Iraq, where some studies included HCWs. Nonetheless, even when comparing similar groups, the rates in Lebanon remained lower. This is true for Beirut and Sidon, 2 heavily populated cities in Lebanon.[28,29] It is also unclear why Kuwait in GCC and Tunisia in North Africa had lower rates than neighboring states. The study from the city of Kuwait included 2,429 intensive care patients screened on admission and weekly thereafter, yet only 2% had MRSA colonization.[20] In Tunisia, only 0.2% of 423 community volunteers carried MRSA,[36] while rates in similar groups reached 5% in Algeria and 7% in Egypt.[12,31-35]

Moreover, the reported rates of MRSA carriage varied widely between centers and communities within the same country. Here again, the difference in rates may be driven by the aforementioned factors. Perhaps the interplay between varying environmental and social factors across a county could explain why certain areas serve as pockets for higher prevalence. In the healthcare setting, discrepancies in rates between hospitals might be driven by differences in the type of patients served i.e., high acquity versus low acuity hospitals) and the institutional infection control efforts.

MRSA Infections in the MENA Region:

MRSA Infection Rates: We report rates of MRSA infection as percent of clinical *S. aureus* isolates showing methicillin resistance (total MRSA/total *S. aureus* derived from clinical specimen). **Figure 2** demonstrates percent methicillin resistance in total isolates derived from all studies per country. **Supplementary table 2** provides more details for each cited study.

When examining all isolates recovered per country, methicillin-resistance ranged from 9%-38% in GCC,[11,37-44] 28%-67% in the Levant,[45-53] and 28%-57% in North African states.[54-65] In the GCC, lower rates were recorded in UAE and Qatar compared to Oman and KSA. In UAE, the highest rate reached 29% in a study from Dubai examining 62 *S. aureus* isolates derived from purulent skin and soft tissue infections (SSTI).[41] In the Levant and North Africa, Lebanon and Tunisia again had the lowest rates in clinical isolates. Notably, one of the studies from Lebanon saw a rate of 72% resistance in 32 isolates.[48] These isolates were randomly selected, not consecutive, and examined only wound and respiratory specimen. A subsequent study testing 4,890 isolates from 16 different hospitals across Lebanon showed a much lower rate of 28%.[49] In Iraq, very high rates were seen in combat



Country	All subjects		Cities (year)
	Total # *S. aureus* isolate	% MRSA	
Gulf Cooperation Council			
KSA	960	367 (38%)	Dhahran, Taif, Makkah (2004-15)
UAE	763	70 (9%)	Al Ain, Dubai (2003-12)
Oman	2,001	737 (37%)	Muscat, Sohar (2007-17)
Qatar	893	183 (21%)	Doha (2007-10)
Levant Region			
Gaza	215	121(56%)	Gaza (2008-12)
Jordan	418	154 (37%)	Northern Jordan, Amman (2008-12)
Lebanon	6,187	1725 (28%)	Beirut, mount Lebanon, south Lebanon, north Lebanon (2006-13)
Iraq	1,333	894 (67%)	Baghdad, Sulaymaniyah (2005-11)
North African Region			
Egypt	788	438 (56%)	Zagazig, Assuit, Ismailia, Alexandria, Cairo (2010-13)
Algeria	803	454 (57%)	Annaba, Algiers, Tlemecen (2006-12)
Tunisia	602	170 (28%)	Tunis (1998-12)

Figure 2. Reported Rates of Methicillin-resistance among *Staphylococcus aureus* from Clinical Specimen in the MENA Region. The figure demonstrates rates as percent of all clinical *S. aureus* isolates derived from all studies per country showing methicillin resistance (total MRSA/total *S. aureus* derived from clinical specimen).
KSA [37-40] UAE [41] Oman [42, 43] Qatar [11, 44] Gaza[45] Jordan [46,47] Lebanon [48-50] Iraq [51-53] Egypt [54-57] Algeria[58-62] Tunisia [63-65]

support hospitals among U.S. military personnel,[51,52] particularly when examining skin and soft tissue infections (SSTI), and in a burn center where the rate reached 88%.[53] In North Africa, Algeria reached a high of 86% in Annaba when examining diabetic foot infections.[60] A high rate of 75% in another study was also seen in surgical wound infections >48 hours postoperatively in Tlemecen.[62] On the other hand, a study from Algiers showed a lower rate of 19% which again highlights the varying epidemiology depending on site within a country.[59] When testing clinical isolates from neutropenic patients in Tunisia, a rate of 18% was detected, still lower than most studies in Egypt and Algeria.[63]

Only few studies specified site of acquisition based on epidemiological criteria, i.e., CO-MRSA vs HO-MRSA, outlined in **table 3**. Based on these few studies, isolates causing hospital-onset infections showed higher rates of methicillin resistance. *S. aureus* isolates causing community-onset infections had 51% methicillin resistance in KSA,[40] 12%-47% in Egypt,[56,57] 24%-40% in Algeria,[58,59,61,62] 29% in Tunisia.[64] In Egypt, the 40% rate was in community-onset SSTI.[56] On the other hand, isolates causing hospital-onset infection had 66% resistance in KSA,[40] 77% in Egypt,[56,57] 47%-75% in Algeria,[58,59,61,62] 18%-55% in Tunisia.[63,64]

Molecular Types of MRSA in MENA Region: As expected, heterogeneity between studies in the typing techniques utilized and the reporting of results was evident. Some studies reported SCCmec types alone while others reported MLST and/or *spa* typing with or without CC assignment. Therefore, determining the relatedness of reported strains from different studies is challenging. For example, in the study from Bahrain, PFGE typing was used. While this is a good tool to investigate relatedness of strains in an institution, it does not allow for comparison with other centers.[6]

Studies demonstrated a wide clonal diversity across the region. This was evident by the large number of different *spa* and/or MLST types and their corresponding CCs . Furthermore, the epidemiology varied depending on center, city, study period, and subject cohort.

The bulk of studies recovered in our review did not classify their samples based on site of acquisition (CO-MRSA vs HO-MRSA). This would have been a valuable tool to distinguish the epidemiology between community and healthcare settings.

All studies examining colonizing MRSA were limited by a small sample size. **Table 4** lists the relative frequencies of *PVL*, *Tst1*, SCCmes, MLST, *Spa*, and CCs in colonizing strains. **Supplementary table 3** organizes

Table 3. Stratification of clinical isolates based on epidemiological criteria.

Ref	*S. aureus* isolates			MRSA isolates			
	Total #	CO	HO	**Total #**	CO	HO	
[5]	**252**[A]	136	116	**146**	70	76	KSA
[7]	**62**[B]	NS	NS	**18**	17	1	UAE
[23]	**38**[C, D]	38	0	**18**	18	0	Egypt
[24]	**631**[A]	183	448	**364**	21	343	Egypt
[25]	**148**[A]	29	119	**92**	7	85	Algeria
[26]	**129**[A]	NS	NS	**25**	10	15	Algeria
[28]	**221**[A]	84	137	**99**	34	65	Algeria
[29]	**220**[C, E]	0	220	**165**	0	165	Algeria
[30]	**72**[F]	0	72	**13**	0	13	Tunisia
[31]	**143**[A]	77	66	**58**	22	36	Tunisia

CO: community-onset; HO: hospital-onset; NS: not specified. [A] Various clinical infections, [B] Purulent SSTI, [C] SSTI, [D] Study examined community-onset infections only, [E] Study examined hospital-onset infections only, [F] Neutropenic patients in bone marrow transplant center.

the genotypes into clones. In the GCC, *PVL* gene carriage reached 12% in outpatients in KSA.[12] *Tst1* gene prevalence was not examined in studies from GCC.[12,16,20] Low *PVL* carriage was also detected in the Levant, 3%-9%.[23,26,27] *Tst1* was examined in Jordan only, and very high rates were depicted in both community and healthcare settings.[26,27] In North Africa, *PVL* carriage was low in Egypt, 2%-15%,[12,31,33] but reached 33% in Algeria,[34] while *Tst1* carriage reached 22% in Algeria,[34] but 50% in Egypt.[31]

Table 4. Molecular Typing of Colonizing MRSA Isolates in the MENA Region.

Ref	# MRSA	*PVL*	*Tst1*	SCCmec (%)	*Spa* (%)	MLST	Clonal Complexes/PFGE/singletons (%)	Study location (year)
KSA								
[12]	26 OP	12%	ND	V (42), NT (35), IVa (23)	**t084** (14), t085 (13), **t008** (13), t349 (7), t660 (7), **t002** (7), **t223** (7), t376 (7), **t189** (7), t442 (7), t6836 (7), t11841 (7)	ND	CC15 (27), **CC8** (13), CC25 (13), **CC5** (7), **CC22** (7), **CC80** (7), CC188 (7), CC-NA (20)	Buraydah (2011)
[16]	20 CV	ND	ND	IV (90), IVa (10)	t131 (20), t1328 (20), t688 (20), **t304** (20), t128 (10), t1339 (10)	ND	**CC80** (20), **CC22** (20), **CC5** (20), PFGE F (20), CC1 (10), PFGE K CC88 (10)	Al-Ahsa (NR)
Kuwait								
[20]	18 IP[B]	ND	ND	III (72), IV (28)	t421 (33), t945 (28), t4410 (6), t388 (6), **t223** (6), t3010 (6), t6665 (6), t1234 (6), **t044** (6)	ST239 (72), ST22 (11), ST97 (11), ST80 (6)	ND	Kuwait City (2005-7)
Gaza								
[23]	94 CV	9%	ND	IV (1), IVa (81), V (11), ND (5), IVc (2)	**t223** (76)[A]	ST22 (74), ST78 (7), ST80 (5), ST-ND (5), ST1784 (2), ST1785 (2), ST5 (1), ST30 (1), ST1734 (1), ST913 (10)	**CC22** (76), CC88 (7), **CC80** (5), **CC5** (3), **CC30** (2), CC913 (1), CC-ND (5)	Gaza (2009)
Jordan								
[26]	37 HCW	5%	100%	IVe (81), IV (14), IVc (5)	t9519 (73), **t223** (14), **t044** (5), NT (8)	ND	ND	Amman (2009)
[27]	26 CV	8%	58%	IVa (69), IVc (19), NT (8), IVg (4)	**t223** (39), t214 (12), **t021** (8), t1651 (8), t386 (8), t6397 (4), t790 (4), **t012** (4), t253 (4), **t044** (4), t1234 (4), t803 (4)	ND	**CC22** (46), **CC30** (23), **CC5** (12), CC1 (8), **CC80** (4), CC97 (4), CC15 (4)	Al-karak (2011-12)
	30 HCW	3%	57%	IVa (80), IVc (17), V (3)	**t223** (40), t386 (20), t309 (7), **t018** (7), t10683 (7), **t021** (6), t693 (3), **t012** (3), **t044** (3), t370 (3)	ND	**CC22** (47), CC1 (23), **CC30** (17), **CC5** (7), **CC80** (4), CC45 (3)	

Egypt								
[33]	30 HCW	2%	ND	ND	ND	ND	ND	Fayoum (NR)
[31]	21 OP	15%	50%	IV (48), I (38), V (5), NT (5), II (5)	**t223** (24), t267 (24), t14339 (20), t3689 (10), **t084** (10), t380 (10), t8506 (5), t1339 (5)	ND	*Spa*-CC223 (52), *Spa*-S-t267 (24), *Spa*-S-t084 (10), *Spa*- S-t380 (10), *Spa*-S-t1339 (5)[C]	Beni-Suef (NR)
[12]	33 OP	15%	ND	IVa (49), V (52)	t688 (30), **t044** (15), t786 (15), **t021** (10), t318 (10), **t223** (10), **t008** (5), t11839 (5)	ND	**CC5** (30), **CC30** (20), **CC80** (15), CC88 (15), **CC22** (10), **CC8** (5), CC-NA (5)	Al-Kanater (2011)
Algeria								
[34]	9 IP	33%	22%	IVa (33), IVc (44), IVh (11) , VII (11)	**t223** (22%)[A]	ST80 (44%), ST22 (22%), ST5 (22%), ST535 (11%)	ND	Bejaia (2010-12)

Bolded CCs and *spa* types are frequently reported globally (refer to **table 1** and **supplementary table 1**). Values were rounded to the nearest digit. CC: clonal complex; CV: community volunteer; HCW: healthcare worker; IP: inpatient; ND not determined; NT not typeable; OP: outpatient; S-: singleton; *Spa*-CC: *spa* clonal complex.
[A] Only ST22 was *spa* typed in this study, [B] ICU patients, [C] The predicted MLST-CC for the *spa*-CC are: *Spa*-CC223 = CC22, *Spa*-S-t267 = CC80, *Spa*-S-t084 = CC15, *Spa*-S-t380 = CC80, *Spa*-S-t1339 = CC-NT.

Table 5 lists the *PVL*, *Tst1*, SCCmes, MLST, *Spa*, and CCs in infective strains. **Supplementary table 4** organizes the genotypes into clones. In GCC, *PVL* carriage ranged from 0%-77%,[7,11,37,66-73] while *Tst1* carriage ranged from 4%-24%.[7,66-68,71,73] In the Levant, *PVL* gene was detected in 37%-96% of infective MRSA.[45,47,48,74] *Tst1* gene was screened for in Gaza and detected in 40% of isolates.[45] *PVL* detection rate ranged from 21%-88%.[54,58,75,76] Most cited studies did not determine *Tst1* carriage except one from Algeria where none of the isolates carried the toxin gene.[61]

Both HA-MRSA and CA-MRSA genotypes were frequently detected among colonizing and infective strains in the MENA region. Most of the globally prevalent *spa* types were detected in the Arab countries, as illustrated in **supplementary table 1**. *Spa* types belonging to European CA-MRSA, Brazilian/Hungarian HA-MRSA, and EMRSA-15 HA-MRSA were most widely distributed across the region. The most frequently detected CCs were CC5, CC8, CC22, CC30, and CC80, which are globally spread complexes briefly reviewed in **table 1**. In this section we review the epidemiology of these CCs in the MENA Arab world.

Clonal Complex 5: Members of CC5 are widespread geographically.[8] Established clones from this group can carry SCCmec-I, II, III, IV, and V and can be HA-MRSA and CA-MRSA. It consists of several clones including the South German Epidemic HA-MRSA (ST228-SCCmec-I), Geraldine CA-MRSA (ST5-SCCmec-I), West Australian (W.A.) MRSA-18, and -21 (both ST5-SCCmec-I) and -48 (ST835-SCCmec-I), New York/Japan (ST5-SCCmec-II), and Paediatric (ST5-SCCmec-IV) clones, among others.[8] The last 2 clones are described as pandemic. Another clone previously described is ST5-SCCmec-V which is colloquially known as WA MRSA-11, -14, -34, and -35. This isolate was detected in Australia, Ireland, and Germany.[8]

Colonizing isolates of this group were detected in KSA,[12] Gaza,[23] Jordan,[27] and Egypt.[12] These included the CC5-V and CC5-IV which are likely related to WA MRSA and Paediatric clones, respectively. All these strains were [*PVL*-]. In Egypt, CC5-V made up 30% of colonizing strains from outpatients.[12]

In infective strains from the MENA, the CC5 and its clones were among the less commonly detected strains. Detected SCCmec types were II, IV, and V. Therefore, observed clones included the Paediatric, New York/Japan, and WA MRSA-(11, -14, -34, and-35).

Clonal Complex 8: Several clones belong to this complex, including both CA-MRSA and HA-MRSA.[8] Its strains can carry SCCmec-I, IV, V, and VIII. MLST types include ST8, ST72, and ST239/ST240/ST241. It houses the first known MRSA clone (ST250-SCCmec-I), known as Ancestral MRSA. This clone is disappearing with time. It also houses the famous Iberian (ST8-SCCmec-I), USA300 CA-MRSA ([*PVL*+] ST8-SCCmec-IV+ACME) and Brazilian/Hungarian HA-MRSA ([*PVL*-] ST239-SCCmec-III). USA300 has disseminated throughout the United States of America (U.S.) in few years. Sporadic cases have been identified in some European countries. The Brazilian/Hungarian HA-MRSA is considered the oldest pandemic strain. It is described from countries in every continent. This clone is always [*PVL*-]. It is prevalent in Europe, Australia, Middle East, and Asia and can be divided into 3 clades [European, Asian, and south American]. ST240 and 241 are closely related to ST239, each differ in mutations within 1 housekeeping gene only.[8]

In MENA region, the Brazilian/Hungarian HA-MRSA was very prevalent in some centers in Kuwait[7,69] and KSA[66,67] but had a decreasing presence in a center from UAE,[71] and was completely absent in 1 hospital in Qatar.[11] It had a modest presence in the Levant.[45,47,48,74] It was notably nonexistent in combat support hospitals in Iraq.[74] In Algeria, It was very common in Annaba but not in Algiers,[58-61,75] and in Tunisia, it was frequently encountered in HO-MRSA isolates but not CO-MRSA.[75] All ST239 isolates in the MENA region were [*PVL*-] and

Table 5. Molecular Typing of Infective MRSA Isolates in the MENA Region.

Ref	#MRSA	*PVL*	*Tst1*	SCCmec (%)	*Spa* (%)	MLST (%)	Clonal Complexes/PFGE/singletons (%)	Study location (year)
KSA								
[66]	120[A]	0%	8%	III (100)	**t037** (35), **t044** (19), t030 (5), t363 (5), **t304** (4), **t002** (4), t631 (3), t690 (3), t019 (2), t388 (2), **t032** (2), **t223** (2), t3059 (2), t138 (1), t459 (1), t748 (1), t932 (1), t1070 (1), t790 (1), t4573 (1), t7604 (1), t8506 (1), t8855 (1), t376 (1), t8731 (1), t729 (1), t8507 (1), t701(1), t364 (1), t2235 (1)	ND	*Spa*-CC037 (55), *spa*-CC790 (8), *spa*-CC376 (21), cluster 4 *spa* CC690 (4), *Spa*-no founder (5), S-t002 (4), S-t3059 (2), S-t364 (1), S-t2235 (1)	Riyadh (210)
[67]	107[B]	54%	8%	III (21), IV (75), V (4)	ND	ST239 (21), ST772 (1), ST834 (1)	**CC8** (21), **CC22** (28), **CC80** (20), **CC30** (12), **CC5** (8), CC6 (3), CC88 (3), CC97 (2), CC1 (2), CC9 (1), CC45 (1)	Riyadh (NR)
[68]	117	49%	9%	III (8), IV (80), V (10)	ND	ST239 (8), ST8 (1), ST72 (1), ST913[C]	**CC80** (30), CC6 (13), **CC5** (11), **CC22** (10), **CC8** (9), **CC30** (7), CC97 (7), CC88 (5), CC15 (3), CC2250 (2), CC1 (1), CC96 (1), CC45 (1), CC913 (1)	Riyadh (2009-15)
[72]	101	38%	ND	III (39), IV (43), IVa (16), IVc (3)	ND	ND	ND	Jeddah (2009-11)
[87]	100	19%	ND	I (3), II (9), III (47), IV (29), NT (12)	ND	ND	ND	Makkah (2012)
[37]	71	28%	ND	I (34), II (10), III (20), IV (20), V (16), NT (1)	ND	ND	ND	Taif city (2013-15)
Kuwait								
[69]	400[D]	16%	ND	II (5), III (55), IV (32), V (8), VI (0.2)	t030, **t037**, t421, t945, t860, t064, **t008**, t1902, t138, t459, **t032**, t790, **t223**, t5708, t309, t3935, t2251, t852, t3107, t5983, **t002**, **t003**, t242, t105, **t045**, t306, t2164, t688, t5258, t1154, t376, t8154, t1154, **t018**, t042, **t044**, t019, t345, t318, t1130, t605, t6811, **t127**, t321, t345, t10795, t657, t12211, **t304**, t1234, t13204, t690, t4067, t5041, t5562, t314, t991, t370, t050, t315, t1427, t4000, t605	ST239 (46), ST22 (9), ST80 (7), ST5 (7), ST30 (4), ST241 (3), ST6 (2), ST36 (2), ST772 (2), ST8 (2), ST97 (2), ST113 (1), ST225 (1), ST105 (1), ST149 (1), ST361 (1), ST1 (0.3), ST88 (0.3), ST121 (0.3), ST913 (0.3), ST46 (0.3), ST72 (0.3), ST508 (0.3), ST1289 (0.3), ST1465 (0.3), ST1637 (0.3), ST2816 (0.3)	**CC8** (58), **CC22** (9), **CC5** (9), **CC80** (7), **CC30** (6), CC1 (3), CC6 (2), CC97 (2), CC88 (1), CC121 (1), CC913 (1), CC45 (1), CC361 (1)	Multiple sites (1992-2010)
[84]	6922	ND	ND	I (0.3), II (1), III (29), IV (54), V (15), NT (1)	ND	ND	ND	Multiple sites (2011-15)
[70]	26 *SCC*mec-IV	77%	ND	IV (89), IVa (8), IVc (4)	ND	ST80 (46), ST30 (31), ST5 (8), ST6 (4), ST8(8), ST361 (4)	**CC80** (46), **CC30** (31), **CC5** (12), **CC8** (8), CC-ND (4)	Multiple sites (2001-3)

[78]	37 ST22 Urease (-)	22%	62%	IV (22), IVa (70), IVh (8)	**t223 (51), t032** (8), t853 (14), t790 (8), t3107 (5), t309 (3), t2251 (3), t3935 (3), t5708 (3), t5983 (3)	ST22 (100)	ND	Multiple sites (2005-10)
[7]	209 [E, F]	31%	5%	IV (40), III (34), V (26), VI (4)	t860 (24), t945 (9), **t127** (7), t688 (7), **t304** (6), t044 (6), *spa*-NT (1), **t003**, **t002**, **t005**, **t008**, **t018**, t019, **t021**, **t032**, **t037**, t042, **t045**, t148, t105, t1120, t11836, t14700, t1247, t12398, t16185, t1839, t16202, t148, t306, t314, t355, t359, t362, t363, t376, t3841, t425, t535, t5414, t657, t6845, t690, t701, t713, t7583, t790, t8154, t8168, t852, **t084**	ST239 (27), ST2867 (1)[F]	**CC8** (27%), **CC5** (18%), CC1 (9%), CC6 (9%), **CC22** (9%), **CC80** (7%), **CC30** (6%), CC97 (3%), CC15 (3%), CC152 (2%), CC88 (2%), CC361 (2%), CC2250/2277 (1%), CC45 (1%), CC121 (1%), CC59 (1%), singleton ST2867 (1%)	Farwaniya h (2016)
[73]	1,327 [G]	45%	24%	IV (50), V (27), III (9), VI (8), I (0.1), II (1)	261 identified; t688, **t304**, t860, **t127**, t044, t311, **t002**, **t223**, t267, t019, t3841, **t005**, **t084**, t852, and t657 (collectively made 51%)	ND	CC361 (32), **CC30** (15), **CC22** (13), CC1 (11), **CC8** (6), CC152 (6), CC121 (6), CC913 (3), CC45 (2), CC88 (2), CC97 (2), CC1153 (1), CC5 (1), CC6 (1), S-ST2867 (1)	Multiple sites (2016)
UAE								
[71]	26 (2003)[H]	27%	4%	II (19), III (12), IIIa (12), IV (54), IVa (4)	**t002** (23), **t032** (19), **t037** (16), **t044** (12), t421 (8), t690 (8), t019 (4), t359 (4), t064 (4), t878 (4)	ST239 (23), ST5 (23), ST22 (19), ST80 (12), ST88 (8), ST30 (4), ST97 (4), ST113 (4), ST779 (4)	ND	Al-Ain (2003-8)
	26 (2008)[H]	39%	19%	III (8), IV (69), NT (23)	**t044** (27), **t002** (16), t688 (12), **t127** (12), **t037** (8), **t018** (4), t019 (4), **t304** (8), **t005** (4), t1081 (4), t315 (4)	ST80 (27), ST5 (27), ST1 (12), ST239 (8), ST30 (8), ST6 (8), ST22 (4), ST45 (4), ST361 (4)	ND	
[88]	57 **CO**	100%	ND	IV (100)	ND	ND	ND	Sharjah (2011-12)
Qatar								
[11]	61	66%	ND	IV (90), V (10)	t019 (28), **t002** (21), **t044** (13), t852 (13), *spa*-NT (8), **t008** (3), t121 (3), t690 (3), t267 (2), t657 (2), t7358 (2), t314 (2)	ST30 (28), ST5 (21), ST80 (13), ST22 (13), ST8 (12), ST15 (5), ST88 (3), ST-NT (3),	Based on PFGE: **Southwest pacific** (28), **Pediatric** (21), **UK-EMRSA-15** (13), **European** (13), USA300 (7), USA900 (5), USA400 (5), USA1200 (2), Unknown (7)	Doha (2009-10)
Bahrain								
[6]	53	ND	ND	III (87), IV (13)	ND	ND	PFGE: A (83), C (6), D (6), B (2), E (2)	Manama (2005)
Gaza								
[45]	121	42%	40%	I (3), III (7), IV (2), IVa (49), IVc (29), V (7), VI (3)	**t044** (30), **t223** (28), t7063 (9), t318 (8), **t037** (8), **t008** (6), t309 (2), t541 (2), t5485 (2), t2229 (2), t001 (2), t688 (2), t14480 (2), t7793 (2), t903 (1), t458 (1), t4229 (1)	ST22 (41), ST80 (31), ST8 (8), ST30 (8), ST239 (7), ST228 (2), ST5 (1), ST6 (1), ST121 (1), ST1153 (1)	**CC22** (41), **CC80** (31), **CC8** (8), **CC30** (8), CC239 (7), **CC5** (3), CC6 (1), CC121 (1%), CC1153 (1)	Gaza (2008-12)
Jordan								
[47]	41	37%	ND	ND	**t044** (38), **t037** (11), t318 (5), t386 (5), t1149 (5), t701(3), t5849 (3), t318 (3), t6438 (3), **t091** (3), t6432 (3), **t012** (3), t743 (3), t6439 (3), t6303 (3), t363 (3), t159 (3), t5802 (3)	ND	ND	Amman (2009-10)
[81]	31 *Spa*-CC044	48%	58%	ND	**t044** (83), t5849 (6), t131 (3), t5802 (3). t6438 (3)	ST80 (97), ST997(3)	**CC80** (100%)	Amman (2000-11)

Lebanon								
[48]	93	62%	ND	II (1), III (10), IVb (1), IVc (87), V (1)	**t044** (53), **t037(6)**, t030 (4), **t008** (4), t267 (4), **t304** (3), **t032** (3), t131 (2), t311 (1), t318 (1)	ST80 (55), ST239 (11), ST8 (4), ST97 (4), ST6 (3), ST22 (3), ST5 (1), ST30 (1)	**CC80** (55), **CC8** (15), CC97 (4), CC6 (3%), CC22 (3), **CC5** (1), **CC30** (1)	Beirut (2006-7)
[81]	63 *spa*-CC044	92%	0%	IV (100)	**t044** (85), t131 (8), t4222 (2), t6438 (2), **t021** (2), t9135 (2)	ST80 (100)	**CC80** (100%)	Beirut (2000-11)
Iraq								
[74]	182[I]	96%	ND	IV (90), III (3), I (1), NT (4)	ND	ND	Based on PFGE: **USA300** (80), USA100 (4), USA1100 (3), USA400 (2), USA800 (2), USA1000 (1), CSH5 (3), CSH1(1), CSH2 (1), CSH3 (1), CSH4(1), CSH6 (1), CSH7(1), CSH8(1), CSH9 (1), CSH10 (1), CSH11 (1)	Multiple sites (2007-9)
Egypt								
[55]	12	ND	25%	ND	ND	ND	ND	Ismailia (2013)
[56]	18 **CO**	33%	ND	V (50), NT (33), IV (11), IVc (6)	ND	ND	ND	Alexandria (NR)
[54]	18	83%	ND	II (33), V (17), IVd (17), III (11), IVa (6), IVc (6), NT (11)	ND	ND	ND	Zagazig and Assuit (2010-12)
Algeria								
[58]	92	21%	ND	III (78), IVc (22)	**t037** (43), t932 (35), **t044** (21), **t005** (1)	ST239 (78), ST80 (21), ST22 (1)	**CC8** (78), **CC80** (21), **CC22** (1)	Annaba (2010)
[59]	15 **HO**[J]	100%	ND	IVc (100)	ND	ST80 (100)	ND	Algiers (2010-11)
	10 **CO**[J]	70%	ND	II (10), IVc (90)	ND	ST80 (90), ST39 (10)	ND	
[61]	84 **CO**[K, L]	88%	0%	IV (97), V (6), III (3)	**t044** (85), t4143 (3)	ST80 (91), ST8 (6), ST241 (3)	ND	Algiers (2006-7)
	137 **HO**[K, L]	75%	0%	IV (88), III (12)	**t044** (96)	ST80 (89), ST5 (11)	ND	
[75]	84	86%	ND	IV (88), III (8), II (1), ND (2)	ND	ST80 (86), ST239 (8), others (6)	ND	Algiers (2006-11)
[76]	64	30%	0%	IV (50), V (44)	ND	ND	ND	Constantine (2005-7)
[60]	73[M]	15%	0%	ND	ND	ST239 (82), ST80 (14), ST-NT (4)	ND	Annaba (2011-12)
Tunisia								

[64]	58	36%	ND	ND	ND	ND	ND	Tunis (2005-7)
[65]	24 tetracycline resistant	4%	0%	ND	t052 (5), **t037** (21), t14712 (4), t129 (4), **t044** (8), t311 (4), t7144 (4), t899 (4)	ST247 (50), ST239 (25), ST728 (8), ST241 (4), ST641 (4), ST7144 (4), ST398 (4)	**CC8** (80), **CC80** (8), **CC5** (8), CC398 (4)	Tunis (2011-12)
[77]	28 **CO**[N]	79%	ND	IVc (79), NT (18), I (4)	ND	ST80 (74), ST5 (8), ST153 (8), ST2563 (4), ST1 (4), ST45 (4)	**CC80** (86), **CC5** (7), CC1 (4), CC45 (4)	Tunis (2004-8)
	41 **HO**[N]	51%	ND	I (15), III (17), IVc (56), NT (12)	ND	ST80 (49), ST239 (10), ST241 (7), ST247 (7) ST1819 (7), ST5 (7), ST97 (5), ST1440 (2), ST1 (2), ST22 (2)	**CC80** (51), **CC8** (32), **CC5** (7), CC15 (5), CC1 (2), **CC22** (2)	

CO: CO-MRSA; HO: HO-MRSA; NR: not reported; NT: not typeable; S-: singleton; *Spa*-CC: *spa* cluster. When a sample is not designated "CO" or "HO" it indicates that the study does not distinguish site of acquisition. Values were rounded to the nearest whole number.

[A] 60 cancer and 60 non-cancer patients, [B] MLST types in this study were only reported for CC8, CC1, and CC9, [C] MLST types in this study were reported only for CC8, and CC913, [D] Percentages for each *spa* type was not provided in the study, [E] *Spa* types with no percentages were described as sporadic in this study, [F] In this study only 120 from the 209 isolates underwent DNA microarray analysis; these isolates represented the 56 *spa* types found. The MLST types were only reported for CC8 and S-ST2867, [G] Only 102 novel variants from the 1,327 were further typed into CCs . *PVL* and *Tst1* rates were provided only for the 102 novel variants. SCCmec and *spa* types were provided for the entire 1,327 sample, [H] Study distinguished between 2003 and 2008 isolates, [I] Isolates from USA service members deployed to Iraq. Sixteen strains displayed 11 unique pulsotypes not previously described and were labeled CSH1-CSH11, [J] subjects were neonates. In this study, outpatients and inpatients <48 hrs from admission were considered CO-MRSA while inpatients >48 hrs. post admission were HO-MRSA. Other epidemiological risk factors for HO-MRSA were not specified, [K] This study distinguished between CO-MRSA and HO-MRSA by the epidemiological criteria specified in text, [L] spa typing was done for 46 [*PVL* +] isolates only and revealed only 2 spa types: t044 and t4143, [M] Diabetic foot infections,[N] Criteria used to distinguish between HO-MRSA and CO-MRSA is not specified.

had SCCmec-III. *Spa* types t037, t030, and t008 were most commonly seen.[12,16,20,23,26,27,31,34]

The USA300 CA-MRSA was overall less commonly encountered than the Brazilian/Hungarian clone. It was isolated infrequently in KSA,[67,68] Kuwait,[69,70] Qatar,[11] Gaza,[45] and Lebanon.[48] In Kuwait, it accounted for 8% of 26 SCCmec-IV MRSA isolates only, as opposed to the European CA-MRSA, which made up 46%. Nonetheless, USA300 was very common in Iraq, where it accounted for 80% of infective isolates from deployed U.S. soldiers.[74] The clinical specimen was 95% from wound infections. Most non-wound isolates were not USA300. Almost all USA300 isolates were [*PVL*+]. Despite being in separate geographical locations, similar pulsotypes were identified in the 3 combat support hospitals (CSH), which indicated the same origin of MRSA.[74] It is possible that soldiers were colonized before deployment as USA300 is a prevailing clone in the U.S.[8]

Finally, a [*PVL*-] CC8-V-t008 clone was detected in few isolates from KSA,[12] Egypt,[12] and Kuwait.[73] This clone was previously described in Saxony and Australia.[8]

Clonal complex 22: This complex contains multiple MRSA lineages.[8] The best example is the ST22-SCCmec-IV pandemic clone, also known as UK-EMRSA-15 HA-MRSA. When present, it tends to become abundant. It is considered HA-MRSA but can also disseminate in the community. In previous reports, it accounted for 50%-80% of isolates from countries in Europe. It is typically [*PVL*-] and [*Tst1*-], but variants carrying either or both toxins exist. For example, [*PVL*+] ST22-SCCmec-IV was previously described in a large hospital outbreak in Germany.[8] This variant was also detected in other parts of Europe. A [*PVL*+, *Tst1*+] variant was previously identified in India.[8] Investigators hypothesize that these variants could have a polyphyletic origin since they can exist in epidemiologically unrelated settings. A [*PVL*-] SCCmec-V clone was also infrequently detected in Saxony and western Australia. CC22-SCCmec-I, II, or III are not described in the literature.[8]

[*PVL*-] ST22-SCCmec-IV or its related *spa* types were commonly reported in colonizing strains from the MENA region,[12,16,20,23,27,31,34] particularly common in Gaza, Jordan, Egypt, and Algeria.[12,23,27,31,34] This clone was also prevalent in infective strains from the GCC and Gaza. It was reported in 10%-28% of isolates from KSA,[67,68] 13% in Qatar,[11] and 9% in Kuwait.[7,69,73] In UAE, it accounted for 19% of isolates in 1 center in 2003 but then dropped to 4% in 2008, showing a decreasing presence with time while other clones dominated.[71] The ST22-SCCmec-IV clone was exceptionally common in Gaza, where it made up 41% of isolates in 1 study. On the other hand, this clone was infrequently encountered in the other Levant and North African countries.[47,48,58-61,65,74,75,77]

All the CC22 isolates from the MENA carried either SCCmec-IV or V. The most common *spa* types were t223 and t032. The majority were [*PVL*-] as expected. Nonetheless, the [*PVL*+] variant was detected in KSA, Kuwait, and Qatar, where, in some centers, this variant exceeded the [*PVL*-] ST22 strains.[11,68,69] Furthermore, many isolates from KSA and Kuwait were [*Tst1*+], also known as the "Middle Eastern" variant. In Kuwait, 62% of a subset of urease (-) EMRSA-15 isolates belonged to the Middle Eastern variant.[78] This variant mostly carried SCCmec-IVa and was [*PVL*-], except for some isolates from Kuwait, [*PVL*+] indicating the potential to acquire both toxins. Notably, the bulk (91%) of infective isolates in Gaza were [*Tst1*+].[45] Nonetheless, these were collectively referred to as the "Gaza" strain.[45] The Gaza strain also exists in Jordan where it was dominant in colonizing strains in 1 study.[27] On the other hand, it was not detected in studies from Lebanon.[48,79] The Gaza strain was associated with the SCCmec-IVa-t223 genotype. Like the Middle Eastern variant, the Gaza strain was mostly [*PVL*-].

While the PFGE analysis of the Gaza strain in Gaza showed 76% pattern similarity with UK-EMRSA-15, some distinguishing features exist. The UK-EMRSA-15 is associated with SCCmec-IVh-t032 and t022 instead of SCCmec-IVa-t223.[23,27] Furthermore, Unlike UK-EMRSA-15, the Gaza strain is susceptible to ciprofloxacin and resistant to tetracycline.[23,27] Some of the ST22-SCCmec-IV strains in GCC and North African Arab regions also carried SCCmec-IVa-t223 distinguishing them from UK-EMRSA-15 clone.[12,23,27,34,45,78] One study examined 47 CC22-SCCmec-IV isolates from patients from KSA, Abu Dhabi, Kuwait, and Germany.[80] Six distinct albeit related strains were detected. Only 9 isolates showed complete resemblance to the UK-EMRSA-15.[80] The study concluded that none of the isolates from Riyadh were true UK-EMRSA-15. True UK-EMRSA-15, however, was identified in Abu Dhabi and Kuwait.[80]

Lastly, [*PVL*-] CC22-SCCmec-V was detected in few strains from KSA and Gaza.[12,23,45] This clone carried t223 and t7063 *spa* types and was [*Tst1*+] in Gaza.

Clonal complex 30: Important clones include UK-EMRSA-16 HA-MRSA (ST36/39-SCCmec-II) and Southwest Pacific CA-MRSA ([*PVL*+] ST30-SCCmec-IV).[8] The former was an important clone in Europe but is becoming rare. The latter is widespread globally. A [*PVL*-, *Tst1*+] ST30-SCCmec-IV is sporadically isolated from Ireland and Australia.[8]

Overall, CC30 was only occasionally encountered in most of the countries in the region. It was detected in few colonizing isolates from Gaza,[23] Jordan,[27] and Egypt.[12] Most colonizing isolates were [*PVL*-], and in Jordan, several of them were [*Tst1*+] It was also rarely seen in infective isolates from KSA,[68] Kuwait,[69] and UAE,[71]

Gaza,[45] Lebanon,[48] and Jordan.[47] None of the studies from Algeria and Tunisia isolated CC30.[65,77] However, this was the most common clone in infective isolates from 1 center in Qatar.[11] Also, it made up 31% of a sample of 26 SCCmec-IV isolates in Kuwait.[70] Almost all isolates from the region carried SCCmec-IV, resembling Southwest pacific CA-MRSA.[27] Associated *spa* types were t019 and t018 in the GCC,[68,69,71] and t318 in the Levant.[45,47,48] Unlike colonizing strains, all infective isolates from this region were [PVL+] except for 1 in Jordan.

The UK-EMRSA-16 HA-MRSA was also rarely reported in the region; only 8 isolates from Kuwait.[69] Finally, when isolates carrying novel genotypes in Kuwait were tested, 15% carried CC30-SCCmec-VI.[73]

Clonal complex 80: This complex houses the European CA-MRSA clone (ST80-SCCmec-IV), which gains its name due to its significant presence throughout Europe. However, this clone is encountered worldwide; most isolates belonging to CC80 carry [*PVL*+] ST80-SCCmec-IV and IV variants. [*PVL*-] strains are infrequently detected.

ST80-SCCmec-IV or the associated *spa* types were detected in colonizing strains from all recovered studies.[12,16,20,23,27,31,34] Among infective strains, it was detected in 20-30% of isolates from KSA,[67,68] 7% in Kuwait,[7,69] and 13% in Qatar.[11] In UAE, one center experienced a rise in rates from 12% in 2003 to 27% in 2008.[71] When examining a sample of SCCmec-IV isolates in Kuwait, 46% were ST80-SCCmec-IV.[70] This clone was even more prevalent in infective isolates from the Levant and North Africa. It made up 31% of isolates in Gaza,[45] and 55% in Lebanon.[48] In Jordan, [*PVL*+] t044 and [*PVL*-] t044 were detected in 27% and 11% of isolates, respectively.[47] This clone was completely absent in an Iraqi study examining clinical isolates from U.S. soldiers.[74] In Algeria, this was the most frequently encountered clone in Algiers, 77%-100% of isolates.[59,61,75] This was true even for HO-MRSA isolates, indicating the infiltration of this CA-MRSA clone into the hospital setting. However, its presence was less frequently encountered in studies from a different city, Annaba.[58,60] In Tunisia, it accounted for 51% of HO-MRSA and 86% of CO-MRSA.[77]

There is evidence that isolates belonging to European CA-MRSA in the region could have different evolutionary lineages. For example, PFGE typing revealed 21 different clonal groups among *spa*-clonal-cluster-044 isolates from Lebanon and Jordan.[81] Moreover, the *PVL* gene was detected more frequently in the Lebanese subset, while the *Tst1* gene was detected only in the Jordanian subset.[81]

The [*PVL*-] variant was infrequently encountered in KSA,[67] Kuwait,[69,82] Jordan,[47,81] Lebanon[81], Algeria,[59,61] and Tunisia.[65,77] A [*Tst1*+] variant was detected in Kuwait,[82] Gaza,[45] and Jordan.[81] On the other hand, all strains in UAE,[71] Qatar,[11] Gaza[45] were [*PVL*+]. The most encountered *spa* type was t044.[45,48,58,61,65,81]

Other Clonal Complexes: CC15 was detected in a small number of colonizing isolates from KSA,[12] Jordan,[27] and Egypt.[31] These were carrying t083, t084, and t085. It was also seen in some infective strains from KSA,[68] Kuwait,[7] and Tunisia.[77] This CC is rarely described.[8] It was detected in a collection of strains from Italy in 1980, 4 SCCmec-I isolates.[8] More recently, it was reported in Europe, Iran, Gabon, and the Gulf of Guinea.[12] In Europe, it accounted for 17% of MRSA and methicillin-susceptible (MSSA) isolates combined and carried ST1, ST15, ST188, ST772, and ST1835. In KSA, isolates of CC15 carried both SCCmec-IVa and V.[12]

In Jordan, a novel genotype, [*PVL*-,*Tst1*+]-IVe-t9519, made up the bulk of colonizing isolates from Amman.[26]

There are still other CCs and clones identified in the region but seem to be of lower prevalence compared to the 5 main CCs we chose to discuss.

Antimicrobial Resistance Patterns of MRSA in the MENA Region: An in-depth description of the antimicrobial susceptibility of MRSA in the MENA region is not the primary objective of our review. Therefore, we do not discuss this topic in detail. **Table 6** lists cumulative susceptibilities for 462 colonizing and 11, 373 infective MRSA isolates per country. **Supplementary Table 5** provides the susceptibilities from individual studies. The susceptibility ranges are wide for some antimicrobials, indicating a significant difference in resistance patterns between different centers within a country.

Antimicrobial Resistant patterns of Colonizing MRSA: Studies from GCC and North African Arab countries showed high resistance to TMP-SMX.[12,14,19,20,34,83] On the other hand, all isolates from the Levant were susceptible to this agent.[23,29] For ciprofloxacin, isolates from North Africa and Levant were largely sensitive as opposed to the GCC.[12,14,19,20,23,27,29,34] Nonetheless, studies from Gaza and Jordan showed that high resistance to ciprofloxacin could be encountered in isolates retrieved from healthcare workers.[25,27] Furthermore, while some centers in KSA showed high resistance, others showed 100% susceptibility to ciprofloxacin.[12,14] Almost all countries showed high resistance to tetracycline, clindamycin, and erythromycin.[12,14,19-23,25,27,29,34] Isolates also remained highly susceptible to rifampin in most centers. Surprisingly, significant vancomycin resistance was detected in KSA, Oman, Egypt, and Gaza.[12,14,21,22,25] The majority of these studies used Kirby Bauer's disk diffusion method using Mueller-Hinton agar[12,14,22,25] except for 1 study, which used E-test for minimum inhibitory concentration (MIC).[21] The remaining studies showed 100% susceptibility to vancomycin.[19,20,23,27,29,34] Isolates were almost universally susceptible to linezolid except in 1 study from KSA.[14]

Table 6. Percent susceptibility of total MRSA isolates. Susceptibility presented as total # isolates susceptible/total isolates tested (% susceptible).

Country	Ref (date)	# MRSA	Rif	FA	Cl	TS	Cip	Tet	Dox	EM	Vanc	Lin	Teic	Dap	Mup	Gen
Colonizing MRSA strains- Susceptibility presented as total # of susceptible isolates /total # of tested isolates tested (%)																
Oman[A]	[21, 22] (NR)	83	81/83 (98)	-	58/83 (70)	-	-	-	75/83 (90)	42/83 (51)	73/83 (88)[B]	83/83 (100)	69/83 (83)	-	-	-
KSA[A]	[12, 14, 19] (2011-15)	110	53/74 (72)	-	40/110 (36)	60/110 (55)	62/110 (56)	39/110 (35)	-	29/110 (26)	108/110 (98)[B]	68/84 (81)	26/48 (54)	-	-	63/74 (85)
Lebanon[A]	[29] (2006-7)	8	-	-	-	8/8 (100)	8/8 (100)	-	-	-	8/8 (100)	-	-	-	8/8 (100)	8/8 (100)
Gaza[C]	[23] -2009	145	45/51 (88)	89/94 (95)	104/145 (72)	94/94 (100)	138/145 (95)	44/51 (86)	-	91/145 (63)	137/145 (94)[B]	-	-	-	-	138/145 (95)
Jordan[F]	[27] (2011-12)	56	56/56 (100)	52/56 (93)	53/56 (95)	-	54/56 (96)	-	-	24/56 (43)	56/56 (100)	56/56 (100)	56/56 (100)	56/56 (100)	56/56 (100)	56/56 (100)
Egypt[A]	[12] -2011	33	30/33 (91)	-	22/33 (67)	17/33 (52)	33/33 (100)	-	-	15/33 (45)	30/33 (91)[B]	-	-	-	-	22/33 (67)
Algeria[A]	[34] (2010-12)	9	9/9 (100)	-	9/9 (100)	7/9 (78)	9/9 (100)	6/9 (67)	-	8/9 (89)	9/9 (100)	9/9 (100)	9/9 (100)	-	-	6/9 (67)
Kuwait[A]	[20] (2005-7)	18	18/18 (100)	6/18 (33)	6/18 (33)	13/18 (72)	5/18 (28)	5/18 (28)	-	6/18 (33)	18/18 (100)	18/18 (100)	18/18 (100)	-	17/18 (95)	5/18 (28)
Infective MRSA Strains- Susceptibility presented as total # of susceptible isolates /total # of tested isolates tested (%)																
KSA[D]	[66, 72, 85] (2004-11)	733	170/221 (77)	148/733 (20)	136/221 (62)	175/632 (28)	63/101 (62)	58/101 (57)	-	103/221 (47)	733/733 (100)[E]	575/613 (94)	89/101 (88)	-	565/733 (77)	275/613 (45)
Kuwait[A]	[7, 73, 84] (2011-16)	8,458	8389/8458 (99)	4911/8458 (58)	4911/8458 (58)	5480/8458 (65)	4859/8458 (57)	5218/8458 (62)	-	4911/8458 (58)	8389/8458 (99)[E]	8458/8458 (100)	8250/8458 (98)	-	8054/8458 (95)	4316/7131 (61)
Oman[A]	[43] (2016-17)	733	-	-	571/733 (78)	689/733 (94)	506/733 (69)	-	-	520/733 (71)	733/733 (100)	733/733 (100)	-	-	-	623/733 (85)
Bahrain[A]	[6] -2005	53	53/53 (100)	4/53 (8)	7/53 (13)	6/53 (11)	4/53 (8)	6/53 (11)	-	5/53 (9)	53/53 (100)	53/53 (100)	53/53 (100)	-	47/53 (89)	14/53 (26)
Lebanon[A]	[79] -2011	39	39/39 (100)	-	34/39 (87)	38/39 (97)	34/39 (87)	27/39 (69)	-	31/39 (80)	39/39 (100)	-	39/39 (100)	-	-	-

Gaza[F]	[45] (2008-12)	121	111/121 (92)	-	93/121 (77)	97/121 (80)	-	82/121 (68)	-	86/121 (71)	121/121 (100)	121/121 (100)	121/121 (100)	121/121 (100)	121/121 (100)	97/121 (80)
Jordan[A]	[46] (2008-12)	113	97/113 (86)	-	62/113 (55)	66/113 (58)	-	66/113 (58)	-	26/113 (23)	113/113 (100)	110/113 (97)	110/113 (97)	-	-	53/113 (47)
Iraq[G]	[51, 52, 74] (2005-9)	500	462/500 (92)	-	379/500 (76)	454/500 (91)	158/318 (50)	401/485(83)	-	66/500 (13)	485/485 (100)	174/182 (96)	-	-	-	423/485 (87)
Egypt[A]	[57] (2005-13)	364	292/364 (80)	-	171/364 (47)	302/364 (83)	122/364 (34)	58/364 (16)	-	140/364 (39)	364/364 (100)	-	-	-	-	84/364 (23)
Algeria[A]	[59, 62] (2007-11)	190	25/25 (100)	-	167/190 (88)	24/25 (100)	20/25 (80)	6/25 (24)	-	91/165 (55)	187/190 (98)[H]	25/25 (100)	25/25 (100)	-	-	141/190 (74)
Tunisia[A]	[77] (2004-8)	69	80	-	84	91	59	17	-	48	100	-	100	-	-	74

Cip: ciprofloxacin; Cl: clindamycin; CO-MRSA: community-onset MRSA [isolates from healthy individuals, outpatients or inpatients within 48-72 hours of admission]; Dapt: daptomycin; EM: erythromycin; FA: fusidic acid; Gen: gentamicin; HCWs: health-care workers; HO-MRSA: hospital-onset MRSA [isolates from HCWs or inpatients > 72 hours after admission]; Lin: linezolid; Mup: Mupirocin; NR: not reported; Rif: Rifampicin; Tet: tetracycline; Teic: teicoplanin; TS: trimethoprim-sulfamethoxazole; Vanc: vancomycin. [A] Antibiotic susceptibility testing (AST) by standard agar disk diffusion methodology according to clinical and laboratory standards institute guidelines. [B] Non-susceptible strains (whether intermediate or resistant) detected by disk diffusion method. [C] 94 MRSA isolates were tested by VITEK-2 system; 51 were tested by disk diffusion method. [D] AST for 613 MRSA isolates was performed via disc diffusion method; AST methodology for 120 MRSA isolates can't be confirmed (access to abstract only). [E] AST performed via E-test methodology. [F] AST for 2003 isolates performed via VITEK2 system; AST for 2012 isolates done via MicroScan WalkAway Plus System (Siemens Healthcare, Erlangen, Germany). [G] AST for 485 MRSA isolates was performed via disc diffusion method; AST methodology for 15 isolates not specified. [H] These were specifically identified as vancomycin resistant and not vancomycin intermediate.

Antimicrobial Resistant patterns of Infective MRSA: Infective MRSA in the MENA region were highly resistant against most antimicrobials. Susceptibility to TMP-SMX varied widely depending on the center. It reached acceptable to high levels in UAE and Oman in some studies.[41,43,71] Strains from Lebanon and Iraq were highly sensitive to TMP-SMX as opposed to Gaza and Jordan.[45,46,79] Nonetheless, the Gaza strain commonly encountered in Gaza was susceptible to TMP-SMX.[23,27]

Reported sensitivities to vancomycin, linezolid, and teicoplanin remained high among infective isolates in the region.[6,25,41,43,45,46,57,59,66,71,77,79,84,85] Exceptionally, 5% resistance to vancomycin was detected in 1 study from Egypt using the broth microdilution method.[54]

ST22-IV clones from GCC were highly susceptible to rifampin, vancomycin, linezolid, and teicoplanin.[71,78] The UK-EMRSA-15 and its [*PVL*+] and [*PVL*-] variants all had high susceptibility to tetracycline but low to ciprofloxacin.[78] In contrast, [*Tst1*+] Middle Eastern variant was 100% sensitive to ciprofloxacin but only 70% to tetracycline.[71,78] The "Gaza strain" was susceptible to most tested antimicrobials, including ciprofloxacin and TMP-SMX.[23,27] It was often resistant to tetracycline. When compared to ST22-IV isolates from GCC, similar susceptibility rates were seen with few exceptions. The Middle Eastern variant was similarly sensitive to ciprofloxacin but, unlike the Gaza strain, was resistant to TMP-SMX.[78] On the other hand, the [*PVL*+] and [*PVL*-] variants in GCC were similarly sensitive to TMP-SMX but differed due to high resistance to ciprofloxacin and high sensitivity to tetracycline.[71,78]

ST239 isolates from UAE were sensitive to vancomycin, linezolid, teicoplanin but resistant to other tested agents.[71] In Egypt, they were highly resistant to tested antibiotics such as TMP-SMX, tetracycline, and gentamicin.[58]

ST80-IV CA-MRSA strains in GCC had high susceptibility rates to rifampin, TMP-SMX, vancomycin, linezolid, teicoplanin, and gentamicin.[25,71,82] Furthermore, the majority of *Spa*-clonal cluster-044 isolates from the Levant were susceptible to rifampin and gentamicin,[81] which was consistent with GCC reports.[71,82] The Lebanese isolates were often resistant to tetracycline, while the Jordanian isolates showed significantly higher resistance to erythromycin.[81] In Egypt, this strain was often susceptible to TMP-SMX but resistant to tetracycline.[58]

Discussion. This review highlights a significant threat imposed by MRSA on both the community and healthcare settings within the Arab world. The rates of MRSA varied depending on the country and center. A significant spread of MRSA in some Arab communities was evident by the high nasal MRSA carriage rate among healthy outpatients, hospital visitors, or university students seen in certain cities.[12,21-23] As expected, HCWs had higher nasal MRSA rates.[15,19,21,22,25,30]

In the clinical setting, methicillin resistance was highly prevalent among clinical isolates of *S. aureus* in the region.[4,11,42,45-53,56-59,61,71,85] Thus, while some countries like UAE, Lebanon, Qatar, and Tunisia showed lower cumulative rates compared to others, there is still evidence of a high burden in some centers within these countries.

Regional variability in MRSA rates has been detected in other areas of the world, such as Europe.[3,11,86] In the Arab world, this variance in rates could be due to differences in antibiotic prescribing practices and infection control efforts across the region and within each country. Additionally, Arab countries of the Levant and North Africa have suffered decades of economic and political instability, which negatively impacted medical resources and healthcare infrastructure instead of the prospering Arab countries in the GCC region. This could explain the lower rates seen in UAE and Qatar. Nonetheless, such a theory is challenged by the high MRSA rates seen in KSA. Perhaps these factors are offset by other determinants in KSA.

Certain genotypes were particularly prevalent in the Arab world, many of which belonged to 5 CCs known to spread worldwide. These were previously discussed in **table 1**. This is not surprising given that the Arab World is a center for multinational ex-pats seeking jobs abroad. Furthermore, KSA is the home of al-Kaʿbah al-Musharrafah, the destination of Muslim pilgrimage, where masses of Muslims from across the globe crowd up every year to perform religious rituals. These crowded conditions are likely to facilitate the spread of various MRSA strains.

Three clones were particularly important: European CA-MRSA, UK-EMRSA-15 HA-MRSA, and Brazilian/Hungarian HA-MRSA. Genotypes linked to these clones were distributed across the region. Notably, HA-MRSA clones might be decreasing in prevalence in some centers while CA-MRSA takes over. With time, a shift in clonal distribution was noted in Kuwait and UAE, where CA-MRSA genotypes became more prevalent.[69,71,73,84] In Kuwait, this was clearly seen in 3 studies examining large samples from several hospitals across the country from 1992 to 2016.[69,73,84] This is particularly true of the European CA-MRSA, which was detected in almost all cited studies and often accounted for a significant proportion of the study sample. Hence, this clone or its related strains seem to be infiltrating into the Arab world. Nonetheless, the presence of HA-MRSA clones remained strong in many studies, including both the Brazilian/Hungarian clone and the UK-EMRSA-15 clone.

USA300 CA-MRSA is another important clone that made up the bulk of isolates in Iraq's CSHs. However, the subjects here were U.S. military personnel and might

have been colonized prior to being deployed. Hence this might not be reflective of the Iraqi population.

It is important to acknowledge distinguishing features when comparing local strains with these epidemic/pandemic clones. Strains from the Arab world have distinguishing antimicrobial resistance, SCCmec subtypes, and virulence factors.[82] This was highlighted briefly during our discussion of CC22 in section Clonal complex 22. Another distinction was previously made between ST80-SCCmec-IV strains from the Arab world and the European CA-MRSA clone.[81,82] The European CA-MRSA is known to be [*PVL*+] and resistant to tetracycline, streptomycin, kanamycin, and fusidic acid (TSKF profile).[81] Overall, only 16% of the ST80 isolates recovered from Lebanon and Jordan had this profile.[81] A more commonly detected pattern in both countries included resistance to streptomycin, kanamycin, and fusidic acid (SKF pattern).[81] Phenotypical variation between the Kuwaiti ST80 isolates and the European CA-MRSA clone was pointed out, particularly regarding some differences in antimicrobial resistance patterns and enterotoxin gene profiles.[82] PFGE analysis of ST80 isolates from a subset of these hospitals in Kuwait showed that a large proportion was related but not identical, further pointing out the heterogeneity among local strains.[82] This was mirrored in another study from Kuwait, which identified 102 novel variants of previously known genotypes reported locally and worldwide.[73] Furthermore, it was shown that isolates derived from different regions in the Arab world could have a heterogeneous lineage despite belonging to the same *Spa*-clonal complex.[81] These findings raise the possibility that local strains might have polyphyletic origins.

Our review provides a comprehensive summary of the available literature on the epidemiology of MRSA in the MENA. Multiple important points were highlighted. Nonetheless, our work is not without limitations. Most studies in our review were single-centered reports, limiting our ability to uncover the full burden of MRSA. Furthermore, there was significant heterogeneity in molecular typing methods and reporting of results, which hinders our ability to compare between different centers or countries in the region. Furthermore, the bulk of studies did not distinguish between CO-MRSA and HO-MRSA based on epidemiological criteria, and so we are unable to accurately distinguish the epidemiology of MRSA in the community vs. healthcare setting.

Conclusion. This manuscript provides a review of the current literature on MRSA epidemiology in Arab countries. There is enough evidence to suggest that the Arab region struggles from a heavy MRSA burden. Genotypes associated with European CA-MRSA play the biggest role, but Brazilian/Hungarian HA-MRSA and UK-EMRSA-15 HA-MRSA are also prevalent. Therefore, the Arab countries need to implement a nationwide surveillance system to understand better the true epidemiology and burden of MRSA in this part of the world.

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Supplementary Files

Supplementary Table 1. The table presents the relative global frequencies of *spa* types. Only those >/= 0.5% are reported here. Data is adopted from http://www.spaserver.ridom.de. It also lists the Arab countries that reported these spa types based on our review of literature.

Common Globally Reported *spa Types*		
Spa type	Relative global frequency	Arab countries reporting this *spa* type
t032	9.98%	KSA, Ku, Leb, UAE
t003	8.57%	Ku
t002	6.56%	KSA, Ku, Qa, UAE
t008	5.81%	Egy, Gaz, KSA, Ku, Leb, Qa
t011	3.30%	
t127	2.64%	Ku, UAE
t034	2.18%	
t084	1.75%	Egy, Ku, KSA
t012	1.53%	Jor
t037	1.12%	Alg, Gaz, Jor, KSA, Ku, Leb, Tun, UAE
t021	1.07%	Egy, Jor, Ku, Leb
t015	1.02%	
t091	0.99%	Jor
t044	0.85%	Alg, Egy, Gaz, Jor, KSA, Ku, Leb, Qa, Tun, UAE
t022	0.79%	
t437	0.78%	
t005	0.70%	Alg, Ku, UAE
t045	0.69%	Ku
t067	0.66%	
t024	0.64%	
t223	0.62%	Alg, Egy, Gaz, Jor, KSA, Ku
t189	0.59%	KSA
t304	0.58%	KSA, Ku, Leb, UAE
t018	0.56%	Jor, Ku, UAE
t004	0.51%	
t026	0.51%	

Alg: Algeria; Egy: Egypt; Gaz: Gaza; Jor: Jordan; KSA: kingdom of Saudi Arabia; Ku: Kuwait; Leb: Lebanon; Qa: Qatar; Tun: Tunisia; UAE: United Arab Emirates

Supplementary Table 2. Reported Rates of Methicillin-Resistance among Staphylococcus aureus from clinical specimen in MENA Region. MRSA rates presented as total MRSA/total *S. aureus* isolates. All isolates were from various clinical samples unless otherwise specified. Numerical values are rounded to the nearest whole digit.

Ref	# S. aureus isolate	# MRSA (%)	Study site (year)
		KSA	
[87]	*S. aureus* from clinical samples: Year 1999 Year 2002 Year 2003	(6%) (2%) (10%) (8%)	Dhahran Health Center, Dhahran (1999-2003)
[37]	445	71 (16%)	Multiple hospitals (n=NS), Taif city (2013-15)
[38]	206	114 (55%)	Multiple hospitals (n=5), Makkah city (2012)
[39]	57	36 (63%)	Multiple hospitals (n=2), Makkah city (2015)
[40]	252	146 (58%)	Al-Hada Armed Forces Hospital, Taif city (2004)
		UAE	
[71]	701 490 Year 2003 211 Year 2008	52 (7%) 26 (5%) 26 (12%)	Tawam Hospital, Al Ain (2003-8)
[41]	62[A]	18 (29%)	Rashid Hospital and Trauma Center, Dubai (2011-12)
		Oman	
[42]	29	4 (14%)	Royal Hospital, Muscat (2007)
[43]	1972	733 (37%)	Sohar Hospital, Sohar (2016-17)
		Qatar	
[44]	53 [B]	7 (13%)	Hamad General Hospital, Doha (2007-8)
[11]	840	176 (21%)	Al-Ahli Hospital, Doha (2009-10)
		Gaza	
[45]	215 126 Year 2008 89 Year 2012	121(56%) 69 (55%) 52 (58%)	Al-Shifa Hospital (2008-12)
		Jordan	
[46]	358	113 (32%)	Multiple hospitals (n=NS), Northern Jordan. (2008-12)
[47]	60	41 (68%)	Jordan University Hospital, Amman (2009-10)
		Lebanon	
[48]	130[C]	93 (72%)	American University of Beirut Medical Center, Beirut (2006-7)
[49]	4890[D]	1350 (28%)	Multiple hospitals (n= 16), Beirut, Mount Lebanon, North Lebanon, and South Lebanon
[50]	1167 378 Year 2000-1 310 Year 2005-6 479 Year 2010-11	282 (24%) 124 (33%) 62 (20%) 96 (20%)	American University of Beirut Medical Center, Beirut (2000-11)
		Iraq	
[51]	505[E]	251 (50%)	Ibn Sina Hospital, Baghdad (2005-9)
[51]	152	52 (34%)	Ibn Sina Hospital, Baghdad (2005-9)
[52]	22[F]	15 (68%)	Witmer Troop Medical Clinic, Camp Liberty, Baghdad (2008)
[53]	654[G]	576 (88%)	Sulaymaniyah Burns and Plastic Hospital, Sulaymaniyah, Kurdistan region (2008-11)
		Egypt	
[54]	55	18 (33%)	University Hospital and Diagnostic Laboratories, Zagazig, and Assuit (2010-12)
[55]	64	38 (59%)	Suez Canal University, Ismailia (2013)
[56]	38[H]	18 (47%)	Alexandria University, Alexandria (NR)
[57]	631	364 (58%)	Multiple hospitals (n=12)
		Algeria	
[58]	148	92 (62%)	Multiple hospitals (n=4), Annaba (2010)
[59]	129	25 (19%)	Beni Messous University Hospital, Algiers (2010-11)
[60]	85[I]	73 (86%)	University Hospital Ibn Rochd, Annaba (2011-12)
[61]	221	99 (44%)	Mustapha Bacha University Hospital, Algiers (2006-7)
[62]	220 [J]	165 (75%)	Tlemecen teaching hospital, Tlemecen (2007-9)
		Tunisia	
[63]	72[K]	13 (18%)	Centre National de Greffe de Moelle Osseuse, Laboratory Service, Tunis (1998-2007)
[64]	143	58 (40%)	Charles Nicolle Hospital of Tunis, Tunis (2005-7)
[65]	387	99 (26%)	Military Hospital of Tunis, Tunis (2011-12)

[A] Purulent skin and soft tissue infection, [B] Bacteremia, [C] Random wound and respiratory infections, [D] Study sites represent 40.7% of all hospital, eds in Lebanon at time of study, [E] US military personnel in combat support hospital, [F] 70% of the patients were active-duty service members; the rest were a mix of U.S. Department of Defense civilians and contractors and third country nationals (including India, Pakistan, and Turkey), [G] Burn patients, [H] Skin and soft tissue infection (does not specify if purulent vs non-purulent), [I] Diabetic foot infection, [J] Surgical wound infection > 48 hours postoperatively, [K] Neutropenic patients at bone marrow transplant center.

Ref	Description	Molecular typing (CC, Spa, MLST, PFGE)		Study location (year)
KSA				
[12]	26 MRSA from nasal swabs of outpatients[A]	**CC15 (27%):** [PVL-] CC15-IVa-t084 (7%) [PVL-] CC15-V-t084 (7%) [PVL-] CC15-V-t085 (13%) **CC8 (13%):** [PVL-] CC8-V-t008 (13%) **CC25 (13%):** [PVL-] CC25-V-t349 (7%) [PVL-] CC25-IVa-t660 (7%) **CC5 (7%):** [PVL-] CC5-V-t002 (6.7%)	**CC22 (7%):** [PVL-] CC22-V-t223 (6.7%) **CC80 (7%):** [PVL+] CC80-NT-t376 (6.7%) **CC188 (7%):** [PVL-] CC188-V-t189 (6.7%) **CC-NA (20%):** [PVL-] IVa-t442 (6.7%) [PVL+] NT-t6836 (6.7%) [PVL+] IVa-t11841 (6.7%)	Outpatient clinics, Buraydah city (2011)
[16]	20 MRSA from nasal swabs of healthy volunteers, clinical students, HCWs	**CC80 (20%):** CC80-ST80-IV-t131 (20%) **CC22 (20%):** CC22-IV-t1328 (20%) **CC5 (20%):** CC5-IV-t688 (20%)	**PFGE F (20%):** PFGE F-ST6-II-t304 (20%) **CC1 (10%):** CC1-IVa-t128 (10%) **PFGE K CC88(10%):** PFGE K-CC88-IV-t1339 (10%)	Al-Ahsa (NR)
Kuwait				
[20]	18 Nasal, axillary, and groin swabs from ICU inpatients	**ST239 (72%):** ST239-III-t421 (33%) ST239-III-t945 (28%) ST239-III-t4410 (6%) ST239-III-t388 (6%) **ST22 (11%):** ST22-IV-t223 (6%) ST22-IV-t3010 (6%)	**ST97 (11%):** ST97-IV-t6665 (6%) ST97-IV-t1234 (6%) **ST80 (6%):** ST80-IV-t044 (6%)	Farwania Hospital, Kuwait City (2005-7)
Gaza				
[23]	94 MRSA from nasal swabs of healthy children and parents	**CC22 (76%):** [PVL-] ST22-IVa-t223 (64%) [PVL+] ST22-IVa-t223 (2%) [PVL-] ST22-V-t223 (7%) [PVL-] ST1784-V-t223 (2%) **CC88 (7%):** [PVL-] ST78-IVa (7%) **CC80 (5%):** [PVL+] ST80-IVa (4%) [PVL+] ST80-IV (1%)	**CC5 (3%):** [PVL-] ST5-V (1%) [PVL-] ST1785-IVa (2%) **CC30 (2%):** [PVL+] ST30-IVc (1%) [PVL-] ST1734-IVc (1%) **CC913 (1%):** [PVL-] ST913-IVa (1%) **Others (5%):** [PVL-] ND (5%)	12 Gaza neighborhoods and villages, northern and central Gaza (2009)
Jordan				
[26]	37 MRSA from nasal and hand swabs of healthy volunteers	**T9519 (73%):** [PVL-, *Tst1*+]-IVe-t9519 (73%) **T223 (14%):** [PVL-, *Tst1*+]-IV-t223 (14%)	**T044 (5%):** [PVL+, *Tst1*+]-IVc-t044 (5%) **NT (8%):** [PVL-, *Tst1*+]-IVe-NT (8%)	University of Jordan, Amman, (2009)
[27]	26 MRSA from nasal swabs of healthy volunteers	**CC22 (46%):** [PVL-, *Tst1*+] CC22-IVa-t223 (39%) [PVL-, *Tst1*+] CC22-IVa-t6397 (4%) [PVL-, *Tst1*-] CC22-IVa-t790 (4%) **CC30 (23%):** [PVL-, *Tst1*+] CC30-IVc-t012 (4%) [PVL-, *Tst1*-] CC30-Ivg-t021 (4%) [PVL-, *Tst1*-] CC30-IVa-t021 (4%) [PVL-, ts1+] CC30-Ivc-t253 (4%) [PVL-, *Tst1*+] CC30-Ivc-t1651 (8%)	**CC5 (12%):** [PVL-, *Tst1*-] CC5-IVa-t214 (12%) **CC1 (8%):** [PVL-, *Tst1*-] CC1-IVa-t386 (8%) **CC80 (4%):** [PVL+, *Tst1*-] CC80-IVc-t044 (4%) **CC97 (4%):** [PVL-, *Tst1*-] CC97-NT-t1234 (4%) **CC15 (4%):** [PVL+, *Tst1*-] CC15-NT-t803 (4%)	Al-Karak Hospital, Alkarak province (2011-12)

	30 MRSA from nasal swabs of HCWs	**CC22 (47%):** [PVL-, *Tst1*+] CC22-IVa-t223 (40%) [PVL-, *Tst1*+] CC22-IVa-t309 (6.7%) **CC1 (23%):** [PVL-, *Tst1*-] CC1-IVa-t386 (20%) [PVL-, *Tst1*-] CC1-IVa-t693 (3.3%) **CC30 (17%):** [PVL-, *Tst1*+] CC30-IVc-t018 (6.7%) [PVL-, *Tst1*+] CC30-IVc-t012 (3.3%) [PVL-, *Tst1*-] CC30-IVa-t021 (3.3%) [PVL-, *Tst1*-] CC30-V-t021 (3.3%)	**CC5 (7%):** [PVL-, *Tst1*-] CC5-IVa-t10683 (6.7%) **CC80 (3%):** [PVL+, *Tst1*-] CC80-IVc-t044 (3.3%) **CC45 (3%):** [PVL-, *Tst1*-] CC45-IVc-t370 (3.3%)	
Egypt				
[33]	30 MRSA from nasal swabs of HCWs	-	-	Fayoum University Hospital, Fayoum, Egypt. (NR)
[31]	21 MRSA from hands and nasal swabs of HCWs	**Spa-CC223 (52%):** **Predicted MSLT-CC22 (52%):** [PVL-, *Tst1*-] t223-I (10%) [PVL-, *Tst1*-] t223-NT (5%) [PVL-, *Tst1*+] t223-I (5%) [PVL-, *Tst1*+] t14339-I (5%) [PVL-, *Tst1*+] t14339-II (5%) [PVL+, *Tst1*+] t14339-IV (5%) [PVL-, *Tst1*-] t14339-V (5%) [PVL-, *Tst1*+] t3689-I (5%) [PVL-, *Tst1*-] t3689-IV (5%) [PVL+, *Tst1*+] t8506-IV (5%)	**Singleton t267 (24%):** **Predicted MLST CC 80 (24%):** [PVL-, *Tst1*-] t267-IV (10%) [PVL-, *Tst1*-] t267-I (5%) [PVL-, *Tst1*+] t267-I (5%) [PVL-, *Tst1*+] t267-IV (5%) **Singleton t084 (10%):** **Predicted MLST CC15 (10%)** [PVL-, *Tst1*-] t084-IV (10%) **Singleton t1339 (5%):** **Predicted MLST-CC80 (5%)** [PVL-, *Tst1*-] t1339-IV (5%) **Singleton t380 (10%):** **Predicted MLST-CC NT (10%):** [PVL+, *Tst1*-] t380-IV (5%) [PVL-, *Tst1*-] t380-I (5%)	Beni-Suef University, Beni-Suef (NR)
[12]	33 MRSA from nasal swabs of outpatients[B]	**CC5 (30%):** [PVL-] CC5-V-t688 (30%) **CC30 (20%):** [PVL-] CC30-IVa-t021 (10%) [PVL-] CC30-IVa-t318 (10%) **CC80 (15%):** [PVL+] CC80-IVa-t044 (5%) [PVL+] CC80-V-t044 (10%)	**CC88 (15%):** [PVL-] CC88-IVa-t786 (15%) **CC22 (10%):** [PVL-] CC22-V-t223 (5%) [PVL-] CC22-IVa-t223 (5%) **CC8 (5%):** [PVL+] CC8-V-t008 (5%) **CC-NA (5%):** [PVL-] V-t11839 (5%)	Al Kanater, Al Kheireya (2011)
Algeria				
[34]	9 MRSA from nasal swabs of inpatients < 48 hours of admission	**ST80 (44%)** [PVL+, *Tst1*-] ST80-IVc (33%) [PVL-, *Tst1*-] ST80-IVa (11%) **ST22 (22%)** [PVL-, *Tst1*+] ST22-IVa-t223 (22%)	**ST5 (22%)** [PVL-, *Tst1*-] ST5-IVc (11%) [PVL-, *Tst1*-] ST5-VII (11%) **ST535 (11%)** [PVL-, *Tst1*-] ST535-IVh (11%)	Frantz-fanon nephrology department and Amizour Hospital in Bejaia (2010-12)

Supplementary table 3. Molecular Typing of Colonizing MRSA Strains in the MENA Region. Numerical values are rounded to the nearest whole digit.
NR: Not reported. [A] *spa* typing, and CC assortment was done for 15 randomly selected isolates out of 26 total MRSA isolates. [B] *spa* typing, and CC assortment was done for 15 randomly selected isolates out of 33 total MRSA isolates.

Ref	# MRSA	Molecular typing (CC, Spa, MLST, PFGE)		Study location (study date)
KSA				
[66]	120[A]	**Spa-CC037 (55%):** t037 (35%) t030, t363 (5% each) t631 (3%) t019, t388 (2% each) t138, t459, t748, t932, t1070 (1% each) **Spa-CC790 (8%):** t032, t223 (2% each)) t790, t4573, t7604, t8506, t8855 (1% each) **Spa-CC376 (21%):** t044 (19%) t376, t8731 (1% each)	**Spa-CC690 (4%):** t690 (2.5%) t729, t8507 (0.8%) **Cluster 5 no founder (5%):** t304 (4.2%) t701 (0.8%) **Singletons (8%):** t002 (4.2%) t3059 (1.7%) t364, t2235 (0.8%)	Armed Forces Hospital, Riyadh (2010)
[67]	107	**CC22 (28%):** [PVL+, *Tst1*-] CC22-IV (19%) [PVL-, *Tst1*-] CC22-IV (4%) [PVL-, *Tst1*+] CC22-IV (6%) **CC8 (21%):** [PVL-, *Tst1*-] ST239-III (21%) **CC80 (20%):** [PVL+, *Tst1*-] CC80-IV (18%) [PVL-, *Tst1*-] CC80-IV (2%) **CC30 (12%):** [PVL+, *Tst1*-] CC30-IV (12%) **CC5 (8%):** [PVL-, *Tst1*-] CC5-IV (3%) [PVL+, *Tst1*-] CC5-IV (2%) [PVL-, *Tst1*-] CC5-IV/SCCfus (2%) [PVL-, *Tst1*+] CC5-IV/SCCfus (1%) [PVL-, *Tst1*-] CC5-V (1%)	**CC6 (3%):** [PVL-] CC6-IV (3%) **CC88 (3%):** [PVL+, *Tst1*-] CC88-IV (3%) **CC97 (2%):** [PVL-, *Tst1*-] CC97-V (2%) **CC1 (2%):** [PVL-, *Tst1*-] CC1-IV/SCCfus (1%) [PVL+, *Tst1*-] CC1-ST772-V (1%) **CC9 (1%):** [PVL-, *Tst1*+] CC9-ST834-(atypical SCCmec) (0.9%) **CC45 (1%):** [PVL-, *Tst1*-] CC45-IV (1%)	King Fahad Medical City, Riyadh (NR)
[72]	101	-	-	Multiple hospitals (n=NS), Jeddah (2009-2011)
[38]	100	[PVL-] I (3%) [PVL-] II (9%) [PVL-] III (39%) [PVL+] III (8%)	[PVL-] IV (20%) [PVL+] IV (9%) [PVL-] NT (10%) [PVL+] NT (2%)	Multiple hospitals (n=5), Makkah city (2012)
[68]	117	**CC80 (30%):** [PVL+, *Tst1*-] CC80-IV (30%) **CC6 (13%)** [PVL-, *Tst1*-] CC6-IV (13%) **CC5 (11%):** [PVL-, *Tst1*-] CC5- IV/SCCfus (6%) [PVL-, *Tst1*-] CC5-V/SCCfus (3%) [PVL+, *Tst1*-] CC5-IV (2%) [PVL+, edinA+, *Tst1*-] CC5-IV (1%) **CC22 (10%):** [PVL-, *Tst1*+] CC22-IV (6%) [PVL+, *Tst1*-] CC22- IV (3%) [PVL-, *Tst1*-] CC22-IV (1%) **CC8 (9%):** [PVL-, *Tst1*-] CC8-ST239-III (8%) [PVL-, ACME+, *Tst1*-] CC8-ST8-IV (1%) [PVL-, *Tst1*-] CC8-ST72-IV (1%) **CC30 (7%):** [PVL+, *Tst1*-] CC30- IV (5%) [PVL-, *Tst1*-] CC30-MRSA-? [VI+fus composite] (2%)	**CC97 (7%):** [PVL-, *Tst1*-] CC97-V (6%) [PVL-, *Tst1*-] CC97-IV (1%) **CC88 (5%):** [PVL-, *Tst1*-] CC88-IV (5%) **CC15 (3%):** [PVL-, *Tst1*-] CC15-MRSA (1%) [PVL-, *Tst1*-] CC15-V/SCCfus (2%) **CC2250 (2%):** [PVL-, *Tst1*-] CC2250/2277-IV (2%) **CC1 (1%):** [PVL-, *Tst1*-] CC1-IV (1%) **CC96 (1%):** [PVL-, *Tst1*-] CC96-IV (1%) **CC45 (1%):** [PVL-, *Tst1*-] CC45-IV (1%) **CC913 (1%):** [PVL-, *Tst1*-] CC913-ST913-IV (1%)	King Khalid University Hospital, Riyadh (2009-15)
[37]	71	**SCCmec I, II, and III (63%):** [PVL-] I (34%) [PVL-] III (20%) [PVL-] II (10%)	**SCCmec IV, V, and NT (37%):** [PVL+] IV (17%) [PVL+] V (10%) [PVL-] V (6%) [PVL-] IV (3%) [PVL+] NT (1%)	Multiple hospitals, Taif city (2013-15)
Kuwait				

[69]	400[B]	**CC8 (58%):** [PVL-] ST239-III-t030/t037/t421/t945/t860 (46%) [PVL-] ST8-IV-t064 (1%) [PVL+] and [PVL-] ST8-IV-t008 (1%) [PVL-] ST8-V-t064 (1%) [PVL-] ST113-IV-t064 (1%) [PVL-] ST241-III-t1902/t037/t138 (9%) [PVL-] ST1465-III-t459 (0.3%) **CC22 (9%):** [PVL-, *Tst1*-] ST22-IV-t032/t790 [PVL-, *Tst1*+] ST22-IV-t223/t5708/t309/t3935/t2251/t852/t3107/t5983 (9%) **CC5 (9%):** [PVL-, *Tst1*+] ST105-II-t002 (1%) [PVL-, *Tst1*-] ST5-II-t003/t242/t105 and ST225-II-t045 (2%) [PVL+, *Tst1*-] ST5-IV-t306/t2164/t002/t688 (3%) [PVL+, *Tst1*-] ST5-V-t688/t2164 (2%) [PVL+, *Tst1*-] ST5-VI-t688 (0.3%) [PVL+, *Tst1*-] ST1637-V-t5258 (0.3%) [PVL-, *Tst1*-] ST149-IV-t1154/t2164 (1%) **CC80 (7%):** [PVL-, *Tst1*-] ST80-IV-t376/t8154 and [PVL+, *Tst1*-] ST80-IV-t1154/t018/t042/t044 (7%) **CC30 (6%):** [PVL+, *Tst1*-] ST30-IV-t019/t345/t318/t1130 (4%) [PVL-, *Tst1*-] ST36-II-t018 and [PVL-, *Tst1*+] ST36-II-t605 (2%)	**CC1 (3%):** [PVL-] ST1-V-t6811 and [PVL+] ST1-V-t127/t321 (1%) [PVL+] ST772-V-t345/t10795/t657/t12211 (2%) **CC6 (2%):** [PVL-, *Tst1*-] ST6-IV-t304 (2%) **CC97 (2%):** [PVL-, *Tst1*-] ST97-V-t1234/t13204 (2%) **CC88 (1%):** [PVL+, *Tst1*-] ST88-IV-t690/t4067/t5041 (1%) [PVL-, *Tst1*-] ST1289-t5562 (0.3%) **CC121 (2%):** [PVL+, *Tst1*-] ST121-IV-t314 (1%) [PVL+, *Tst1*-] ST121-V-t314 (1%) **CC913 (1%):** [PVL-, *Tst1*-] ST913-IV-t991 (1%) **CC45 (1%):** [PVL-, *Tst1*-] ST46-IV-t370 (0.3%) [PVL-, *Tst1*-] ST508-IV-t050 (0.3%) **CC361 (1%):** [PVL-, *Tst1*+] ST361-IV-t315/t1427 (0.5%) **ST72 (0.3%):** [PVL-, *Tst1*-] ST72-V-t4000 (0.3%) **New Sequence Type (0.3%):** [PVL-, *Tst1*-] ST2816-V-t605 (0.3%)	Multiple hospitals (n=13), Kuwait. (1992-2010)
[70]	26 SCCmec-IV	**CC80 (46%):** [PVL+] CC80-ST80-IV (46%) **CC30 (31%):** [PVL+] CC30-ST30-IVc (4%) [PVL+] CC30-ST30-IV (27%) **CC5 (12%):** [PVL-] CC5-ST5-IV (8%) [PVL-] CC5-ST6-IV (4%)	**CC8 (8%):** [PVL-]CC8-ST8-IVa (4%) [PVL-] CC8-ST8-IV (4%) **CC undetermined (4%):** [PVL-] ST361-IV (4%)	Multiple hospitals (=7), Kuwait. (2001-3)
[82]	69 ST80-*SCC*mec-IV	**ST80 (51%):** [PVL+, tst-]-ST80-IV (35%) [PVL+, tst-] ST80-IVa (1%) [PVL+, tst-] ST80-IVc (1%) [PVL+, *Tst1*+]-ST80-IV (2%) [PVL-, *Tst1*-]-ST80-IV (13%)		Multiple hospitals (n=8), Kuwait. (2005-6)
[84]	6,922	**SCCmec IV, V, NT (70%):** IV (positive for urease production) (46%) IV (negative for urease production) (8%) V (15%) NT (1%)	**SCCmec I, II, III (30%):** I (0.3%) II (1%) III (29%)	Multiple hospitals (n=14), Kuwait (2011-15)
[78]	37 EMRSA-15 ST22 Urease (-)	**{UK-EMRSA-15/Barnim EMRSA} (16%):** [PVL-, *Tst1*-] ST22-IVh-t032 (8%) [PVL-, *Tst1*-] ST22-IVa-t790 (8%) **{UK EMRSA-15/ [*Tst1*+] Middle-Eastern variant} (62%):** [PVL-, *Tst1*+] ST22-IVa-t223 (51%) [PVL-, *Tst1*+] ST22-IVa-t309 (3%) [PVL-, *Tst1*+] ST22-IVa-t2251 (3%) [PVL-, *Tst1*+] ST22-IVa-t3935 (3%)	[PVL-, *Tst1*+] ST22-IVa-t5708 (3%) **{[PVL+] CC22-MRSA-IV variant} (22%):** [PVL+, *Tst1*-] ST22-IV-t852 (14%) [PVL+, *Tst1*-] ST22-IV-t3107 (5%) [PVL+, *Tst1*-] ST22-IV-t5983 (3%)	Multiple hospitals (n=10), Kuwait (2005-10)

[73]	102 novel MRSA variants from 1,327 MRSA	**CC361 (32%):** [PVL-, *Tst1*-] CC361-V-t3841(28%) [PVL-, *Tst1*-] CC361-V-t1309 (1%) [PVL-, *Tst1*-] CC361-V-t15778 (1%) [PVL-, *Tst1*-] CC361-V-t3175 (1%) [PVL-, *Tst1*-] CC361-V-t16901 (1%) **CC30 (15%):** [PVL+, *Tst1*-] CC30-VI-t018 (6%) [PVL+, *Tst1*-] CC30-VI-t012 (1%) [PVL+, *Tst1*-] CC30-VI-t021 (4%) [PVL+, *Tst1*-] CC30-VI-t318 (1%) [PVL-, *Tst1*-] CC30-VI-t018 (1%) [PVL-, *Tst1*-] CC30-VI-t021 (1%) [PVL-, *Tst1*-] CC30-VI-t253 (1%) **CC22 (13%):** [PVL+, *Tst1*+] CC22-IV-t005 (7%) [PVL+, *Tst1*+] CC22-IV-t309 (3%) [PVL+, *Tst1*+] CC22-IV-t223 (1%) [PVL+, *Tst1*+] CC22-IV-t10659 (1%) [PVL-, *Tst1*-] CC22-VI-t16578 (1%) **CC1 (11%):** [PVL+, *Tst1*-] CC1-V-t127 (4%) [PVL+, *Tst1*-] CC1-V-t2207 (6%) [PVL-, *Tst1*-] CC1-pseudoSCCmec-t127 (class B mec) (1%) **CC8 (6%):** [PVL-] CC8-V-t008 (5%) [PVL-] CC8-t211 (1%)	**CC152 (6%):** [PVL+, *Tst1*-] CC152-V-t355 (3%) [PVL+, *Tst1*-] CC152-V-t4019 (1%) [PVL+, *Tst1*-] CC152-V-t11206 (1%) [PVL+, *Tst1*-] CC152-VI-t4019 (1%) **CC121 (6%):** [PVL+, *Tst1*-] CC121-V-t314 (5%) [PVL+, *Tst1*-] CC121-V-t1991 (1%) **CC913 (3%):** [PVL-, *Tst1*-] CC913-VI-t991 (3%) **CC45 (2%):** [PVL-, *Tst1*-] CC45-VI-t362 (2%) **CC88 (2%):** [PVL-, *Tst1*-] CC88-IV-t786 (1%) [PVL-, *Tst1*-] CC88-IV-t2622 (1%) **CC97 (2%):** [PVL-, *Tst1*-] CC97-V-t2297 (1%) [PVL-, *Tst1*-] CC97-VI-t359 (1%) **CC1153 (1%):** [PVL+, *Tst1*-] CC1153-ND-t504 (1%) **CC5 (1%):** [PVL+, *Tst1*-] CC5-V-t1588 (1%) **CC6 (1%):** [PVL-] CC6-IV-t14700 (1%) **Singleton (1%):** [PVL+, *Tst1*-]ST2867-V-t148 (1%)	Multiple hospitals (n=13), Kuwait (2016)
[7]	209[C]	**CC8 (27%):** [PVL-] ST239-III-t860 (13%) [PVL-] ST239-III-t945 (8%) [PVL-[ST239-III-t037 (1%) [PVL-] ST239-III-t713 (1%) [PVL-] ST239-III-t425 (1%) [PVL-] ST239-III-t1247 (1%) **CC5 (18%):** CC5-VI+SCCfus (5%) CC5-V+SCCfus (WA-MRSA-14/109) (4%) **CC1 (9%) :** [PVL+] CC1-V+SCCfus (4%) **CC6 (9%):** CC6-IV (WA-MRSA-51) (8%) **CC22 (9%):** [PVL+, tst+] CC22-IV (3%) [PVL+, tst-] CC22-IV (2%)	**CC80 (7%):** [PVL+] CC80-IV (7%) **CC30 (6%):** [PVL+] CC30-IV (4%) **CC97 (3%)** **CC15 (3%)** **CC152 (2%)** **CC88 (2%)** **CC361 (2%)** **CC2250/2277 (1%)** **CC45 (1%)** **CC121 (1%)** **CC59 (1%)** **Singleton ST2867 (1%)**	Farwaniya Hospital, Farwaniyah (2016)
UAE				
[71]	26 (year 2003)	**ST239 (23%):** [PVL-, *Tst1*-] ST239-IIIa-t037 (8%) [PVL-, *Tst1*-] ST239-III-t037 (8%) [PVL-, *Tst1*-] ST239-III-t421 (4%) [PVL-, *Tst1*-] ST239-IIIa-t421 (4%) **ST5 (23%):** [PVL-, *Tst1*-] ST5-II-t002 (19%) [PVL+, *Tst1*+] ST5-IV-t002 (4%) **ST22 (19%):** [PVL-, *Tst1*-] ST22-IV-t032 (19%) **ST80 (12%):** [PVL+, *Tst1*-] ST80-IV-t044 (12%)	**ST88 (8%):** [PVL+, *Tst1*-] ST88-IV-t690 (8%) **ST30 (4%):** [PVL+, *Tst1*-] ST30-IV-t019 (4%) **ST97 (4%):** [PVL-, *Tst1*-] ST97-IV-t359 (4%) **ST113 (4%):** [PVL-, *Tst1*-] ST113-IVa-t064 (4%) **ST779 (4%):** [PVL-, *Tst1*-] ST779-IV-t878 (4%)	Tawam Hospital, Al Ain (2003-8)

	26 (year 2008)	**ST80 (27%):** [PVL+, *Tst1*-] ST80-IV-t044 (27%) **ST5 (27%)** [PVL-, *Tst1*+] ST5-IV-t002 (12%) [PVL+, *Tst1*+] ST5-IV-t002 (4%) [PVL-, *Tst1*-] ST5-NT-t688 (8%) [PVL-, *Tst1*-] ST5-IV-t688 (4%) **ST1 (12%):** [PVL-, *Tst1*-] ST1-NT-t127 (8%) [PVL-, *Tst1*+] ST1-NT-t127 (4%) **ST239 (8%):** [PVL-, *Tst1*-] ST239-III-t037 (8%)	**ST30 (8%):** [PVL+, *Tst1*-] ST30-IV-t018 (4%) [PVL+, *Tst1*-] ST30-IV-t019 (4%) **ST6 (8%):** [PVL-, *Tst1*-] ST6-IV-t304 (8%) **ST22 (4%):** [PVL-, *Tst1*-] ST22-NT-t005 (4%) **ST45 (4%):** [PVL-, *Tst1*-] ST45-IV-t1081 (4%) **ST361 (4%):** [PVL-, *Tst1*-] ST361-IV-t315 (4%)	
[87]	57 **CO**	**SCCmec IV (100%):** [PVL+] IV (100%)		Al Qassimi hospital, Sharjah (2011-12)
Qatar				
[11]	61	**ST30 (28%):** [PVL+] ST30-IV-t019 (28%) **ST5 (21%):** [PVL-] ST5-IV-t002 (21%) **ST80 (13%):** [PVL+] ST80-IV-t044 (13%) **ST22 (13%):** [PVL+] ST22-IV-t852 (8%) [PVL-] ST22-IV-t852 (5%) **ST8 (12%):** [PVL+, ACME+] ST8-IV-t008/t121 (7%) [PVL-] ST8-IV-spa-NT/t267 (5%) **ST15 (5%):** [PVL+] ST15-V-spa-NT/t657/7358 (5%)	**ST88 (3%):** [PVL+] ST88-IV-t690 (3%) **ST-NT (3%):** [PVL-, ACME+] ST-NT-V-spa-NT (2%) [PVL-] ST-NT-V-spa-NT (2%) **ST121 (2%):** [PVL+] ST121-V-t314 (2%)	Al-Ahli Hospital, Doha (2009-10)
Bahrain				
[6]	53	**PFGE A (83%):** SCCmec-III (83%) **PFGE C (6%):** SCCmec-IV (6%) **PFGE D (6%):** SCCmec-IV (6%)	**PFGE B (2%):** SCCmec-IV (2%) **PFGE E (2%):** SCCmec-IV (2%)	Salmaniya Medical Complex, Manama (2005)
Gaza				
[45]	121	**CC22 (41%):** [PVL-, *Tst1*+] ST22-IVa-t223 (23%) [PVL+, *Tst1*+] ST22-IVa-t223 (1%) [PVL-, *Tst1*-] ST22-IVa-t223 (3%) [PVL-, *Tst1*+] ST22-V-t223 (1%) [PVL-, *Tst1*+] ST22-IVa-t309 (2%) [PVL-, *Tst1*+] ST22-IVa-t541 (2%) [PVL-, *Tst1*+] ST22-IVa-t5485 (2%) [PVL-, *Tst1*+] ST22-IVa-t7063 (2%) [PVL-, *Tst1*+] ST22-V-t7063 (7%) **CC80 (31%):** [PVL+, *Tst1*+] ST80-IVc-t044 (1%) [PVL+, *Tst1*-] ST80-IVc-t044 (29%) [PVL+, *Tst1*-] ST80-IV-t458 (1%) **CC8 (8%):** [PVL-, *Tst1*-] ST8-IVa-t008 (5%) [PVL-, *Tst1*-] ST8-VI-t008 (1%) [PVL-, *Tst1*-] ST8-VI-t2229 (2%) [PVL+, *Tst1*-] ST8-IVa-t4229 (1%)	**CC30 (8%):** [PVL+, *Tst1*-] ST30-IVa-t318 (8%) **CC239 (7%):** [PVL-, *Tst1*+] ST239-III-t037 (1%) [PVL-, *Tst1*-] ST239-III-t037 (6%) [PVL-, *Tst1*-] ST239-IIIHg-t037 (1%) **CC5 (3%):** [PVL-, *Tst1*-] ST228-I-t001 (2%) [PVL-, *Tst1*-] ST5-VI-t688 (1%) **CC6 (1%):** [PVL-, *Tst1*-] ST6-IVa-t14480 (1%) **CC121 (1%):** [PVL+, *Tst1*-] ST121-IV-t7793 (1%) **CC1153 (1%):** [PVL+, *Tst1*-] ST1153-I-t903 (1%)	Al-Shifa Hospital, Gaza (2008-12)
Jordan				

[47]	41	[PVL+] t044 (27%) [PVL-] t044 (11%) [PVL-] t037 (11%) [PVL+] t318 (5%) [PVL-] t386 (5%) [PVL-] t1149 (5%) [PVL-] t701(3%) [PVL+] t5849 (3%) [PVL-] t318 (3%)	[PVL-] t6438 (3%) [PVL-] t091 (3%) [PVL-] t6432 (3%) [PVL-] t012 (3%) [PVL-] t743 (3%) [PVL+] t6439 (3%) [PVL-] t6303 (3%) [PVL-] t363 (3%) [PVL-] t159 (3%) [PVL+] t5802 (3%)	Jordan University Hospital, Amman (2009-10)
[81]	31 Spa-CC044 MRSA	**CC80 (100%):** [PVL+, *Tst1*-] CC80-ST80-IV-t044 (19%) [PVL-, *Tst1*+] CC80-ST80-IV-t044 (29%) [PVL+, *Tst1*+] CC80-ST80-IV-t044 (19%) [PVL-, *Tst1*-] CC80-ST80-IV-t044 (13%)	[PVL+, *Tst1*+] CC80-ST997-IV-t044 (3%) [PVL-, *Tst1*+] CC80-ST80-IV-t131 (3%) [PVL-, *Tst1*+] CC80-ST80-IV-t5849 (3%) [PVL+, *Tst1*-] CC80-ST80-IV-t5849 (3%) [PVL+, *Tst1*-] CC80-ST80-IV-t5802 (3%) [PVL-, *Tst1*-] CC80-ST80-IV-t6438 (3%)	Jordan University Hospital, Amman (2000-11)
Lebanon				
[48]	93	**CC80 (55%):** [PVL+] ST80-IVc-t044 (53%) [PVL+] ST80-IVc-t131 (2%) **CC8 (15%):** [PVL-] ST239-III-t037/t030 (11%) [PVL-] ST8-IVc-t008 (4%) **CC97 (4%):** [PVL-] ST97-V-t267 (4%)	**CC6 (3%):** [PVL-] ST6-IVc-t304 (3%) **CC22 (3%):** [PVL-] ST22-IVc-t032 (3%) **CC5 (1%):** [PVL-] ST5-IVc-t311 (1%) **CC30 (1%):** [PVL+] ST30-IVc-t318 (1%)	American University of Beirut Medical Center, Beirut, Lebanon. (2006-7)
[81]	63 spa-CC044	**CC80 (100%):** [PVL+, *Tst1*-] ST80-IV-t044 (79%) [PVL-, *Tst1*-] ST80-IV-t044 (6%) [PVL+, *Tst1*-] ST80-IV-t131 (8%)	[PVL+, *Tst1*-] ST80-IV-t4222 (2%) [PVL+, *Tst1*-] ST80-IV-t6438 (2%) [PVL-, *Tst1*-] ST80-IV-t021 (2%) [PVL+, *Tst1*-] ST80-IV-t9135 (2%)	American University of Beirut Medical Center, Beirut, Lebanon. (2000-11)
Iraq				
[74]	182[D]	**USA300** (80%): [PVL+] IV (78%) [PVL+] MB (2%) [PVL-] IV (1%) **USA100** (4%): [PVL+] NT (3%) [PVL+] IV (1%) **USA1100** (3%): [PVL+] IV (3%) **USA400** (2%): [PVL+] IV (2%) **USA800** (1.6%): [PVL+] IV (2%)	**USA1000** (1%): [PVL+] IV (1%) **CSH1, CSH2, CSH3, CSH6, CSH9, CSH10, and CSH11 (1% each):** [PVL+] IV (4%) **CSH4 (0.5%), CSH5 (2%), CSH7(1%):** [PVL+] III (3%) [PVL-] III (1%) **CSH8 (1%):** [PVL+] I (1%) **CSH5 (1%):** [PVL+] NT (1%)	Multiple combat support hospitals (n=3), Baghdad and Al Anbar province (2007-9)
Egypt				
[55]	12	-	-	Suez Canal University, Ismailia (2013)
[56]	18 **CO**	-	-	Alexandria University, Alexandria (NR)
[54]	18	[PVL+] II (33%) [PVL+] IVd (11%) [PVL+] III (11%) [PVL-] V (11%) [PVL+] NT (11%)	[PVL+] IVa (6%) [PVL-] IVd (6%) [PVL+] V (6%) [PVL+] IVc (6%)	University Hospital and Diagnostic Laboratories, Zagazig and Assuit (2010-12)

Algeria				
[58]	92	**CC8 (78%):** [PVL-] ST239-III-t037 (43%) [PVL-] ST239-III-t932 (35%)	**CC80 (21%):** [PVL+] ST80-IVc-t044 (21%) **CC22 (1%):** [PVL-] ST22-IVc-t005 (1%)	Annaba Hospitals, Annaba (2010)
[59]	15 **HO**[E]	**ST80 (100%):** [PVL+] ST80-IVc (100%)		Beni Messous University Hospital, Algiers (2010-11)
	10 **CO**[E]	**ST80 (90%):** [PVL+] ST80-IVc (70%) [PVL-] ST80-IVc (20%)	**ST39 (10%):** [PVL-] ST39-II (10%)	
[61]	84 **CO**[F, G]	**ST80 (97%):** [PVL+] ST80-IV-t044 (85%) [PVL+] ST80-IV-t4143 (3%) [PVL-] ST80-IV (3%) [PVL-] ST80-V (6%)	**ST241 (3%):** [PVL-] ST241-III (3%)	Mustapha Baᶜha University Hospital, Algiers (2006-7)
	137 **HO**[F, G]	**ST80 (77%):** [PVL+] ST80-IV-t044 (75%) [PVL-] ST80-IV (2%)	**CC80 (21%):** [PVL+] ST80-IVc-t044 (21%) **ST5 (11%):** [PVL-] ST5-IV (11%)	
[76]	64	-	-	Didouche Mourad Hospital, Constantine Province (2005-7)
[75]	84	**ST80 (86%):** [PVL+] ST80-ND (2%) [PVL+] ST80-IV (83%) **ST239 (8%):** [PVL-] ST239-III (8%)	**Other (6%):** [PVL-] IV (5%) [PVL-] II (1%)	Bolghine Ibn Ziri University hospital, Algiers (2006-11)
[60]	73[H]	**ST239 (82%):** [PVL-, *Tst1*-] ST239 (82%)	**ST80 (14%):** [PVL+, *Tst1*-] ST80 (14%) **Unknown (4%)** [PVL-, *Tst1*-] (4%)	University Hospital Ibn Rochd, Annaba (2011-12)
Tunisia				
[64]	58	-	-	Charles Nicolle Hospital, Tunis (2005-7)
[65]	24 tetracycline-resistant	**CC8 (79%):** [PVL-, *Tst1*-] ST247-t052 (50%) [PVL-, *Tst1*-] ST239-t037 (21%) [PVL-, *Tst1*-]ST239-t14712 (4%) [PVL-, *Tst1*-] ST241-t129 (4%) **CC80 (8%):** [PVL-, *Tst1*-] ST728-t044 (4%) [PVL+, *Tst1*-] ST728-t044 (4%)	**CC5 (8%):** [PVL-, *Tst1*-] ST641-t311 (4%) [PVL-, *Tst1*-] ST5-t7144 (4%) **CC398 (4%):** [PVL-, *Tst1*-] ST398-t899 (4%)	Military Hospital of Tunis, Tunis (2011-12)
[77]	28 **CO**[I]	**CC80 (86%):** [PVL+] ST80-IVc (60%) [PVL+] ST80-NT (7%) [PVL+] ST153-IVc (4%) [PVL+] ST153-NT (4%) [PVL+] ST2563-IVc (4%) [PVL-] ST80-IVc (7%)	**CC5 (7%):** [PVL-] ST5-I (4%) [PVL-] ST5-IVc (4%) **CC1 (4%):** [PVL-] ST1-NT (4%) **CC45 (4%):** [PVL-] ST45-NT (4%)	Habib Bourguiba Hospital and Charles Nicolle Hospital, Tunis (2004-8)
	41 **HO**[I]	**CC80 (51%):** [PVL+] ST80-IVc (49%) [PVL+] ST1440-IVc (2%) **CC8 (32%):** [PVL-] ST239-III (10%) [PVL-] ST241-III (7%) [PVL-] ST247-I (7%) [PVL-] ST1819-I (7%)	**CC5 (7%):** [PVL-] ST5-IVc (5%) [PVL-] ST5-NT (2%) **CC15 (4.9%):** [PVL-] ST97-NT (4.9%) **CC1 (2%):** [PVL-] ST1-NT (2%) **CC22 (2%):** [PVL-] ST22-NT (2%)	

Supplementary Table 4. Molecular Typing of Infective MRSA Isolates in the MENA Region.

CO: CO-MRSA; HO: HO-MRSA; NR: not reported; NT: not typeable; S-: singleton; Spa-CC: spa cluster. When a sample is not designated "CO" or "HO" it indicates that the study does not distinguish site of acquisition. Values were rounded to the nearest whole number.

[A] 60 cancer and 60 noncancer patients, [B] Percentages for each spa type was not provided in the study, [C] In this study only 120 from the 209 isolates underwent DNA microarray analysis; these isolates represented the 56 *spa* types found. The MLST types were only reported for CC8 and S-ST2867, [D] Isolates from USA service members deployed to Iraq. Sixteen strains displayed 11 unique pulsotypes not previously described and were labeled CSH1-CSH11, [E] subjects were neonates. In this study, outpatients and inpatients <48 hrs from admission were considered CO-MRSA while inpatients >48 hrs. post admission were HO-MRSA. Other epidemiological risk factors for HO-MRSA were not specified,

[F] This study distinguished between CO-MRSA and HO-MRSA by the epidemiological criteria specified in text, [G] spa typing was done for 46 PVL [+] isolates only and revealed only 2 spa types: t044 and t4143, [H] Diabetic foot infections, [I] Criteria used to distinguish between HO-MRSA and CO-MRSA is not specified.

Country	Ref (date)	# MRSA	Rif	FA	Cl	TS	Cip	Tet	Dox	EM	Vanc	Lin	Teic	Dap	Mup	Gen
Colonizing MRSA strains																
Oman[A]	[21, 22] (NR)	34 CV	100	-	76	-	-	-	88	50	88	100	82	-	-	-
Oman[A]	[21, 22] (NR)	49 HCW	96	-	65	-	-	-	92	51	88	100	84	-	-	-
KSA[A]	[12] (2011)	26 OP **CO[B]**	96	-	89	54	100	-	-	42	96	-	-	-	-	73
KSA[A]	[14] (2014-15)	48 IP	58	-	13	33	12	29	-	15	98[C]	67	54	-	-	92
KSA[A]	[19] (2012-14)	36 HCWs	-	-	3	83	83	69	-	3	100[E]	100	-	-	-	-
Lebanon[A]	[29] (2006-7)	8 CV	-	-	-	100	100	-	-	-	100	-	-	-	100	100
Gaza[D]	[23] (2009)	94 CV	-	95	64	100	99	-	-	62	100	-	-	-	-	97
Gaza[A]	[25] (2015)	51 HCW	88%	-	86%	-	88%	86.3%		65%	84%	-	-	-	-	92%
Jordan[F]	[27] (2011-12)	26 CV	100	96	100	-	100	-	-	42	100	100	100	100	100	100
Jordan[F]	[27] (2011-12)	30 HCW	100	90	90	-	93	-	-	42	100	100	100	100	100	100
Egypt[A]	[12] (2011)	33 OP **CO[B]**	91	-	67	52	100	-	-	45	91	-	-	-	-	67
Algeria[A]	[34] (2010-12)	9 IP	100	-	100	78	100	67	-	89	100	100	100	-	-	67
Kuwait[A]	[20] (2005-7)	18 IP	100%	33%	33%	72%	28%	28%		33%	100%	100%	100%	-	95%	28%
Infective MRSA Strains																
KSA[A]	[85] (2004-5)	397 NS	-	4	-	21	-	-	-	-	100[E]	97	-	-	74	30
KSA[A]	[85] (2004-5)	115 NS	-	6	-	77	-	-	-	-	100 [E]	91	-	-	89	74
KSA[NS]	[66] (2010)	120 NS	68	45	57	2	-	-	-	38	100	-	-	-	68	-
KSA[A]	[72] (2009-11)	101 NS	87	71	67	-	62	57	-	56	100	83	88	-	88	71
Kuwait[A]	[84] (2011-15)	6, 922 NS	99	59	58	66	57	61	-	58	99[E]	100	97	-	95	61
Kuwait[A]	[73] (2016)	1,327 NS	100	53	60	60	61	68	-	60	100[E]	100	100	-	96	-
Kuwait[A]	[7] (2016)	209 NS	100	36	48	55	50	45	-	48	100[E]	100	100	-	98	45
Oman[A]	[43] (2016-17)	733 NS	-	-	78	94	69	-	-	71	100	100	-	-	-	85
Bahrain[A]	[6] (2005)	53 NS	100	8	13	11	8	11	-	9	100[E]	100	100	-	89	26
Lebanon[A]	[79] (2011)	39 NS	100	-	87	97	87	69	-	80	100	-	100	-	-	-
Gaza[G]	[45] (2008-12)	121 NS	92	-	77	80	-	68	-	71	100	100	100	100	100	80

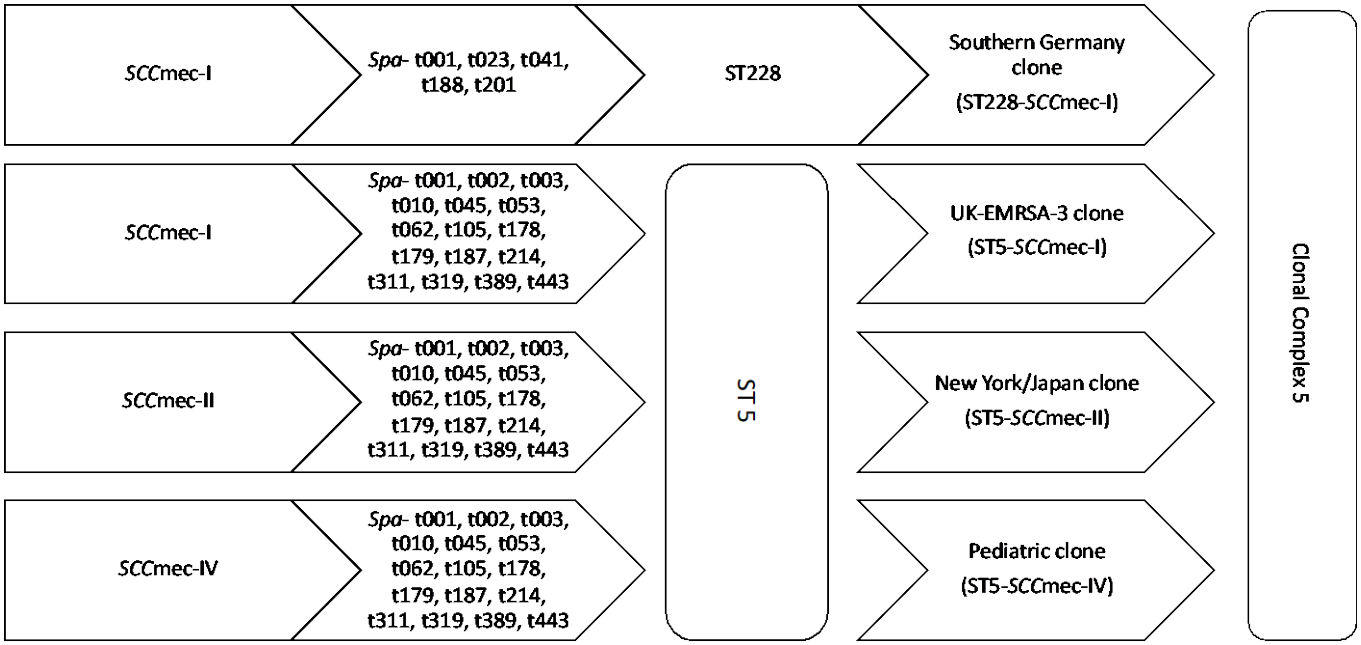
Jordan[A]	[46] (2008-12)	113 NS	86	-	55	58	-	58	-	23	100	97	97	-	-	47
Iraq[NS]	[74] (2007-9)	182 NS[H]	95	-	77	91	-	91	-	10	100	96	-	-	-	87
Iraq[NS]	[51] (2005-9)	303 NS[H]	91	-	75	91	49	80	-	15	100	-	-	-	-	89
Iraq[A]	[52] (2008)	15 NS[H]	100	-	87	100	73	-	-	13		-	-	-	-	-
Egypt[A]	[57] (2005-13)	21 **CO[I]**	86	-	100	81	91	14		81	100	-	-	-	-	91
Egypt[A]	[57] (2005-13)	343 **HO[I]**	80	-	44	83	30	16		36	100	-	-	-	-	19
Algeria[A]	[75] (2006-11)	84 NS	100	46	91	76	-	85		42	-	100	-	100	-	-
Algeria[A]	[59] (2010-11)	10 **CO[I]**	100	-	80	100	70	40	-	70	100	100	100	-	-	100
Algeria[A]	[59] (2010-11)	15 H**O[I]**	100	-	93	100	87	13	-	73	100	100	100	-	-	100
Algeria[A]	[62] 2007-9	165 **HO[B]**	-	-	88	-	-	-	-	44	98[J]	-	-	-	-	70
Tunisia[A]	[77] (2004-8)	69 NS	80	-	84	91	59	17	-	48	100	-	100	-	-	74

Supplementary table 5. Antimicrobial Susceptibility Profile of MRSA Isolates in the Arab World. Presented values are percentages of tested isolates. Infective isolates are labeled as CO-MRSA or HO-MRSA when specified by the cited study, otherwise they are labeled as Not specified. Cip: ciprofloxacin; Cl: clindamycin; CO: community-onset MRSA; CV: community volunteers; Dapt: daptomycin; EM: erythromycin; FA: fusidic acid; Gen: gentamicin; HCWs: health-care workers; HO: hospital-onset MRSA; IP: inpatient; Lin: linezolid; Mup: Mupirocin; NR: not reported; NS: not specified; OP: outpatients; Rif: Rifampicin; Tet: tetracycline; Teic: teicoplanin; TS: trimethoprim-sulfamethoxazole; Vanc: vancomycin.

[A] Antibiotic susceptibility testing (AST) by standard agar disk diffusion methodology according to clinical and laboratory standards institute guidelines, [B] CO-MRSA by epidemiological criteria described in text, [C] Non-susceptible strain identified as Vancomycin intermediate *S. aureus* (VISA), [D] AST determined using the VITEK-2 system, [E] AST to this antibiotic was tested via E-test method, [F] AST by standard agar disk diffusion and interpretation according to British society for antimicrobial chemotherapy method, [G] AST for 2003 done with VITEK2 system, AST for 2012 done with MicroScan WalkAway Plus System (Siemens Healthcare, Erlangen, Germany), [H] Combat support hospitals, [I] CO-MRSA was defined as infection diagnosed < 2-3 days from admission, and HO-MRSA >2-3 days from admission, [J] Non-susceptible isolates identified as vancomycin resistant *S. aureus* (VRSA) as opposed to VISA

Supplementary Figure 1. Illustrates how different typing techniques can be grouped together into a clonal complex.

Interconnection Between the Various Molecular Typing Techniques.



- One *spa* type can have multiple *SCC*mecs. One *spa* type can belong to multiple STs and multiple clones but only 1 clonal complex (CC).
- One ST can have multiple *spa* types and *SCC*mecs. One ST can belong to multiple clones but only 1 CC.
- Clone nomenclature depends on ST + *SCC*mec combination. Therefore, one clone can have only 1 ST and *SCC*mec combination. One clone can belong to only 1 CC.
- The highest level of classification is the CC. One CC can have multiple clones, STs, *spa* types and *SCC*mecs.