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Antimicrobial Susceptibility Results and Characterization of Skin and Soft Tissue Infections Caused by *Staphylococcus aureus* in Children

Çocuklarda *Staphylococcus aureus* Kaynaklı Cilt ve Yumuşak Doku İnfeksiyonlarının Özellikleri ve Antimikrobiyal Duyarlılık Sonuçları

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ABSTRACT

Introduction: *Staphylococcus aureus is a major cause of skin and soft tissue infections (SSTIs). This study aimed to determine the antimicrobial susceptibility and clinical and epidemiological characteristics of community-acquired SSTIs caused by methicillin-susceptible and methicillin-resistant S. aureus (MSSA-MRSA) in children.*

Materials and Methods: *This was a retrospective, single-center study of pediatric SSTIs caused by S. aureus at a tertiary care hospital in Türkiye between January 2014 and November 2019.*

Results: *Demographic, clinical, and microbiological data of 431 patients were examined during the study period. Overall, 333 (77.3%) isolates were MSSA, and 98 (22.7%) were MRSA. Antibiotic courses and hospital stays were significantly longer in patients with MRSA infection. The antimicrobial susceptibility patterns for 17 antibiotics were assessed in both MSSA and MRSA isolates. Penicillin resistance rate was 91%, while fosfomycin, gentamicin, mupirocin, trimethoprim-sulfamethoxazole, and fusidic acid resistance rates were 1.2%, 3.2%, 2.7%, 4.2%, and 8.1%, respectively. All S. aureus isolates were susceptible to teicoplanin, vancomycin, linezolid, and tigecycline, and 335 (77%) isolates showed susceptibility to daptomycin. A statistically significant increase was detected in resistance of MSSA isolates to trimethoprim-sulfamethoxazole in 2019 compared to 2014, 2015, 2016 and 2018 (p_1= 0.029 (2014 vs. 2019); p_2= 0.008 (2015 vs. 2019); p_3= 0.019 (2016 vs. 2019); p_4= 0.032 (2018 vs. 2019).*

Conclusion: *S. aureus strains causing SSTIs showed a continued high prevalence of MSSA and multi-drug susceptibility. A striking result was the detection of increased resistance to trimethoprim-sulfamethoxazole, which was frequently used in oral therapy against MSSA strains in 2019 compared to the other years. These results may provide guidance for clinical management of SSTIs in children.*

Key Words: *Antimicrobial susceptibility; Skin and soft tissue infection; Staphylococcus aureus; Children*

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ÖZ

Çocuklarda *Staphylococcus aureus* Kaynaklı Cilt ve Yumuşak Doku İnfeksiyonlarının Özellikleri ve Antimikrobiyal Duyarlılık

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Giriş: *Staphylococcus aureus, cilt ve yumuşak doku infeksiyonlarının (CYDİ) en sık etkenlerinden birisidir. Bu çalışmada çocuklarda metisiline duyarlı ve metisiline dirençli S. aureus'un (MSSA-MRSA) neden olduğu CYDİ'lerin klinik ve epidemiyolojik özelliklerini ve antimikrobiyal duyarlılıklarını tanımlamayı amaçladık.*

Materyal ve Metod: *Ocak 2014 ile Kasım 2019 yılları arasında, İstanbul'daki üçüncü basamak bir hastanede izlenen S. aureus kaynaklı CYDİ tanılı çocuk hastaların kayıtları retrospektif olarak incelendi.*

Bulgular: *Çalışma süresince toplam 431 hastanın demografik, klinik ve mikrobiyolojik özellikleri tanımlandı. Toplam 333 (%77.3) izolat MSSA ve 98 (%22.7) izolat MRSA olarak saptandı. Antibiyotik kullanım ve hastane yatış süresi MRSA kaynaklı infeksiyonlarda istatistiksel olarak anlamlı düzeyde uzun saptandı. MSSA ve MRSA izolatlarının 17 antimikrobiyal ajana karşı duyarlılıkları değerlendirildi. Penisiline direnç oranı %91, fosfomisine, gentamisine, mupirosine, trimetoprim-sülfametoksazole ve fusidik aside karşı direnç oranları sırasıyla %1.2, %3.2, %2.7, %4.2 ve %8.1 olarak saptandı. Antimikrobiyal duyarlılık testine göre, tüm S. aureus izolatları teikoplanin, vankomisin, linezolid ve tigesikline, duyarlılık testi çalışılan 335 (%77) izolat daptomisine duyarlıydı. 2019 yılında, 2014, 2015,2016 ve 2018 yılları ile karşılaştırıldığında MSSA izolatlarının trimetoprim-sülfametoksazol direncinde istatistiksel olarak anlamlı bir artış tespit edildi (p_1= 0.029 (2014'e karşı 2019); p_2= 0.008 (2015'e karşı 2019); p_3= 0.019 (2016'ya karşı 2019); p_4= 0.032 (2018'e karşı 2019).*

Sonuç: *Cilt ve yumuşak doku infeksiyonlarına neden olan S. aureus izolatlarında MSSA baskınlığı ve çoklu ilaç duyarlılığı saptanmıştır. Oral tedavide, özellikle MSSA suşlarına karşı kullanılan trimetoprim-sülfametoksazole karşı artan direnç dikkat çekmektedir. Bu sonuçlar, çocuklarda S. aureus'un neden olduğu CYDİ'lerin daha iyi yönetilmesinde yol gösterici olabilir.*

Anahtar Kelimeler: *Antimikrobiyal duyarlılık; Cilt yumuşak doku infeksiyonları; Staphylococcus aureus; Çocuklar*

INTRODUCTION

Skin and soft tissue infections (SSTIs) are common bacterial infections associated with significant morbidity and with admission in ambulatory settings, including the emergency department[1,2]. The most common cause of these infections is *Staphylococcus aureus* which colonizes the skin, mouth, and upper respiratory system[3]. Although methicillin-resistant *S. aureus* (MRSA) strains are a main concern for clinicians, methicillin-susceptible *S. aureus* (MSSA) is also very important as they are the most common causative agents of SSTIs in many parts of the world[4,5]. Management of SSTIs has become more challenging with the emergence of resistance to commonly used antibiotics[6].

The epidemiology of skin and soft tissue infections (SSTIs) caused by *S. aureus*, as well as the antimicrobial susceptibility of *S. aureus*, varies based on the patient population and geographic regions[7]. This information is crucial due to the essential role of appropriate empirical therapy in managing these infections. This study evaluated the antimicrobial susceptibility trends of *S. aureus* isolates during a six-year period and the clinical and epidemiological characteristics of SSTIs caused by *S. aureus* (MSSA-MRSA) in children in a tertiary hospital.

MATERIALS and METHODS

Data Collection and Definitions

This retrospective, single-center study examined 431 patients with SSTIs caused by *S. aureus* from a tertiary care hospital in Türkiye. The medical records were obtained from inpatients and outpatients (≤18 years old) with SSTIs between January 2014 and December 2019.

The following demographic, clinical, and microbiological data were collected retrospectively: age, gender, hospital unit, underlying medical conditions, duration of hospital stay, *S. aureus* strains, results of antimicrobial susceptibility testing, and treatment with antibiotics.

Microbiological samples were obtained with a sterile swab from skin lesions or taken from aspirated exudates.

S. aureus Identification and Antimicrobial Susceptibility Testing

A total of 431 non-repetitive *S. aureus* strains were evaluated retrospectively. All isolates were identified by MALDI-TOF MS (VITEK MS). Methicillin susceptibility was verified by cefoxitin disc tests, and antimicrobial susceptibility testing for penicillin, gentamicin, ciprofloxacin, levofloxacin, moxifloxacin, erythromycin, clindamycin, linezolid, teicoplanin, vancomycin, daptomycin, tetracycline, tigecycline, fosfomycin, fusidic acid, trimethoprim/sulfamethoxazole and mupirocin was performed using the VITEK®2 system. The data obtained during the study period were evaluated according to current clinical breakpoints of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines (Version 11.0)[8].

Statistical Analysis

Data were entered into Microsoft Office Excel 2010 (Microsoft, Redmond, WA, USA). The statistical analysis was performed using SPSS version 22.0 (IBM, SPSS). Mean, median, minimum, and maximum values were used as continuous variables. Frequencies and percentages were used to summarize categorical data. The significance of the nonparametric data was assessed using the Mann-Whitney U test. The statistical significance of dichotomous outcomes was determined using the Chi-square test, Fisher's exact test, Fisher Freeman Halton test, and Yates's continuity correction. A p-value of <0.05 was considered statistically significant.

RESULTS

Patient Characteristics

A total of 431 patients with SSTIs caused by *S. aureus* were examined during the six-year study period. Of these, 227 were male (52.7%) and 204 were female (47.3%). The median age was 39 (range, 0-216) months. Almost 30% of the infections (n= 127) occurred in newborns. Wound infection (44.5%) was the most common type of infection, followed by abscess (37.1%). In total, 77 patients (17.9%) had underlying diseases. The most common underlying diseases were neuromuscular diseases in 21 patients and immune deficiency in 11 patients. Overall, 333 (77.3%) patients were infected with MSSA and 98 (22.7%) with MRSA. A comparison of the clinical and epidemiological characteristics and treatment modalities between MSSA and MRSA infections indicated a significantly longer duration of antibiotic therapy and hospitalization in patients with MRSA infections (Table 1).

Antimicrobial Susceptibility Pattern

Antimicrobial susceptibility was evaluated against 17 different antibiotics in MSSA and MRSA isolates obtained from abscess and wound swab cultures. The results revealed full susceptibility of all *S. aureus* isolates to teicoplanin, vancomycin, linezolid, and tigecycline. Additionally, susceptibility to daptomycin was observed in 335 (77%) isolates. The highest resistance (91%) was detected against penicillin. Resistance to fosfomycin, gentamicin, mupirocin, trimethoprim-sulfamethoxazole (TMP/SMX), and fusidic acid was rarely detected (1.2%, 3.2%, 2.7%, 4.2%, and 8.1%, respectively) among the *S. aureus* isolates. The prevalence of resistance to clindamycin and erythromycin was 11.8% and 13%, respectively. In addition, 95.6% of the isolates showed indeterminate susceptibility to ciprofloxacin and 96.7% were indeterminate to levofloxacin. The antimicrobial susceptibility pattern according to the years of isolate collection is shown in Table 2.

A statistically significant increase was detected in resistance of MSSA isolates to trimethoprim-sulfamethoxazole in 2019 compared to 2014, 2015, 2016 and 2018 (p_1= 0.029 (2014 vs. 2019); p_2= 0.008 (2015 vs. 2019); p_3= 0.019 (2016 vs. 2019); p_4= 0.032 (2018 vs. 2019). No statistically significant differences in TMP/SMX susceptibility were observed between the other years (Figure 1A). Antimicrobial susceptibility comparisons for the MSSA isolates between years are shown in Table 3.

Table 1. Clinical and epidemiological characteristics and treatment modalities of patients with *Staphylococcus aureus* (MSSA-MRSA) infections

		S. aureus strains		
Variables		**MSSA**	**MRSA**	
		Median (min-max)	**Median (min-max)**	**p**
Age (months)		48 (0-216)	31 (1-186)	[1]0.098
Hospital stay (day) (mean ± SD)		10.41 ± 6.58 (9)	15.15 ± 10.04 (14)	[1]0.002*
Duration of antibiotic therapy (day) (mean ± SD)		9.13 ± 4.83 (7)	11.64 ± 7.16 (10)	[1]0.000*
White blood cells (/mm^3)		12539.68 ± 6203.33 (11300)	13741.25 ± 7953.37 (12700)	[1]0.147
Granulocytes (/mm^3) median (min-max)		5600 (4800-53400)	5850 (5100-54300)	[1]0.531
		n (%)	**n (%)**	
Age groups	Newborn	95 (28.5%)	32 (32.7%)	[2]0.183
	1-24 months	52 (15.6%)	16 (16.3%)	
	25-144 months	116 (34.8%)	39 (39.8%)	
	145-216 months	70 (21%)	11 (11.2%)	
Gender	Female	159 (47.7%)	45 (45.9%)	[2]0.750
	Male	174 (52.3%)	53 (54.1%)	
Underlying condition	Immune deficiency	9 (2.7%)	2 (2%)	[3]0.731
	Neuro-muscular diseases	14 (4.2%)	7 (7.1%)	
	Other	16 (4.8%)	2 (2%)	
	Congenital heart disease	4 (1.2%)	1 (1%)	
	Diabetes mellitus	4 (1.2%)	0 (0%)	
	Malignancy	6 (1.8%)	2 (2%)	
	Prematurity	3 (0.9%)	1 (1%)	
	Bone fracture	6 (1.8%)	0 (0%)	
Underlying condition	No	271 (81.4%)	83 (84.7%)	[4]0.547
	Yes	62 (18.6%)	15 (15.3%)	
Year	2014	36 (10.8%)	15 (15.3%)	[2]0.214
	2015	84 (25.2%)	20 (20.4%)	
	2016	42 (12.6%)	8 (8.2%)	
	2017	35 (10.5%)	10 (10.2%)	
	2018	78 (23.4%)	19 (19.4%)	
	2019	58 (17.4%)	26 (26.5%)	

Table 1. Clinical and epidemiological characteristics and treatment modalities of patients with *Staphylococcus aureus* (MSSA-MRSA) infections (continue)

Variables		*S. aureus* strains		
		MSSA	MRSA	
		Mean ± SD (median)	Mean ± SD (median)	p
Hospital unit	Outpatient	194 (58.3%)	51 (52%)	[2]0.275
	Inpatient	139 (41.7%)	47 (48%)	
Type of infection	Abscess	118 (%35.4)	42 (42.9%)	[2]0.437
	Cellulitis	36 (10.8%)	6 (6.1%)	
	Paronychia	4 (1.2%)	2 (2%)	
	Wound infection	152 (45.6%)	40 (40.8%)	
	Omphalitis	23 (6.9%)	8 (8.2%)	
C-reactive protein, mg/dL	Negative	141 (%55.5)	47 (58%)	[2]0.691
	Positive	113 (%44.5)	34 (42%)	
Inducible clindamycin resistance	Negative	318 (%95.5)	87 (88.8%)	[4]0.027
	Positive	15 (%4.5)	11 (11.2%)	

[1]: Mann-Whitney U testi [2]: Chi-square test, [3]: Fisher Freeman Halton test, [4]: Yates's continuity correction, *: p< 0.05.

Methicillin-resistant *S. aureus* susceptibility to fosfomycin and gentamicin was significantly lower in 2014 compared to 2015, 2018 and 2019 [p_1= 0.026 (2014 vs. 2015); p_2= 0.029 (2014 vs. 2018); p_3= 0.013 (2014 vs. 2019); and p_1= 0.040 (2014 vs 2015); p_2= 0.011 (2014 vs. 2018); p_3= 0.049 (2014 vs. 2019), respectively]. No statistically significant differences were observed in susceptibility to other antimicrobials between the years (Figure 1B). Antimicrobial susceptibility comparisons for the MRSA isolates between years are shown in Table 4.

DISCUSSION

This study documented the antimicrobial susceptibility pattern and characteristics of 431 SSTIs caused by *S. aureus* in children in Türkiye. Local studies describing epidemiological characteristics and antimicrobial susceptibility patterns of *S. aureus* isolates causing SSTIs are essential for regional treatment guidelines. Information about this issue in children is limited in our country. To our knowledge, this is the first study to determine the antimicrobial susceptibility profile of *S. aureus* isolates causing SSTIs in children in Türkiye.

Although increases in the proportion of community-acquired MRSA infections have been reported in recent years, the strain distributions of *S. aureus* may vary depending on the study population and geographic region[9,10]. In this study, we found that most patients (77.3%) were infected with MSSA. This result is consistent with several epidemiologic studies of high rates of MSSA and/or low rates of MRSA[11-14]. Similar to our study, a recent study by Arikan et al. conducted on hospitalized children in our country reported that 81.8% of 132 *S. aureus* isolates obtained from different clinical specimens were MSSA[15]. Conversely, some studies have reported a higher prevalence of MRSA than MSSA[16-18]. These findings of regional and geographical differences suggest that each region should determine its epidemiological data.

In our study population, 29.5% of the patients were newborns. In accordance with our study, the US Centers for Disease Control and Prevention have also reported a significant prevalence of SSTIs in newborns[19]. Likewise, a cross-sectional descriptive study by Salazar-Ospina et al. reported that 41.4% of the patients with SSTIs were under one year of age[17].

Table 2. The antimicrobial susceptibility pattern of *Staphylococcus aureus* isolates

	2014		2015		2016		2017		2018		2019	
	S	I	S	I	S	I	S	I	S	I	S	I
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Penicillin	4 (7.8%)	_	13 (12.5%)	-	2 (4%)	-	4 (8.9%)	-	11 (11.3%)	-	5 (6%)	-
Gentamycin	46 (90.2%)	-	102 (98.1%)	-	47 (94%)	-	44 (97.8%)	-	97 (100%)	-	81 (96.4%)	-
Ciprofloxacin	-	47 (92.2%)	-	97 (93.3%)	-	48 (96%)	-	44 (97.8%)	-	94 (96.9%)	-	82 (97.6%)
Moxifloxacin	47 (92.2%)	-	42 (93.3%)	-	89 (92.7%)	-	-	-	-	-	-	-
Levofloxacin	-	-	-	56 (94.9%)	-	48 (96%)	-	44 (97.8%)	-	94 (96.9%)	-	82 (97.6%)
Erytromycin	43 (84.3%)	-	88 (84.6%)	-	46 (92%)	-	39 (86.7%)	-	89 (91.8%)	-	70 (83.3%)	-
Clindamycin	43 (84.3%)	-	93 (89.4%)	-	45 (90%)	-	39 (86.7%)	-	86 (88.7%)	-	74 (88.1%)	-
Linezolid	51 (100%)	-	104 (100%)	-	50 (100%)	-	45 (100%)	-	97 (100%)	-	84 (100%)	-
Daptomycin	-	-	59 (100%)	-	50 (100%)	-	45 (100%)	-	97 (100%)	-	84 (100%)	-
Teicoplanin	51 (100%)	-	104 (100%)	-	50 (100%)	-	45 (100%)	-	97 (100%)	-	84 (100%)	-
Vancomycin	51 (100%)	-	104 (100%)	-	50 (100%)	-	45 (100%)	-	97 (100%)	-	84 (100%)	-
Tetracycline	43 (84.3%)	-	97 (93.3%)	-	46 (92%)	-	40 (88.9%)	-	89 (91.8%)	-	73 (86.9%)	-
Tigecycline	51 (100%)	-	104 (100%)	-	50 (100%)	-	45 (100%)	-	97 (100%)	-	84 (100%)	-
Fosfomycin	47 (92.2%)	-	104 (100%)	-	50 (100%)	-	45 (100%)	-	97 (100%)	-	83 (98.8%)	-
Fucidic acid	48 (94.1%)	-	98 (94.2%)	-	47 (94%)	-	40 (88.9%)	-	92 (94.8%)	-	71 (84.5%)	-
TMP/SMX	50 (98%)	0 (0%)	100 (96.2%)	0 (0%)	49 (98%)	1 (2%)	44 (97.8%)	0 (0%)	90 (92.8%)	2 (2.1%)	76 (90.5%)	1 (1.2%)
Mupirocin	-	-	57 (96.6%)	-	49 (98%)	-	45 (100%)	-	96 (99%)	-	79 (94%)	-

S: Susceptibility, I: Indeterminate.

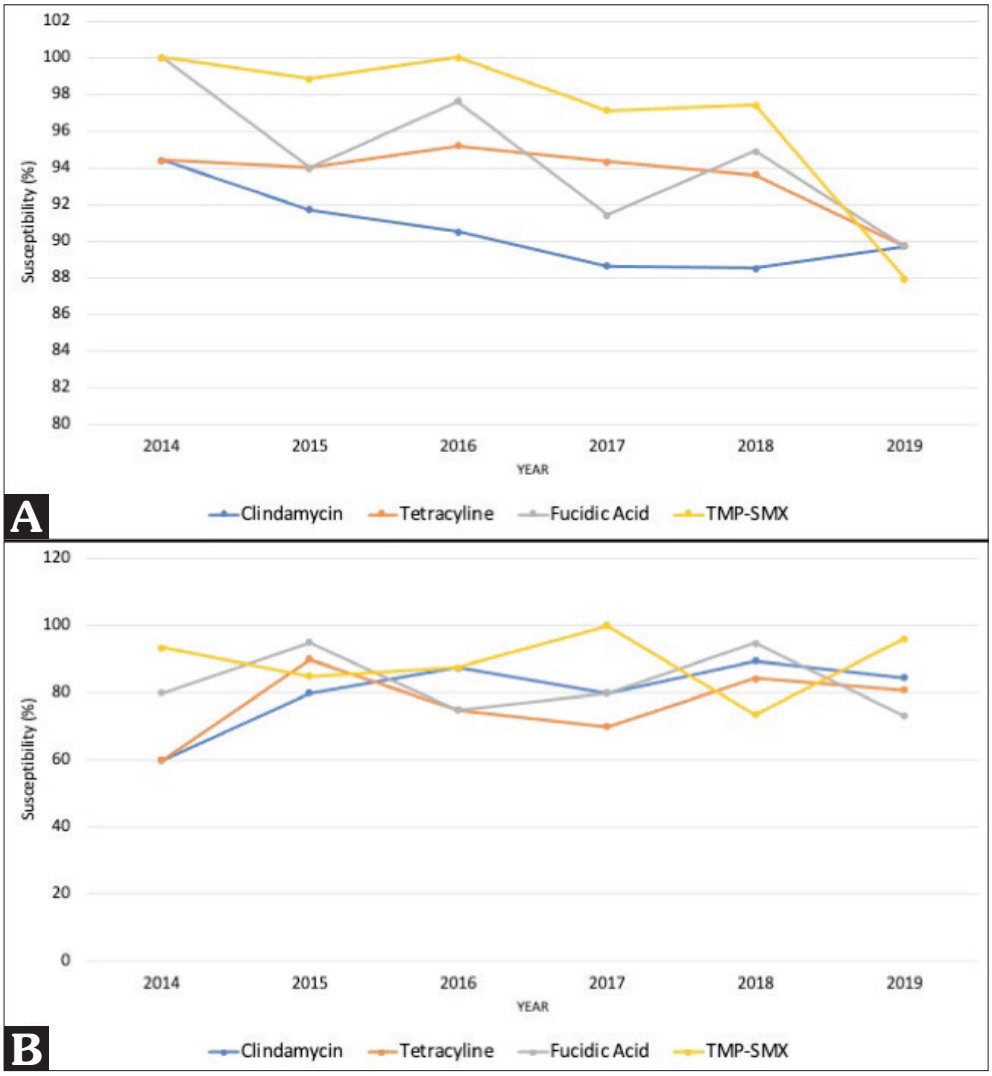

Figure 1. Antimicrobial susceptibility pattern in MSSA and MRSA isolates.

However, other studies that have reported different age groups with different types of *S. aureus* infections have indicated a high prevalence of *S. aureus* infections in children aged between two and five years and between 10 and 17 years[20,21]. The variations in these results may stem from differences in study designs, types of infections, and study populations.

Community-acquired SSTIs caused by MRSA usually occur in young and healthy people but can lead to complications[1]. Community-acquired MRSA infections have also become major public health issues that even affect people without underlying disease[22]. A prospective study by Davis et al. reported longer durations of antibiotic treatment and poorer outcomes in patients with community-acquired MRSA infections than with community-acquired MSSA infections[23]. Similarly, a study by Wang et al., conducted on children with community-acquired SSTIs caused by *S. aureus*, reported a higher hospitalization requirement rate for MRSA infections[10]. Consistent with these studies, we found significantly longer durations of antibiotic treatment and hospitalization in patients with MRSA infections. Therefore, we emphasize that early diagnosis and treatment are crucial for favorable outcomes in complicated SSTIs.

Table 3. Antimicrobial susceptibility comparison in MSSA isolates between years

	2014	2015	2016	2017	2018	2019	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	p
Penicillin	4 (11.1%)	13 (15.5%)	2 (4.8%)	4 (11.4%)	11 (14.1%)	5 (8.6%)	[1]0.551
Gentamycin	36 (100%)	83 (98.8%)	41 (97.6%)	35 (100%)	78 (100%)	57 (98.3%)	[1]0.730
Ciprofloxacin	-	-	-	-	-	-	-
Moxifloxacin	35 (97.2%)	40 (100%)	-	-	-	-	[2]0.474
Levofloxacin	-	-	-	-	-	-	-
Erytromycin	34 (94.4%)	75 (89.3%)	39 (92.9%)	32 (91.4%)	71 (91%)	50 (86.2%)	[1]0.848
Clindamycin	34 (94.4%)	77 (91.7%)	38 (90.5%)	31 (88.6%)	69 (88.5%)	52 (89.7%)	[1]0.937
Linezolid	36 (100%)	84 (100%)	42 (100%)	35 (100%)	78 (100%)	58 (100%)	-
Daptomycin	-	44 (100%)	42 (100%)	35 (100%)	78 (100%)	58 (100%)	-
Teicoplanin	36 (100%)	84 (100%)	42 (100%)	35 (100%)	78 (100%)	58 (100%)	-
Vancomycin	36 (100%)	84 (100%)	42 (100%)	35 (100%)	78 (100%)	58 (100%)	-
Tetracycline	34 (94.4%)	79 (94%)	40 (95.2%)	33 (94.3%)	73 (93.6%)	52 (89.7%)	[1]0.926
Tigecycline	36 (100%)	84 (100%)	42 (100%)	35 (100%)	78 (100%)	58 (100%)	-
Fosfomycin	36 (100%)	84 (100%)	42 (100%)	35 (100%)	78 (100%)	57 (98.3%)	[1]0.514
Fucidic acid	36 (100%)	79 (94%)	41 (97.6%)	32 (91.4%)	74 (94.9%)	52 (89.7%)	[1]0.315
TMP/SMX	36 (100%)	83 (98.8%)	42 (100%)	34 (97.1%)	76 (97.4%)	51 (87.9%)	[1]0.010*
Mupirocin	-	43 (97.7%)	41 (97.6%)	35 (100%)	77 (98.7%)	54 (93.1%)	[1]0.331

[1]: Fisher Freeman Halton test, [2]: Fisher's exact test, *: p< 0.05.

Understanding the local antimicrobial susceptibility profile is crucial for initiating appropriate empirical treatment and ensuring the successful management of suspected or confirmed SSTIs caused by *S. aureus*. Many studies have shown a very high resistance rate of *S. aureus* isolates to penicillin, as in the present study[15,24,25]. This result may be attributed to the extensive use of antibiotics such as penicillin, amoxicillin, and oxacillin, suggesting that penicillin is not suitable for treating SSTIs in children.

Most of the *S. aureus* strains isolated in the present study showed high susceptibility to fosfomycin, gentamicin, mupirocin, TMP/SMX, and fusidic acid. A commentary by Kaplan noted that *S. aureus* isolates were highly susceptible to TMP/SMX, with a >98% susceptibility rate[26]. A retrospective study by Hsiao et al., conducted on adults and children with abscesses caused by *S. aureus*, found that all isolates had a high susceptibility to TMP/SMX, tetracycline, gentamicin, and rifampin[18]. Previous studies conducted on children with atopic dermatitis have also reported that TMP/SMX, rifampin, fusidic acid, and mupirocin were highly effective against *S. aureus* isolates[27,28]. Although TMP/SMX susceptibility was high in our study, the trends in the last two years of the study have shown a decrease in TMP/SMX susceptibility among MSSA isolates. The wide use of TMP/SMX empirically or therapeutically may be contributing to this increased resistance. These findings indicate that TMP/SMX, fusidic acid, and mupirocin remain good treatment options for SSTIs but that caution is needed with TMP/SMX use.

Susceptibility rates to clindamycin have varied in different epidemiologic studies. While many studies have reported resistance rates of less than 10%, others have shown rates exceeding 30% to 50% for clindamycin resistance[29,30]. The *S. aureus* isolates in our study showed a clindamycin resistance rate of 88.2% throughout the study period.

Table 4. Antimicrobial susceptibility comparison in MRSA isolates between years

	2014	2015	2016	2017	2018	2019	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	p
Penicillin	-	-	-	-	-	-	-
Gentamycin	10 (66.7%)	19 (95%)	6 (75%)	9 (90%)	19 (100%)	24 (92.3%)	[1]0.024*
Ciprofloxacin	-	-	-	-	-	-	-
Moxifloxacin	12 (80%)	2 (40%)	-	-	-	-	[2]0.131
Levofloxacin	-	-	-	-	-	-	-
Erytromycin	9 (60%)	13 (65%)	7 (87.5%)	7 (70%)	18 (94.7%)	20 (76.9%)	[1]0.137
Clindamycin	9 (60%)	16 (80%)	7 (87.5%)	8 (80%)	17 (89.5%)	22 (84.6%)	[1]0.417
Linezolid	15 (100%)	20 (100%)	8 (100%)	10 (100%)	19 (100%)	26 (100%)	-
Daptomycin	-	15 (100%)	8 (100%)	10 (100%)	19 (100%)	26 (100%)	-
Teicoplanin	15 (100%)	20 (100%)	8 (100%)	10 (100%)	19 (100%)	26 (100%)	-
Vancomycin	15 (100%)	20 (100%)	8 (100%)	10 (100%)	19 (100%)	26 (100%)	-
Tetracycline	9 (60%)	18 (90%)	6 (75%)	7 (70%)	16 (84.2%)	21 (80.8%)	[1]0.345
Tigecycline	15 (100%)	20 (100%)	8 (100%)	10 (100%)	19 (100%)	26 (100%)	-
Fosfomycin	11 (73.3%)	20 (100%)	8 (100%)	10 (100%)	19 (100%)	26 (100%)	[1]0.002*
Fucidic acid	12 (80%)	19 (95%)	6 (75%)	8 (80%)	18 (94.7%)	19 (73.1%)	[1]0.210
TMP/SMX	14 (93.3%)	17 (85%)	7 (87.5%)	10 (100%)	14 (73.7%)	25 (96.2%)	[3]0.230
Mupirocin	-	14 (93.3%)	8 (100%)	10 (100%)	19 (100%)	25 (96.2%)	[1]0.835

[1]: Fisher Freeman Halton test, [2]: Fisher's exact test, [3]: Chi-square test, *: p< 0.05.

Many studies have shown low resistance rates for vancomycin and linezolid in *S. aureus* isolates[1,5,14]. Consistent with these reports, we found that all the *S. aureus* isolates in our study were fully susceptible to teicoplanin, vancomycin, and linezolid. Therefore, vancomycin and teicoplanin can still be considered first-line agents, for suspected MRSA infections, until different antibiotic susceptibility results emerge.

Fluoroquinolones are not commonly used in SSTIs caused by *S. aureus* because of reports showing high resistance rates[13,18]. We also found that most of our *S. aureus* isolates showed intermediate resistance to ciprofloxacin and levofloxacin. This can be explained by the evolving definition of susceptible categories by EUCAST. The current susceptibility criteria for ciprofloxacin now categorize it as intermediate.

Consistent with previous studies, our findings indicate a low level of resistance to gentamicin[13,18]. Additionally, we observed low MRSA resistance to gentamicin. This result may be explained by the fact that it is not a commonly preferred antibiotic in children.

This study had some limitations, including its retrospective and single-center design. Additionally, it's worth noting that microbiological samples obtained with a skin swab may not provide sufficient distinction between infection and colonization.

CONCLUSION

This study demonstrated that MSSA remains the predominant strain responsible for SSTIs in children in our center. The antimicrobial susceptibility results in our study indicate that TMP/SMX, fusidic acid, mupirocin, clindamycin, teicoplanin, vancomycin, and linezolid can still be used to treat SSTIs caused by both MSSA and MRSA. Local epidemiological data determining antimicrobial susceptibility patterns are essential for optimizing appropriate empirical antibiotherapy. We consider our findings beneficial for informing policies regarding the

clinical management of SSTIs, including the development of appropriate empirical antibiotic regimens, through the provision of local susceptibility patterns. Moreover, our study has contributed regional epidemiological information for future studies.

ETHICS COMMITTEE APPROVAL

This study was approved by the Marmara University Clinical Research Ethics Committee (Decision no: 09.2020.748, Date: 24.07.2020).

CONFLICT of INTEREST

The authors have no conflicts of interest to declare that are relevant to the content of this article.

AUTHORSHIP CONTRIBUTIONS

Concept and Design: NY, EK, ES

Analysis/Interpretation: SB, İA

Data Collection or Processing: ZE, ES

Writing: NY, ES

Review and Correction: EK Aİ

Final Approval: All of authors

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