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Prevalence and Antimicrobial Resistance Trends of *Staphylococcus aureus* in a University Hospital: A 6.5-Year Retrospective Analysis

Bir Üniversite Hastanesinde *Staphylococcus aureus* Prevelansı ve Antimikrobiyal Direncin Değişimi: 6.5 Yıllık Retrospektif Bir Analiz

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Abstract

Introduction: *Staphylococcus aureus* is a major pathogen causing infections in both community and hospital settings. Surveillance of this organism is essential for effective planning of preventive strategies. This study aimed to evaluate changes in the isolation frequency and antimicrobial resistance patterns of *Staphylococcus aureus* strains in a university hospital over recent years.

Materials and Methods: In this retrospective cross-sectional study, data on *Staphylococcus aureus* strains isolated at İnönü University Faculty of Medicine Hospital between January 2019 and June 2025 were collected. Demographic information of patients and antimicrobial resistance profiles of the isolates were analyzed. Changes in strain prevalence and resistance rates over the years were assessed using linear regression analysis.

Results: A total of 3,514 *Staphylococcus aureus* strains were examined, including 861 (24.5%) community-acquired and 2653 (75.5%) hospital-acquired. The median prevalence of *Staphylococcus aureus* among all cultures was 9.96%, showing a nonsignificant variation from 9.2% to 11.57% over the study period. Comparison of pre- and post-pandemic periods revealed a significant increase in hospital-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) ($p < 0.05$), whereas changes in community-acquired MRSA were not significant. Among hospital isolates, methicillin resistance approximately doubled, whereas no significant change was observed in community-acquired strains. Methicillin-resistant strains exhibited two- to seven-fold higher resistance to several antimicrobials, including quinolones, aminoglycosides, macrolides, and co-trimoxazole, compared to methicillin-susceptible strains. During the study period, resistance to amikacin, gentamicin, and erythromycin significantly decreased, while resistance to tetracycline and clindamycin increased.

Conclusion: Although the overall prevalence of *Staphylococcus aureus* remained stable, methicillin resistance increased steadily, particularly in hospital-acquired strains. Targeted strategies to control these highly resistant strains should be a priority.

Keywords: *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus*, methicillin-susceptible *Staphylococcus aureus*, antimicrobial resistance, trend analysis

Öz

Giriş: *Staphylococcus aureus*, hem toplum hem de hastanede enfeksiyona neden olan başlıca patojenlerden biridir. Bu etkene ait sürveyans verilerinin analizi, önleyici girişimlerin doğru planlanması adına önemlidir. Bu çalışmada bir üniversite hastanesinde *Staphylococcus aureus* suşlarının izolasyon sıklığının ve antimikrobiyal direnç özelliğinin son yıllarda bir değişim gösterip-göstermediğinin saptanması amaçlanmıştır.

Gereç ve Yöntem: Bu kesitsel çalışmada, İnönü Üniversitesi Tıp Fakültesi Hastanesi'nde, Ocak 2019 ile Haziran 2025 tarihleri arasında izole edilen *Staphylococcus aureus* suşlarına ait veriler geriye dönük olarak toplandı. Suşların saptandığı hastaların demografik bilgileri ve izolatların antimikrobiyal direnç özellikleri çalışma kapsamında değerlendirildi. Yıllara göre suş ve direnç frekansındaki değişimler doğrusal regresyon ve eğilim analizi ile araştırıldı.

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Öz

Bulgular: Çalışmada, 861'i (%24,5) toplum kaynaklı ve 2653'ü (%75,5) hastane kaynaklı enfeksiyon etkeni olarak değerlendirilen toplam 3514 *Staphylococcus aureus* suşu incelendi. Tüm üremeler arasında *Staphylococcus aureus*'un ortanca prevalansı %9,96 idi ve yıllar içinde %9,2–11,57 arasında istatistiksel olarak anlamlı olmayan bir değişim gösterdi. Pandemi öncesi ve sonrası dönemler karşılaştırıldığında; hastane kaynaklı metisilin dirençli *Staphylococcus aureus* (MRSA) oranlarında anlamlı bir artış saptanırken ($p < 0,05$), toplum kaynaklı MRSA oranlarında anlamlı bir değişiklik gözlenmedi. Hastane izolatları arasında metisilin direnç oranı, çalışma süresince yaklaşık iki kat olmak üzere anlamlı artış gösterirken toplum kökenli suşlardaki artış anlamlı bulunmadı. Metisilin dirençli suşlarda, metisilin-duyarlılara göre kinolonlar, aminoglikozitler, makrolidler ve ko-trimoksazol başta olmak üzere birçok antimikrobiyale karşı anlamlı olarak iki ila yedi kat daha fazla direnç saptandı. Çalışma süresince amikasin, gentamisin ve eritromisin direnci anlamlı azalış gösterirken tetrasiklin ve klindamisin direncinde anlamlı artış bulundu.

Sonuç: Saptanan veriler, *Staphylococcus aureus*'un prevalansında önemli bir değişim olmadığını ancak metisilin direncinin özellikle hastane kökenli suşlarda düzenli bir artış trendi göstererek yükseldiğini ortaya koymuştur. Birçok antibiyotiğe karşı daha yüksek direnç taşıyan bu suşların kontrol altına alınması öncelikli hedeflerden biri olmalıdır.

Anahtar Kelimeler: *Staphylococcus aureus*, metisiline dirençli *Staphylococcus aureus*, metisiline duyarlı *Staphylococcus aureus*, antimikrobiyal direnç, trend analizi.

Introduction

Staphylococcus aureus is an aerobic, gram-positive coccus, testing positive for catalase and coagulase. In humans, it colonizes many body sites, primarily the nose and skin. Through its capsule, cell wall components, and numerous lytic enzymes and toxins, it can cause rapidly developing invasive infections with significant tissue damage under appropriate conditions. Therefore, it can infect multiple parts of the human body in all age groups and both sexes, and unlike many opportunistic hospital pathogens, it is also an important infectious agent in healthy individuals[1].

Staphylococcus aureus is one of the pathogens that can cause infections both in the community and in hospitals. Studies report that it accounts for 7.7%–17.8% of community-acquired bloodstream infections[2] and approximately three-quarters of skin and soft tissue infections[3]. A multicenter prospective study indicated that *Staphylococcus aureus* infections occur more frequently in patients, especially in surgical departments, wound care units, burn and trauma units, and intensive care units; it is responsible for over 10% of hospital-acquired sepsis cases and is the most frequently isolated pathogen in bone and soft tissue infections[4].

Methicillin-resistant *Staphylococcus aureus* (MRSA) significantly limits treatment options and increases morbidity and mortality in life-threatening infections. MRSA bacteremia has been found to result in approximately twice the mortality of methicillin-susceptible *Staphylococcus aureus* (MSSA) bacteremia[5]. MRSA infections are also associated with a 6–14 day longer hospital stay and an additional cost of USD 3,200–9,600 per patient compared with MSSA infections[6]. To control MRSA and other *Staphylococcus aureus* strains in hospitals, interventions such as hand hygiene, wound and catheter care bundles, antimicrobial stewardship, and the use of rapid laboratory diagnostics have been implemented[7]. Following these measures, a considerable decrease in *Staphylococcus aureus* infections has been observed. For instance, an analysis of 130 hospitals in the United States reported a 43% decrease in all *Staphylococcus aureus* infections between 2005 and 2017, more pronounced for MRSA than MSSA[8]. Later studies reported that hospital-acquired MRSA bloodstream infections decreased by 17% annually, especially between 2005 and 2012; however, this rate slowed during 2013–2016, and a slight increase was observed in MSSA infections[9].

However, in recent years, especially in our country, limited data have been published on changes in the frequency of *Staphylococcus aureus* isolation and resistance rates. Moreover, the Coronavirus Disease 2019 (COVID-19) pandemic, which began in March 2020 and lasted at least two years, caused significant changes in community health practices and hospital services, but there is little information on its impact on *Staphylococcus aureus*. Recent reports suggest that the pandemic influenced both the incidence and resistance patterns of *Staphylococcus aureus*, with some studies reporting shifts in detection rates and MRSA proportions[10,11].

This study aimed to investigate the isolation and antimicrobial resistance frequencies of *Staphylococcus aureus* strains in a university hospital over the past 6.5 years, interpret the findings in the context of current scientific evidence, and discuss possible contributing factors.

Materials and Methods

Study Design and Data Collection

This study was retrospectively planned and conducted at İnönü University Turgut Özal Medical Center, a tertiary care hospital with 1,585 beds. In this cross-sectional study, *Staphylococcus aureus* strains isolated from various clinical samples between

January 1, 2019, and June 1, 2025, were analyzed. Demographic characteristics of the patients, including age and gender, type of clinical sample, and isolate-related data, were collected from the hospital information system.

Considering the patient's hospital admission date, isolates from samples collected ≥48 hours after admission were classified as hospital-acquired, while strains isolated from outpatient samples or from clinical samples collected within <48 hours of admission were classified as community-acquired. For repeated growth from the same clinical sample of a patient, only one isolate was included. If *Staphylococcus aureus* growth occurred in different clinical samples from the same patient, one isolate per sample was included. For each study year, the total number of microorganisms grown in laboratory cultures was determined, and the proportional frequency of *Staphylococcus aureus* strains among total isolates was calculated.

Laboratory Tests: Culture, Identification, and Susceptibility

Clinical samples were inoculated onto appropriate culture media, primarily 5% sheep blood agar and eosin methylene blue agar, and incubated aerobically at 35 °C. Colonies suspected to be *Staphylococcus aureus* were identified based on colony morphology, Gram staining, catalase, and coagulase tests, and confirmed using the Vitek MS (bioMérieux, France) matrix-assisted laser desorption/ionization time-of-flight mass spectrometry system.

Susceptibility of the isolates to penicillin, cefoxitin, erythromycin, clindamycin, ciprofloxacin, levofloxacin, trimethoprim-sulfamethoxazole, tetracycline, amikacin, gentamicin, rifampin, vancomycin, and linezolid was tested using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar (Condalab, Spain). When necessary, minimal inhibitory concentrations were determined using the VITEK 2 automated identification and susceptibility system with GP-664 antimicrobial susceptibility cards (bioMérieux, France), the broth microdilution method, or E-test strips (Bioanalyse, Türkiye). In total, 1210 isolates (mainly from intensive care unit patients) were tested using VITEK 2 cards, 314 isolates using E-tests, and 72 isolates using broth microdilution, primarily for vancomycin and linezolid. All susceptibility tests were performed and interpreted according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) criteria[12]. During the study period, the *Staphylococcus aureus* ATCC 29213 strain was used as a control for susceptibility testing.

Methicillin resistance of *Staphylococcus aureus* isolates was determined using a 30 µg cefoxitin disk (Bioanalyse, Türkiye) according to EUCAST guidelines. Isolates with a cefoxitin inhibition zone diameter <22 mm were classified as MRSA, and those with ≥22 mm were classified as MSSA[12].

Statistical Analysis

Categorical data are presented as numbers and percentages. Data analysis was performed using SPSS Statistics (version 20.0, IBM, Chicago, IL, USA). Descriptive statistics were calculated for demographic and clinical variables. The Pearson chi-square test was used to compare categorical variables. Temporal trends in MRSA prevalence and antimicrobial resistance rates were assessed using simple linear regression models. A p-value <0.05 was considered statistically significant.

Results

A total of 3,514 *Staphylococcus aureus* isolates obtained from various clinical samples between January 1, 2019, and June 1, 2025, were examined. Of these, 861 (24.5%) were classified as community-acquired and 2,653 (75.5%) as hospital-acquired. Community-acquired isolates were most frequent in 2024 (160 strains), while hospital-acquired isolates peaked in 2021 (521 strains).

Community-acquired strains were most frequently isolated from wound samples (394 isolates, 45.8%), whereas hospital-acquired strains were most commonly isolated from sputum and lower respiratory tract samples (830 isolates). The numerical distribution of *Staphylococcus aureus* strains by year and clinical sample type is presented in Table 1.

According to susceptibility data, 1,072 (30.5%) of the studied strains were identified as MRSA and 2442 (69.5%) as MSSA. Among community-acquired *Staphylococcus aureus* strains, 234 (27.2%) were MRSA, whereas among hospital-acquired strains, 838 (31.6%) were MRSA; the difference was not statistically significant. Comparison of pre- and post-pandemic periods showed a statistically significant increase in hospital-acquired MRSA strains ($p < 0.05$), whereas no significant change was observed in community-acquired MRSA strains.

As illustrated in Figures 1A and 1B, yearly fluctuations in MRSA and MSSA proportions were observed. Statistical analysis revealed a significant increasing trend for hospital-acquired MRSA ($p < 0.05$), while yearly changes in community-acquired MRSA were not statistically significant. Linear regression analysis confirmed a significant annual increase in hospital-acquired MRSA rates ($p < 0.05$).

Among all *Staphylococcus aureus* isolates (excluding vancomycin and linezolid), the highest susceptibility was observed for amikacin (96.6%), while the highest resistance was seen for penicillin (90.1%). Resistance to all tested antibiotics was significantly higher in MRSA strains compared to MSSA. Specifically, rifampin resistance was higher in community-acquired MRSA strains, levofloxacin resistance was higher in

hospital-acquired MSSA strains, and gentamicin resistance was higher in hospital-acquired MRSA strains.

The comparison of resistance characteristics of *Staphylococcus aureus* strains according to hospital- and community-acquired MRSA and MSSA status is presented in Table 2. Trend analysis (Table 3) showed significant decreases in resistance to amikacin (MRSA, p = 0.02), gentamicin (MRSA, p = 0.02; MSSA, p = 0.04), and erythromycin (MRSA, p = 0.01; MSSA, p = 0.03), while significant increases were observed for tetracycline (MSSA, p = 0.01) and clindamycin (MSSA, p = 0.01). No significant yearly changes were detected for ciprofloxacin, levofloxacin, rifampin, trimethoprim-sulfamethoxazole, or penicillin (all p > 0.05). When pre- and post-pandemic periods were compared, hospital-acquired MRSA strains showed a significant increase (p < 0.05), whereas antibiotic susceptibilities for most agents did not change significantly (p > 0.05).

Table 1. Distribution of *Staphylococcus aureus* strains by year and clinical sample type.

Year		Sample type, n (%)						Total
		Abscess	Urine	Blood	Wound	Sputum	Other	
2019	CA	17 (12.3%)	23 (16.7%)	21 (15.2%)	61 (44.2%)	7 (5%)	9	138
	HA	44 (13.8%)	17 (5.3%)	70 (22%)	64 (20%)	102 (32%)	22	319
2020	CA	16 (20.5%)	14 (18%)	6 (7.7%)	39 (50%)	1 (1.3%)	2	78
	HA	43 (12.2%)	13 (3.7%)	92 (26.1%)	64 (18.2%)	107 (30.4%)	33	352
2021	CA	9 (6%)	51 (34.2%)	13 (8.7%)	62 (41.6%)	4 (2.7%)	10	149
	HA	42 (8%)	36 (6.9%)	112 (21.5%)	117 (22.5%)	176 (33.8%)	38	521
2022	CA	8 (6.3%)	40 (31.7%)	12 (9.5%)	58 (46%)	1 (0.8%)	7	126
	HA	33 (7.4%)	31 (6.9%)	89 (19.9%)	129 (28.9%)	123 (27.5%)	42	447
2023	CA	7 (5.8%)	38 (31.4%)	10 (8.3%)	57 (47.1%)	6 (5%)	3	121
	HA	35 (8.8%)	29 (7.3%)	90 (22.5%)	81 (20.3%)	134 (33.5%)	31	400
2024	CA	11 (6.9%)	42 (26.3%)	18 (11.3%)	85 (53%)	1 (0.6%)	3	160
	HA	30 (6.7%)	34 (7.6%)	107 (23.9%)	117 (26.1%)	130 (29%)	30	448
2025	CA	4 (4.5%)	25 (28.1%)	10 (11.3%)	32 (36%)	1 (1.1%)	17	89
	HA	10 (6%)	9 (5.4%)	35 (21.1%)	46 (27.7%)	58 (35%)	8	166

CA, community-acquired; HA, hospital-acquired.

Table 2. Comparison of resistance characteristics of *Staphylococcus aureus* strains to tested antibiotics according to hospital- or community-acquired status and MRSA/MSSA classification.

Antibiotic	Hospital-acquired		Community-acquired		p	Total MRSA	Total MSSA	p
	MRSA	MSSA	MRSA	MSSA				
AK	7.3	1.7	8.5	1.8	>0.05	7.5	1.7	**<0.001**
GN	15.2	4.5	9.2	6	**0.038**	14	4.8	**0.002**
CIP	26.5	8.4	27.3	10.4	>0.05	26.7	8.9	**<0.001**
LEV	4.9	1.7	7.7	1.3	>0.05	5.6	1.6	**<0.001**
TE	41	6	38.7	7.3	>0.05	40.6	6.4	**<0.001**
RIF	14.3	5.3	22.6	7.2	**0.033**	16	6	**0.009**
SXT	10.5	1.5	14.5	2.1	>0.05	10.9	1.6	**0.001**
DA	43.5	13	40	14.4	>0.05	42.7	13.4	**0.022**
E	50.1	14.7	43.2	14.9	>0.05	48.6	14.6	**0.014**
P	100	83.8	100	81.3		100	83.2	

In the table, resistance rates of hospital-acquired MRSA strains were compared with those of community-acquired MRSA strains, and resistance rates of hospital-acquired MSSA strains were compared with those of community-acquired MSSA strains. On the right side of the table, total resistance rates for MRSA and MSSA strains are shown. Statistically significant differences are indicated in bold. Since all MRSA strains were resistant to penicillin, a statistical comparison between MRSA and MSSA for penicillin was not performed. Statistical analysis was performed using the Pearson chi-square test; p < 0.05 was considered significant. AK, amikacin; CIP, ciprofloxacin; DA, clindamycin; E, erythromycin; GN, gentamicin; LEV, levofloxacin; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible; P, penicillin; RIF, rifampin; SXT, trimethoprim-sulfamethoxazole; TE, tetracycline.

Trend analysis of the isolation and resistance patterns of *Staphylococcus aureus* over the study period showed that its frequency among all culture isolates ranged from 9.2% to 11.57%, without a statistically significant change. Although methicillin resistance increased among community-acquired isolates, this trend was not statistically significant. In contrast, the increase in hospital-acquired MRSA frequency was statistically significant. Yearly changes in community- and hospital-acquired MRSA and MSSA strains during the study period are shown in Figure 1.

In community-acquired isolates, methicillin resistance decreased in 2021 and 2022 compared with the previous two years, but increased approximately twofold over the following three years. However, this increase was not statistically significant when the entire study period was considered ($p > 0.05$). In hospital-acquired isolates, the MRSA rate showed a significant increasing trend with an almost linear yearly increase.

Trend analysis of susceptibility to the tested antimicrobials by year revealed that resistance to amikacin in MRSA strains, and to gentamicin and erythromycin in both MRSA and MSSA strains, significantly decreased. In contrast, resistance to tetracycline and clindamycin significantly increased in MSSA strains. Detailed trend analysis data for changes in antibiotic resistance during the study period are presented in Table 3.

Table 3. Annual trends of antibiotic resistance rates in MRSA and MSSA isolates (2019–2025).

Antibiotic	Strain	Slope (trend)	R- squared	p
AK	MRSA	−1.733	0.684	0.02
	MSSA	−0.245	0.21	0.30
GN	MRSA	−3.284	0.663	0.02
	MSSA	−1.196	0.592	0.04
CIP	MRSA	−0.074	0.001	0.95
	MSSA	0.055	0.003	0.91
The LEV	MRSA	−0.944	0.4	0.3
	MSSA	−0.873	0.326	0.18
TE	MRSA	0.243	0.003	0.91
	MSSA	0.6	0.762	0.01
RIF	MRSA	−3.008	0.467	0.09
	MSSA	−0.652	0.552	0.06
STX	MRSA	−0.481	0.058	0.60
	MSSA	0.247	0.279	0.22
DA	MRSA	−1.588	0.213	0.30
	MSSA	1.174	0.764	0.01
E	MRSA	−7.83	0.738	0.01
	MSSA	−1.618	0.607	0.03
P	MRSA	−6.487	0.474	0.09
	MSSA	−5.574	0.525	0.07

AK, amikacin; GN, gentamicin; CIP, ciprofloxacin; LEV, levofloxacin; TE, tetracycline; RIF, rifampin; SXT, trimethoprim-sulfamethoxazole; DA, clindamycin; E, erythromycin; P, penicillin; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *Staphylococcus aureus*.

Discussion

Until the early 2000s, *Staphylococcus aureus* was considered the second most common pathogen in hospital infections after *Escherichia coli* and the most frequently identified pathogen in community-acquired sepsis and soft tissue infections[13]. In a 2004 study conducted at a university hospital in our country, *Staphylococcus aureus* was reported as the most common pathogen among both community- and hospital-acquired bloodstream infections[14]. Similarly, in a 2003 study in the intensive care units of a training and research hospital, it was identified as the most frequently isolated pathogen in all clinical samples[15].

However, since the mid-2000s, significant declines in the incidence of this pathogen have been recorded, particularly in hospitals in developed countries, due to the implementation of targeted infection control measures. Following the enactment of the "Infection Control Regulation for Inpatient Treatment Institutions" in 2005 in Türkiye, measures such as hand hygiene, patient, wound, and catheter care practices, prospective active surveillance, pathogen screening, isolation of carriers, standardization of disinfection and sterilization procedures, measures to prevent microbial spread, and appropriate antimicrobial use have led to a several-fold reduction in hospital infection rates[16]. These measures have been particularly effective against *Staphylococcus aureus*. In a nine-year surveillance analysis conducted in the intensive care units of a university hospital in Türkiye, the rate of *Staphylococcus aureus* decreased from 11% in 2007 to 3.2% in 2015[17].

Conversely, recent studies from some countries have shown that *Staphylococcus aureus* has exhibited an increasing trend, particularly after 2015. This rise has been associated with an increasing number of patients with multiple risk factors and comorbidities[10,18].

The findings of our study revealed that the incidence of *Staphylococcus aureus* remained stable at approximately 9%–11.5% over the last 6.5 years, showing no significant change in overall isolation. Although this study does not cover as long a period as the studies mentioned above, it provides important data showing that the isolation frequency of *Staphylococcus aureus* in a tertiary regional hospital has fluctuated within a narrow range since 2019, without a clear trend of increase or decrease.

In our study, more than half (54%) of community-acquired *Staphylococcus aureus* strains were isolated from wound and



Figure 1. Changes in methicillin resistance over the years in community-acquired (a) and hospital-acquired (b) *Staphylococcus aureus* strains. MRSA, methicillin-resistant *Staphylococcus* aureus; MSSA, methicillin-susceptible *Staphylococcus aureus*.

abscess cultures, and 10.5% were isolated from blood cultures. Among hospital-acquired isolates, approximately 55% were from these three clinical sample types. Additionally, about 27% of community-acquired isolates were obtained from urine, while more than 30% of hospital-acquired strains were isolated from sputum and lower respiratory tract samples. These findings indicate that at least 90% of community-acquired *Staphylococcus aureus* isolates originated from wound, abscess, blood, and urine, whereas more than 85% of hospital-acquired isolates were from wound, abscess, blood, and respiratory tract samples.

These data highlight unique features of *Staphylococcus aureus* in infection pathogenesis, such as its presence in multiple body sites, primarily the hands, skin, and nose, facilitating access to sterile sites when tissue integrity is compromised. Through its capsule, polysaccharide A, lipoteichoic acid, coagulase, staphylokinase, hyaluronidase, hemolysins, leukocidins, and other virulence factors, *Staphylococcus aureus* can rapidly accomplish colonization, infection, and invasion processes[19].

Although *Staphylococcus aureus* shares important similarities with *Escherichia coli*, one of the most common human pathogens, in terms of adaptation to commensal life in the human body and its broad repertoire of virulence and pathogenicity factors, it remains a unique pathogen with a much wider spectrum of infections. This bacterium, an important outbreak pathogen in hospitals, can also spread efficiently among individuals in the community. In a study conducted in the United States, prior antibiotic treatment was identified as the only independent risk factor associated with *Staphylococcus aureus* colonization of household members and surfaces. The study reported that if a household member carried *Staphylococcus aureus*, the same strain was found in nearly half of the other household members[20]. Therefore, for measures aiming to control this pathogen in both the community and hospitals to be successful, such characteristics must be taken into consideration.

The second key aspect investigated in this study was the level of resistance of *Staphylococcus aureus*, particularly to methicillin and other antimicrobial agents, and whether these resistance characteristics changed over the study period. Our data showed that the frequency of MRSA among the isolates was approximately 30%. Although methicillin resistance in community-acquired isolates increased in a fluctuating pattern from 2019 to 2025, this increase was not statistically significant. In contrast, methicillin resistance in hospital-acquired isolates showed a statistically significant increase of more than twofold, following an almost linear trend.

This steady increase over the 6.5-year study period is a concerning finding, indicating the need to review antibiotic usage practices that may influence the selection of MRSA strains in our hospital as well as to implement strategies for monitoring resistant strains and preventing their spread. To determine whether this increase is specific to our hospital or reflects a national-level trend, further studies are required in our country. Future investigations should be conducted comprehensively to assess the impact of MRSA-related infections on patient survival, morbidity, and hospital costs. Such studies will provide an accurate estimate of the burden imposed by these strains on the healthcare system and guide preventive efforts and collaborations on a national scale.

In our study, gentamicin resistance was significantly higher in hospital-acquired MRSA strains compared with community-acquired MRSA strains, whereas rifampin resistance was significantly higher in community-acquired MRSA strains than in hospital-acquired strains. This pattern is most likely related to differences in the intensity and type of antibiotic use in the community versus hospitals. Overall susceptibility data showed that resistance rates of *Staphylococcus aureus* strains were more strongly associated with methicillin resistance than with whether the strain was hospital- or community-acquired. Indeed, methicillin-resistant strains exhibited approximately two- to seven-fold higher resistance than methicillin-susceptible strains across all tested antibiotics. These findings indicate that methicillin resistance in *Staphylococcus aureus*

is not only a marker for beta-lactam resistance but also an important indicator of multidrug resistance.

Quinolones are indispensable drugs because of their broad gram-positive and gram-negative coverage, activity against aerobic and anaerobic bacteria, effective distribution to many body sites—particularly the respiratory and urinary tracts—availability for oral and parenteral administration, and low incidence of side effects. The quinolone resistance observed in our study appears relatively high compared with 2023 European surveillance data, which also follow EUCAST criteria[21]. In a four-year analysis of intensive care isolates from a university hospital near our region, the greatest increases in resistance were reported for ciprofloxacin and levofloxacin[22]. These findings underscore the need for more selective use of quinolones in both hospitals and the community as well as careful attention to susceptibility results.

In our study, amikacin and co-trimoxazole were identified as the two most effective antimicrobials against all isolates, regardless of whether they were hospital- or community-acquired, or methicillin-resistant or susceptible. The preserved efficacy of amikacin may be related to its parenteral administration and its use typically in combination therapy, which likely limited overuse. However, the high effectiveness of co-trimoxazole, despite the absence of such limiting factors, is notable. It is likely that relatively high resistance to this drug among gram-negative pathogens has led to its reduced overall use, thereby preserving its activity against species such as *Staphylococcus aureus*.

Our country has long faced a growing problem of antimicrobial resistance to last-resort drugs in gram-negative pathogens[23–25]. One major contributing factor is the higher overall use of antimicrobial drugs compared with many other countries worldwide[26]. When the susceptibility data for *Staphylococcus aureus* from our study are compared with resistance patterns in gram-negative pathogens, they appear relatively more favorable. Although the dynamics of antimicrobial resistance differ substantially between gram-negative and gram-positive bacteria, analyzing the relatively low (<20%) resistance observed for many antibiotics in *Staphylococcus aureus* and understanding its components may provide useful insights for addressing the longstanding issue of excessive resistance in gram-negative pathogens.

Our study also includes data from the period affected by the COVID-19 pandemic, which lasted for two years starting in March 2020 in our country. During this time, measures aimed at reducing pathogen transmission in the community—such as social distancing, curfews, mask use, and hand hygiene—were widely implemented. Concurrently, hospitals experienced an increased population of severely ill patients requiring intensive care, broad-spectrum antimicrobials, immunosuppressive therapy, and life support. Studies from our country reported a decreasing trend in many community pathogens during this period[27,28], whereas increases were observed in certain hospital pathogens and resistance patterns[29].

In our study, hospital-acquired MRSA increased significantly in the post-pandemic period compared with pre-pandemic years ($p < 0.05$), whereas community-acquired MRSA showed no significant change. These findings are consistent with recent international reports describing a rise in hospital-onset MRSA bacteremia during the COVID-19 pandemic[10]. This trend has been attributed to prolonged intensive care admissions, increased use of invasive devices, and greater empirical use of broad-spectrum antibiotics during the pandemic[11]. Conversely, the absence of a significant change in community-acquired MRSA may reflect reduced interpersonal contact and transmission in the community due to lockdowns and social restrictions. Taken together, our results underscore the divergent impact of the pandemic on hospital versus community *Staphylococcus aureus* epidemiology and emphasize the importance of continuous surveillance in both settings.

Recent national data support our findings. Yılmaz et al.[30] analyzed resistance trends in 17 hospitals across Türkiye and reported that methicillin resistance in *Staphylococcus aureus* decreased significantly between 2019 and 2020 ($p = 0.03$), followed by an increase in 2021 ($p = 0.04$), returning to pre-pandemic levels. In the same study, susceptibility to fluoroquinolones and gentamicin improved during the pandemic. Furthermore, Hamidi and Yılmaz.[31] demonstrated a significant increase in the consumption of broad-spectrum antibiotics, including piperacillin-tazobactam, meropenem, fluoroquinolones, and teicoplanin, in a tertiary hospital during the pandemic. These changes in antimicrobial prescribing may have contributed to the post-pandemic rise in hospital-acquired MRSA observed in our study. Together, these national findings highlight that pandemic-related changes in both resistance patterns and antibiotic use had a measurable impact on *Staphylococcus aureus* epidemiology in Türkiye, reinforcing the importance of sustained surveillance and antimicrobial stewardship.

Additionally, the major earthquakes that struck our region in February 2023 introduced multiple risk factors potentially threatening public health. When evaluated in the context of these adverse conditions, our data showed two noticeable peaks in MRSA strains in 2020 and 2023 compared with previous years; however, there was no significant difference in the overall incidence of *Staphylococcus aureus* over the entire study period.

Study Limitations

This study has several limitations. Its retrospective, single-center design may limit generalizability. Despite the exclusion of duplicate isolates, misclassification could have occurred if a patient initially had MSSA and later developed MRSA during the same episode. As a laboratory-based study, clinical data were not analyzed. Finally, regression analyses based on annual aggregated data over 6.5 years should be interpreted as descriptive rather than predictive.

Conclusion

In this study, the trends in *Staphylococcus aureus* isolation frequency and antimicrobial resistance were examined in a tertiary hospital serving a city representing approximately 1% of the national population. MRSA strains showed a significant increase during the study period. It is important to determine whether a similar increase is occurring at the national level and, if so, to promptly plan and implement appropriate preventive measures.

Ethics

Ethics Committee Approval: This study was conducted with the ethical approval of İnönü University Scientific Research and Publication Ethics Committee (approval number: 2025/7409, dated: 25.03.2025).

Informed Consent: This study was conducted retrospectively using anonymized laboratory and archival data. No direct patient contact or intervention was involved. All data were de-identified prior to analysis, ensuring that no personally identifiable information was accessible to the researchers. Therefore, individual informed consent was not required.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.S.T., Concept: E.S.T., Y.Y., B.O., Design: E.S.T., Y.Y., D.C., B.O., Data Collection or Processing: E.S.T., H.A., D.C., Analysis or Interpretation: E.S.T., H.A., D.C., Literature Search: E.S.T., Y.Y., H.A., B.O., Writing: E.S.T., Y.Y., B.O.

Conflict of Interest: Barış Otlu, the author of this article, is a member of the editorial board of the Mediterranean Journal of Infection, Microbes and Antimicrobials. However, he was not involved in any stage of the editorial review or decision making process for this manuscript.

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