

Prevalence of MRSA and associated factors among wound patients at Werabe Comprehensive Specialized Hospital, Ethiopia

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Abstract

Introduction: *Staphylococcus aureus* is a major global health threat due to its widespread distribution, ability to cause severe infections, and increasing antimicrobial resistance. It is responsible for a wide range of diseases, particularly skin and soft tissue infections, with wound infections being the most common. The emergence of methicillin-resistant *S. aureus* (MRSA) is of significant concern. However, local data on MRSA in wound infections remain limited. This study assessed the prevalence, antimicrobial susceptibility, and associated factors of MRSA among patients with wound infections at Werabe Comprehensive Specialized Hospital (WCSH).

Methodology: A cross-sectional study was conducted from July 2023 to February 2024 involving 384 patients with wound infections. Wound swabs or pus samples were cultured on blood agar and mannitol salt agar. Identification of *S. aureus* was performed using standard biochemical tests, while MRSA detection used the cefoxitin disk diffusion method following CLSI guidelines. Data were collected using a semi-structured questionnaire, entered into Epi-info, and analyzed with SPSS. Logistic regression identified associations, with $p < 0.05$ considered significant. **Results:** Of 384 participants, 90 (23.4%) had *S. aureus*; of which 24 (26.7%) were MRSA. Most *S. aureus* isolates (87.8%) and all MRSA were resistant to penicillin but fully sensitive to linezolid. All MRSA and 31.1% of *S. aureus* isolates were multidrug resistant. Hospital stay > 72 hours was significantly associated with MRSA (AOR = 3.06, $p = 0.031$).

Conclusions: There is a notable prevalence of MRSA with high multidrug resistance. Strengthening infection control, antimicrobial stewardship, and reducing prolonged hospital stays are recommended.

Key words: wound infection; *S. aureus*; MRSA; MDR; Werabe; Ethiopia.

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Introduction

Wounds, defined as disruptions of the skin that expose underlying subcutaneous tissues, create a favorable environment for microbial colonization and proliferation due to warmth, moisture, and the availability of nutrients. Such conditions particularly support the growth of pathogens such as *Staphylococcus aureus* [1]. *S. aureus* is a Gram-positive, spherical coccus with a diameter of about 1 μm that typically forms irregular grape-like clusters in Gram-stained smears. It is facultative anaerobic, non-motile, no-spore-forming, and coagulase and catalase producing. *S. aureus* is adapted to survive in different environmental surfaces, humans, and other living things [2]. *S. aureus* infections are frequently linked to wounds, particularly in hospitalized patients who are exposed to drug resistant strains [3].

S. aureus strains that lack sensitivity to methicillin are referred to as methicillin resistant *S. aureus*

(MRSA). Methicillin and the related β -lactamase-resistant penicillins have long been regarded as the preferred medications for treating infections caused by β -lactam-resistant *S. aureus* [4]. However, MRSA has emerged through the acquisition of multiple resistance mechanisms against β -lactam antibiotics, including penams (penicillin derivatives like methicillin and oxacillin) and cepheems (like cephalosporins), via horizontal gene transfer or natural selection pressure [5].

The primary mechanism of methicillin resistance in MRSA is the expression of an altered penicillin-binding protein (PBP2a) that exhibits markedly reduced affinity for almost all β -lactam antibiotics, making these drugs ineffective. PBP2a is encoded by the *mecA* or *mecC* genes located within the *staphylococcal cassette chromosome mec* (SCCmec). The SCCmec is a genetic element carried by MRSA, but absent in methicillin-susceptible *S. aureus* (MSSA) [6]. In addition to

PBP2a, recent studies have identified PBP4 as a significant predictor of methicillin resistance in *S. aureus*, especially among community-acquired MRSA strains [7].

The possibility that *S. aureus* colonizes the nose before spreading to wounds highlights its significance in hospital settings [8]. The emergence of new resistance mechanisms; and inappropriate antibiotic use including, the use of antibiotics without a prescription, excessive prescriptions from medical professionals, and overuse by the general public; exacerbate this issue even more [9].

There has been a steady rise of MRSA infections in healthcare facilities over the past 20 years, and these infections have emerged as a serious global public health concern, ranking among the most prevalent and invasive microbes connected to infections in hospitalized patients. All World Health Organization (WHO) regions have reported MRSA prevalence rates exceeding 20%, while national surveillance data from 9 African countries indicate a wide prevalence range of 12% to 80% [10]. Studies conducted in Ethiopia showed that MRSA rates varied markedly ranging from 28.3% in Dessie [11] to 82.3% in Arbaminch [12] making it an important public health concern. Furthermore, regional analyses have shown MRSA prevalence of 40.4% in Southern Ethiopia, which is nearly twice that reported from the Tigray region (20.3%), highlighting marked geographic differences in the burden of MRSA infections within the country [13].

WHO designated MRSA as a high priority pathogen for research and the development of new antibiotics [9]. In line with the WHO recommendations, Ethiopia has implemented standard treatment guidelines (STG) to promote rational antibiotic prescribing. However, despite these efforts the burden of drug resistance, particularly of MRSA, continues to increase [14].

Studies conducted in different parts of Ethiopia exhibit inconsistent and inconclusive data. Moreover, different healthcare settings are characterized by different clinical practice, medication prescription cultures, and protocols that create a difference in the prevalence of MRSA; as well as factors associated with likelihood of getting an infection with such strains. To the best of the researchers' knowledge, studies reporting MRSA prevalence and related factors in the Central Ethiopia Region are absent. Therefore, the current study aimed to fill this gap by determining the prevalence of MRSA and its associated factors among patients attending Werabe Comprehensive Specialized Hospital (WCSH) in Central Ethiopia.

Methodology

Study design, setting, and timing

An institution based cross-sectional study design was employed from July 2023 to February 2024 at WCSH. WCSH offers services at general, specialty, and sub-specialty levels; and includes the out-patient department (OPD), surgery, family planning, antiretroviral therapy (ART), laboratory, pharmacy, antenatal care (ANC), oncology, ear nose throat (ENT), delivery, and neonatal care for the community in and outside the capital city. The hospital provides a wound care service, both in emergency setting as well as a cold care unit, which include simple wound cleaning and medication assisted care to specialized care and amputation.

Study population, and inclusion/exclusion criteria

The source population comprised all patients with wound infections attending WCSH. The study population included patients who visited or were admitted to the hospital during the data collection period and met the inclusion criteria.

The inclusion criteria were: patients of all ages with a clinical diagnosis of wound infection (defined by the presence of purulent discharge, or at least one sign of inflammation such as erythema, warmth, swelling, or localized pain), and who provided informed consent (or assent from a parent/guardian for minors).

The exclusion criteria were: patients who were unwilling to participate, and from whom a proper specimen could not be collected.

Sample size determination and sampling technique

The sample size was calculated using the single population proportion formula:

$$n = \frac{z^2 p(1 - p)}{d^2}$$

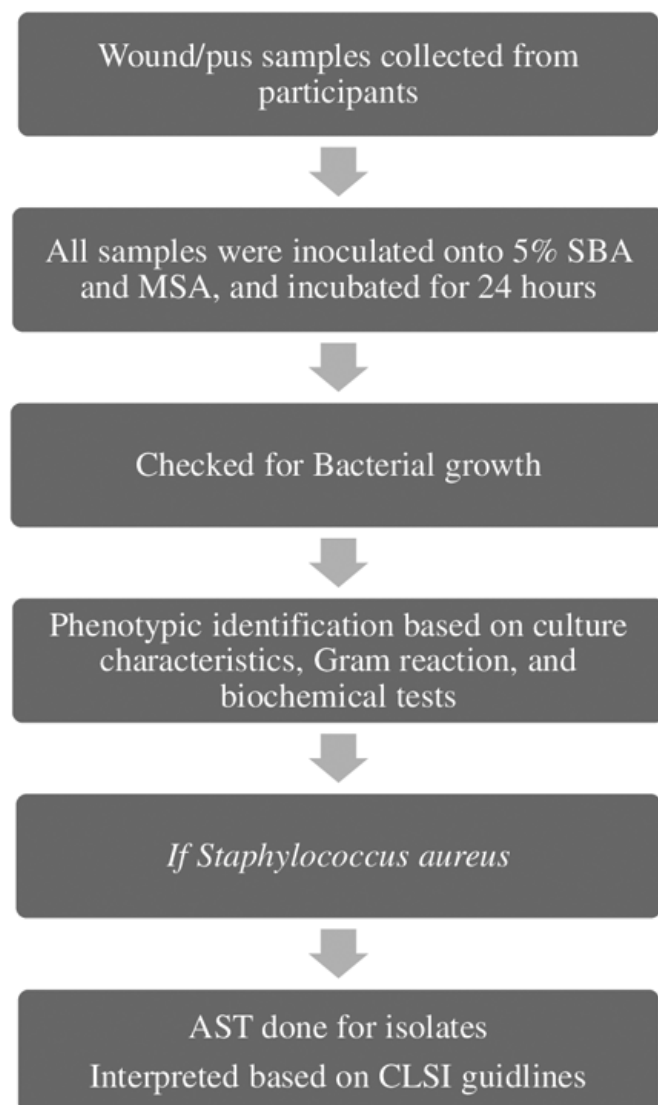
The proportion (p) was considered to be 0.49, based on a previous meta-analysis on wound infections in Ethiopia [15], which reported a high pooled prevalence, thus maximizing the required sample size for a conservative estimate. The calculated sample size was 384 with a 95% confidence level ($z = 1.96$) and a 5% margin of error ($d = 0.05$). A consecutive sampling technique was employed, where all eligible patients presenting during the study period were enrolled until the target sample size was reached, thereby minimizing selection bias.

Data and specimen collection

Data on sociodemographic and clinical characteristics were collected by trained nurses using a

pre-tested, interviewer-administered semi-structured questionnaire. Wound swab specimens were collected aseptically following the interview. The wound was first cleansed with sterile normal saline. A sterile cotton swab was then rotated over a 1 cm² area of viable tissue for 5 seconds with sufficient pressure to express fluid, following the Levine method [16]. In the case of closed wounds or abscesses, specimens were collected via aspiration after drainage. The swabs were placed in a sterile test tube containing Stuart transport medium, labeled, and immediately transported to the hospital's microbiology laboratory. When immediate processing was not possible, the samples were stored at 2–8°C for a maximum of 4 hours.

Figure 1. Work flow for the isolation of methicillin resistant *S. aureus*.



SB: sheep blood agar; MSA: mannitol salt agar; AST: antimicrobial susceptibility testing; CLSI: Clinical and Laboratory Standards Institute.

Laboratory methods

Culture and identification of *S. aureus*

Each wound swab was inoculated onto 5% sheep blood agar (SBA) and mannitol salt agar (MSA) (Oxoid, Basingstoke, UK). The plates were incubated aerobically at 37 °C for 24 hours. Bacterial identification was based on colony morphology (e.g., β -hemolysis on SBA, golden-yellow colonies with fermentation on MSA), Gram stain characteristics (Gram-positive cocci in clusters), and biochemical tests. A catalase test was performed to differentiate staphylococci (positive) from streptococci (negative). All catalase-positive, Gram-positive cocci were subjected to a tube coagulase test using rabbit plasma to identify *S. aureus* (coagulase-positive).

Antibacterial susceptibility testing (AST)

AST was performed for all confirmed *S. aureus* isolates using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar (MHA) (Oxoid, Basingstoke, UK), following the guidelines of the Clinical and Laboratory Standards Institute [17]. A bacterial suspension equivalent to a 0.5 McFarland turbidity standard was prepared in nutrient broth. A sterile swab was used to streak the inoculum evenly across the entire surface of the MHA plate. The plate was allowed to dry for 3–5 minutes before antibiotic disks were applied.

The following antibiotic disks were tested: penicillin (10 U), cefoxitin (30 μ g), ciprofloxacin (5 μ g), clindamycin (2 μ g), erythromycin (15 μ g), trimethoprim-sulfamethoxazole (1.25/23.75 μ g), azithromycin (15 μ g), linezolid (30 μ g), tetracycline (30 μ g), and gentamicin (10 μ g). The diameters of the inhibition zones were measured after 16–18 hours of incubation at 37 °C, and the isolates were classified as susceptible, intermediate, or resistant, according to CLSI interpretive criteria. The cefoxitin disk zone diameter was read after a full 24 hours of incubation for MRSA detection. An inhibition zone of ≤ 21 mm for cefoxitin was interpreted as methicillin resistance (Figure 1).

An *S. aureus* isolate was defined as MDR if it demonstrated non-susceptibility to at least 1 agent in 3 or more antimicrobial categories tested [18].

Data quality assurance

To ensure data quality, the data collectors were trained on the study protocol, questionnaire administration, and aseptic specimen collection. The questionnaire, initially prepared in English, was translated into Amharic and back-translated to ensure consistency. It was pre-tested on 5% of the sample size

(19 patients) at WCSH, and necessary adjustments were made. Standard operating procedures (SOPs) were strictly followed for all laboratory analyses. The quality of the culture media and antibiotic disks was checked using the *S. aureus* reference strain ATCC-25923, which showed expected growth and susceptibility patterns. Sterility of each batch of prepared media was confirmed by incubating 5% of the plates overnight at 37 °C; batches with any growth were discarded. The principal investigator reviewed all completed questionnaires and laboratory results daily for completeness and accuracy.

Data management and analysis

Data were coded and entered into Epi-data version 4.6 and then exported to SPSS version 26 [19] for analysis. Descriptive statistics (frequencies, percentages, mean, median) were used to summarize the data. The association between independent variables and the outcome (MRSA infection) was assessed using logistic regression. Variables with a *p* value < 0.25 in the bivariate analysis were included in a multivariable logistic regression model to control for confounding effects. Multicollinearity between independent variables was checked using the variance inflation factor (VIF), with all values found to be less than 5. The strength of association was measured using the adjusted odds ratio (AOR) with its 95% confidence interval (CI). A *p* value ≤ 0.05 in the final model was considered statistically significant.

Table 1. Sociodemographic characteristics of patients with wound infection at WCSH, 2023 (n = 384).

Variable	Frequency n (%)
Age (years)	
≤ 15	66 (17.2)
16–30	150 (39.1)
31–45	116 (30.2)
> 45	52 (13.5)
Gender	
Male	240 (62.5)
Female	144 (37.5)
Educational status	
No formal education	204 (53.1)
Primary school	114 (29.7)
Secondary school and above	66 (17.2)
Occupation status	
Farmer	74 (19.3%)
Merchant	52 (13.5%)
Housewife	82 (21.4%)
Others	176 (45.8%)
Place of residence	
Urban	116 (30.2)
Rural	268 (69.8)
Marital status	
Married	218 (56.8)
Single	140 (36.4)
Others	26 (6.8)

Ethical consideration

Ethical approval for this study was obtained from the Departmental Research Ethics Review Committee (protocol number DRERC/003/2023; 26 June 2023) of the department of Microbiology, Immunology, and Parasitology (DMIP), Colleges of Health Sciences, Addis Ababa University. Permission to conduct the research was also secured from WCSH through an official support letter. All eligible participants were informed about the study objectives, procedures, potential risks, and confidentiality safeguards; and written informed consent (or assent for minors) was obtained before enrollment. An information sheet was used to explain the purpose of the study, its importance, confidentiality, participation rights, protocol, and associated hazards. Personal identifiers were not recorded; instead, unique codes were assigned to maintain anonymity. All data were stored securely and were accessible only to the principal investigator. Laboratory findings, including culture and antimicrobial susceptibility results, were promptly communicated to the attending clinicians to support patient management.

Results

Socio-demographic characteristics

This study included a total of 384 participants (100% response rate) with wound infections. Among them, 268 (69.8%) were from rural settings, and 240 (62.5%) were men. The age of the participants ranged from 1 to 80 years with median and IQR of 29 years and 16–30 years respectively. The age group < 30 years old comprised more than half of the participants (216, 56.3%). Among the participants, 218 (56.8%) were married, while 204 (53.1%) participants had no formal education (Table 1).

Clinical characteristics

Among the respondents, 52 (13.5%), 73 (19.01%), and 10 (2.6%) had a prior history of hospital admission, co-morbidities, and prior infections of wound respectively. Among the study participants with co-morbidities, 41 individuals (10.7%) had diabetes. The majority of research participants (210, 54.7%) spent fewer than 72 hours in the hospital during their most recent visit. Deep wounds were the most commonly diagnosed (250, 65.1%), while trauma wounds accounted for the majority of the infected wounds (183, 47.7%). A large number of patients (284, or 74%) were from the inpatient ward. Among the participants, 104 (36.5%) were admitted to the orthopedic ward, and among them, 86 (22.4%) and 90 (23.4%) visited the

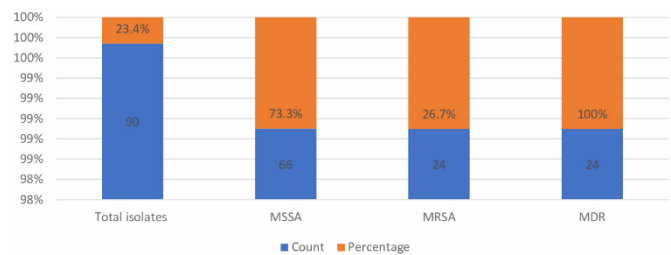
plastic surgery and OPD wards respectively. A total of 154 (40.1%) participants had previously used antibiotics. Of those, 116 (75.3%) stated that the antibiotics were prescribed by a healthcare professional, and 104 (68.4%) completed the entire dosage (Table 2).

Magnitude of MRSA among wound patients

S. aureus was isolated from 23.4% (95% CI: 19.3–28.0) of wound samples. The *S. aureus* isolates from wound infections were further evaluated for antimicrobial resistance, and the proportion of MRSA among them was 26.7% (95% CI: 18–37) (Figure 2).

Twenty-two (91.7%) of the study participants with MRSA had no history of hospitalization and wound infection in the last 12 months. Most (75%) of the MRSA isolates were from patients who had no history of antibiotic use in the last 12 months and patients with no co-morbidity. Those who stayed in the hospital for

Figure 2. MRSA, MSSA, and MDR-MRSA distribution in patients with wound infection at WCSH.



MRSA: methicillin-resistant *Staphylococcus aureus*; MSSA: methicillin-susceptible *Staphylococcus aureus*; MDR-MRSA: multidrug-resistant methicillin-resistant *Staphylococcus aureus*.

more than 72 hours (18, 75%) accounted for more than half of the MRSA cases. Half (12, 50%) of the MRSA were isolated from patients with trauma wound and 6 (25%) from patients with non-healing ulcer. Twenty (83.3%) of the patients with MRSA infection were from the inpatient ward, and 16 (66.7%) of them had deep wound infections. Half of the MRSA (12, 50%) were from wound swab (Table 3).

Antimicrobial resistance profile of MRSA isolates

All the MRSA isolates (24, 100%) were resistant to penicillin, and all remained susceptible to linezolid. The MRSA isolates showed high resistance to tetracycline (84.6%), ciprofloxacin (84.6), and azithromycin (75%). However, the lowest resistance was documented for gentamicin 8 (33.3%) and clindamycin 8 (33.3%) (Table 4).

Factors associated with MRSA

Socio-demographic traits of the study participants were evaluated for potential associations with MRSA infection. Bivariate analysis identified socio-demographic characteristics (gender, occupation, and place of residence) and clinical characteristics (length of hospital stay, use of antibiotics in the previous 12 months, wound infection in the last 12 months, and presence of co-morbidity) as the factors associated with MRSA (at *p* value < 0.25). Variables with a *p* value < 0.25 were subsequently included in the multivariable logistic regression analysis model in order to control for potential confounding effects.

The multivariable logistic regression analysis revealed that while all the socio-demographic variables and most of clinical characteristics had non-significant effect on the odds of having a MRSA infection, duration of hospital stay was the only variable that had a

Table 2. Clinical characteristics of wound-infected patients at WCSH, 2023.

Variables	Frequency	Percentage
Hospitalization history of previous twelve months (n = 384)		
Yes	52	13.5
No	332	86.5
Co-morbidity (n = 384)		
Yes	73	19.01
No	311	80.99
Previous wound infection history (n = 384)		
Yes	10	2.6
No	374	97.4
Current duration of stay in the hospital (n = 384)		
< 72 hours	210	54.7
≥ 72hours	174	45.3
Antibiotics use in previous 12 months(n = 384)		
Yes	154	40.1
No	230	59.9
Health professionals prescribed antibiotics (n = 154)		
Yes	116	75.3
No	38	24.7
Finished the entire dosage (n = 154)		
Yes	104	68.4
No	50	31.6
Wound type (n = 384)		
Surgical wound	80	20.8
Ulcer wound	103	26.8
Burn wound	16	4.2
Trauma wound	183	47.7
Others	2	0.5
Wound depth (n = 384)		
Deep wound	250	65.1
Superficial wound	134	34.9
The hospital's patient setting (n = 384)		
Inpatient	284	74.0
Outpatient	100	26.0
Patient admitted in ward (n = 384)		
Emergency	16	4.2
Gynecology	2	0.5
Orthopedic ward	140	36.5
Outpatient department (OPD)	86	22.4
Plastic surgery	90	23.4
Surgical ward	50	13.0

Table 3. *S. aureus* and MRSA distribution among different variables at WCSH, 2023.

Variables	Bacteria isolates		
	<i>S. aureus</i> (n = 90)	MSSA (n = 66)	MRSA (n = 24)
Age (years)			
≤ 14	17 (18.89%)	12 (18.18%)	5 (20.8%)
15–29	41 (45.6%)	34 (51.52%)	7 (29.2%)
30–49	16 (17.8%)	10 (15.15%)	6 (25%)
50–59	6 (6.7%)	2 (3.03%)	4 (16.7%)
≥ 60	10 (11.11%)	8 (12.12%)	2 (8.3%)
Gender			
Male	62 (68.9%)	42 (63.6)	20 (83.3%)
Female	28 (31.1%)	24 (36.4%)	4 (16.7%)
Place of residence			
Urban	26 (28.9%)	24 (36.4%)	2 (8.3%)
Rural	64 (71.1%)	42 (63.6%)	22 (91.7%)
Educational status			
No formal education	41 (45.6%)	28 (42.4%)	13 (54.2%)
Formal education	49 (54.4%)	38 (57.6%)	11 (45.8%)
Occupation			
Farmer	21 (23.33%)	8 (12.12%)	13 (54.2%)
Merchant	8 (8.9%)	4 (6.06%)	4 (16.7%)
Housewife	12 (13.33%)	10 (15.15%)	2 (8.3%)
Others	49 (54.44%)	44 (66.67%)	5 (20.8%)
History of hospitalization in the last 12 months			
Yes	12 (13.3%)	10 (15.2%)	2 (8.3%)
No	78 (86.7%)	56 (84.8%)	22 (91.7%)
Prior wound infection history in the last 12 months			
Yes	4 (4.4%)	2 (3.03%)	2 (8.3%)
No	86 (94.6%)	64 (96.97%)	22 (91.7%)
Previous antibiotic use history in the last 12 months			
Yes	32 (38.6%)	26 (39.4%)	6 (25%)
No	58 (61.4%)	40 (60.6%)	18 (75%)
Co-morbidity			
Yes	13 (14.4%)	12 (18.2%)	1 (4.2%)
No	77 (85.6%)	54 (81.8%)	23 (95.8%)
Ward where admitted			
Emergency	4 (4.4%)	4 (6.1%)	0 (0%)
Orthopedic ward	36 (40%)	20 (30.3%)	16 (66.7%)
Plastic surgery	24 (26.7%)	22 (33.3%)	2 (8.3%)
Surgical ward	10 (1.1%)	8 (12.1%)	2 (8.3%)
OPD	16 (17.8%)	12 (18.2%)	4 (16.7%)
Length of hospital stay			
< 72 hours	40 (44.4%)	34 (51.5%)	6 (25%)
≥ 72 hours	50 (55.6%)	32 (48.5%)	18 (75%)
Type of wound			
Surgical	14 (15.6%)	10 (15.2%)	4 (16.7%)
Trauma	46 (51.1%)	34 (51.5%)	12 (50%)
Non-healing ulcer	24 (26.7%)	18 (27.3%)	6 (25%)
Burn	6 (6.7%)	4 (6.1%)	2 (8.3%)
Patient setting			
Inpatient	70 (77.8%)	50 (75.6%)	20 (83.3%)
Outpatient	20 (22.2%)	16 (24.4%)	4 (16.7%)
Depth of wound			
Deep	62 (68.9%)	46 (69.7%)	16 (66.7%)
Superficial	28 (31.1%)	20 (30.3%)	8 (33.3%)
Types of specimens			
Pus	32 (35.6%)	22 (33.3%)	10 (41.7%)
Wound swab	52 (57.8%)	40 (60.6%)	12 (50%)
Abscess	6 (6.7%)	4 (6.1%)	2 (8.3%)

S. aureus: *Staphylococcus aureus*; MRSA: methicillin-resistant *Staphylococcus aureus*; MSSA: methicillin-susceptible *Staphylococcus aureus*; OPD: outpatient department.

Table 4. Antimicrobial susceptibility profiles of *S. aureus* and MRSA isolated from wound infections at WCSH.

Antibiotics	<i>S. aureus</i> (n = 90)		MRSA (n = 24)	
	S	R	S	R
Cefoxitin, 30 µg	66 (73.3%)	24 (26.7%)	0	24 (100%)
Ciprofloxacin, 5 µg	64 (71.1%)	26 (28.9%)	4 (15.4%)	20 (84.6%)
Clindamycin, 2 µg	82 (91.1%)	8 (8.9%)	16 (66.7%)	8 (33.3%)
Trimethoprim/Sulfamethoxazole, 1.25/23.75 µg	78 (86.7%)	12 (13.3%)	14 (58.3%)	10 (41.7%)
Azithromycin, 15 µg	70 (77.8%)	20 (22.2%)	6 (25%)	18 (75%)
Gentamicin, 10 µg	82 (91.1%)	8 (8.9%)	16 (66.7%)	8 (33.3%)
Linezolid, 30 µg	90 (100%)	0	24 (100%)	0
Penicillin, 10 IU	11 (12.2%)	79 (87.8%)	0	24 (100%)
Tetracycline, 30 µg	66 (73.3%)	24 (26.7%)	4 (15.4%)	20 (84.6%)
Erythromycin, 15 µg	78 (86.7%)	12 (13.3%)	12 (50%)	12 (50%)

MRSA: methicillin-resistant *Staphylococcus aureus*.

statistically significant association with the likelihood of MRSA infection. Accordingly, compared to patients who stayed less than 72 hours in the hospital, patients who stayed more than 72 hours had a 3 times higher likelihood of developing wound infection with MRSA. ($p = 0.031$, AOR: 3.06, 95%CI: 1.11–8.47) (Table 5).

Discussion

This study provides crucial, contemporary data on the prevalence and characteristics of *S. aureus* and MRSA from wound infections in a tertiary hospital in Central Ethiopia, a region with limited epidemiological surveillance. Nearly 1 in 4 wound infections (23.4%) were caused by *S. aureus*, and of these, over a quarter (26.7%) were methicillin-resistant.

The overall *S. aureus* prevalence of 23.4% is comparable to findings from Hawassa, Ethiopia (23.2%) [20] and a multi-center study across 4 Ethiopian hospitals (21.7%) [21]. However, it is lower than previous prevalence reports in Ethiopia, including Debre Markos Referral Hospital (29.3%) [22], Dessie (34.58%) [11], Addis Ababa (47.4%) [23], and Arbaminch (49.7%) [12], as well as a pooled estimate of 36% from a meta-analysis [24]. Lower *S. aureus* prevalence compared to the present finding were also reported from other countries, such as Eritrea (63.1%) [25] and Brazil (51.5%) [26]. This variation may reflect differences in patient populations, local infection prevention and control standards, antibiotic prescribing habits, and laboratory methodologies across study sites.

In the present study, 26.7% of *S. aureus* from wound infections were MRSA. This proportion is almost, similar to previous reports of 28.3% in Dessie [11], 26.8% in India [27], and 24.5% in 4 referral hospitals in Ethiopia [21]. However, it is far lower than other studies in Ethiopia, including Debre Markos (45.1%) [18], Arbaminch (82.3%) [12], and a

systematic review and meta-analysis (50%) [24]; and from other countries such as Eritrea 72% [25]. However, the proportion of MRSA in the current study is higher than the previous study conducted in Hawassa, Ethiopia (8.8%) [20].

The prevalence of MRSA among all the participants was 6.3%; this is comparable to studies conducted at 4 hospitals in Ethiopia (5.3%) [21], Dessie (9.8%) [11], and Brazil (8.7%) [26]. But much lower than previous studies in Arbaminch (40.4%) [12], Addis Ababa (37.43%) [23], Debre Markos Referral Hospital (13.2%) [22], and Eritrea 63.1% [25]. But it is higher than the study conducted in Hawassa (2.03%) [20]. The variations in the proportion of MRSA between the previous studies and the current study might arise due to variations in infection prevention practices, drug prescription, and geographic differences.

Concerning the antimicrobial resistance profiles of the isolates in the present study, *S. aureus* isolates showed the highest resistance to penicillin (87.8%), followed by ciprofloxacin (28.9%), tetracycline (26.7%), azithromycin (22.2%), erythromycin and trimethoprim/sulfamethoxazole (13.3% each), and gentamicin and clindamycin (8.9% each). All of the isolates were susceptible to linezolid. The high resistance to penicillin in this study is comparable with previous studies conducted in Ethiopia; including Dessie Referral Hospital (84.7%) [11], Hawassa University Comprehensive Specialized Hospital (91.2%) [20], and Yekatit 12 Hospital (96.1%) [23]. Clindamycin resistance was 8.9% in the current study and is consistent with a prior study conducted in Ethiopia that found 7.7% resistance to the drug [11]. These differences may result from overuse or improper usage of antibiotics, as well as from likely bacterial mutations and horizontal gene transfer.

In this study, MRSA isolates showed high levels of

Table 5. Bivariate and multivariate analysis of factors associated with MRSA among patients with wound infection at WCSH 2023.

Variable	Category	MRSA Yes n (%)	MRSA No n (%)	COR (95% CI)	p value	AOR (95% CI)	p value
Gender	Male	20 (83.3)	220 (61.1)	1 (Ref)		1 (Ref)	
	Female	4 (16.7)	140 (38.9)	3.18 (1.065–9.504)	0.038	2.7 (0.5–15.9)	0.28
Place of residence	Urban	2 (8.3)	114 (31.7)	1 (Ref)		1 (Ref)	
	Rural	22 (81.7)	246 (68.3)	5.098 (1.18–22.05)	0.029	2.79 (0.518–14.996)	0.232
Co-morbidity	No	23 (95.8)	288 (80.0)	1 (Ref)		1 (Ref)	
	Yes	1 (4.2)	72 (20.0)	5.8 (0.77–43.29)	0.089	7.196 (0.837–61.86)	0.072
Wound infection	No	22 (91.7)	352 (97.8)	1 (Ref)		1 (Ref)	
	Yes	2 (8.3)	8 (2.2)	4.00 (0.801–19.976)	0.091	2.57 (0.365–18.094)	0.343
Antibiotic use	No	18 (75.0)	210 (58.9)	1 (Ref)		1 (Ref)	
	Yes	6 (25.0)	148 (41.1)	0.473 (0.183–1.220)	0.121	0.601 (0.192–1.875)	0.38
Length of hospital stay	< 72 hrs	6 (25.0)	204 (56.7)	1 (Ref)		1 (Ref)	
	≥ 72 hrs	18 (75.0)	156 (43.3)	3.92 (1.522–10.115)	0.005	3.06 (1.11–8.47)	0.031
	Housewife	2 (8.33)	80 (22.22)	1 (Ref)		1 (Ref)	
Occupational status	Farmer	13 (54.17)	61 (16.94)	0.117 (0.026–0.539)	0.006	0.290 (0.027–3.071)	0.304
	Merchant	4 (16.67)	48 (13.33)	0.300 (0.053–1.700)	0.174	0.524 (0.064–4.280)	0.54
	Others	5 (20.83)	171 (47.5)	0.855 (0.162–4.502)	0.853	1.467 (0.143–15.1)	0.747

MRSA: methicillin-resistant *Staphylococcus aureus*.

resistance to penicillin (100%), tetracycline (84.6%), ciprofloxacin (84.6), and azithromycin (75%); while moderate resistance was observed to erythromycin (50%) and trimethoprim/sulfamethoxazole (41.7%). This pattern suggests that the *mecA*-mediated resistance is co-circulating with resistance determinants for other antibiotic classes; a hallmark of hospital-associated MRSA strains.

The universal resistance to penicillin is consistent with reports from Dessie [11], Hawassa [20], and Addis Ababa [23], likely reflecting the long-standing and widespread use of β -lactam antibiotics that has exerted sustained selective pressure favoring resistant strains. Similarly, the high resistance to tetracycline and macrolides severely limit oral therapeutic options and may be attributed to their frequent empirical use, ease of access, and historical overuse for a broad range of infections. However, the 84.6% resistance to ciprofloxacin documented in the present study is higher than the study reported in Dessie Referral Hospital (61.5%) [11]. This could be explained by the differences in antibiotic prescribing patterns, healthcare settings, and prior patient exposure.

On the other hand, the current study documented lowest resistance to gentamicin (8, 33.3%), clindamycin (8, 33.3%), and linezolid (no resistance). A comparable finding of gentamicin resistance was reported from Yekatit 12 Hospital in Addis Ababa (38.2%) [23]. The universal susceptibility to linezolid for all *S. aureus* isolates, including MRSA in the current study, is a critical finding. This positions linezolid as a reliable agent for treating severe or resistant staphylococcal infections in this setting. However, its high cost and limited availability in low-resource settings like Ethiopia pose significant barriers to its widespread use. This finding underscores the importance of antimicrobial stewardship to preserve the efficacy of last-resort antibiotics.

The finding on cross-resistance of the bacteria (MRSA) implies the importance of being cautious while treating wound patients who are not responding to penicillin, tetracycline, ciprofloxacin, and azithromycin. Furthermore, one needs to consider the possibility of MRSA strain infection while dealing with such patients. On the other hand, the sensitivity of both *S. aureus* isolates as well as MRSA strains for linezolid paves a way as an opportunity to use this drug for treating both the susceptible as well as the resistant strains of *S. aureus* associated wound infection.

Analysis of the risk factors revealed that several sociodemographic variables, including male gender, rural residence, and occupation were associated with

MRSA infection, based on bivariate analysis. However, these associations did not remain significant in the multivariable model. This shift strongly suggests that these factors are not independent predictors, but are likely confounded by the single most dominant risk factor: prolonged hospital stay (≥ 72 hours). For example, patients from rural areas or with certain occupations (e.g., farming) may be more prone to severe trauma, leading to more complex wounds that necessitate longer hospitalization. The multivariable analysis correctly isolates the hospital environment itself as the primary driver, demonstrating that once the duration of exposure to this high-risk setting is accounted for, the other demographic factors lose their predictive power. This is in line with previous studies in Ethiopia that documented significant association between MRSA and hospital stay ≥ 72 hours in Debreworkos (AOR: 7.402) [22], and in the other 4 hospitals in Ethiopia (AOR = 1.856) [21]. Hospitals act as reservoirs for resistant pathogens, and extended stays increase the likelihood of exposure through contact with colonized healthcare workers, contaminated environments, or invasive procedures. This reinforces the central role of robust infection prevention and control (IPC) measures, such as hand hygiene, environmental cleaning, and patient screening in preventing the transmission of MRSA.

Limitations

This study has several limitations that should be acknowledged. First, its cross-sectional design prevents the establishment of causality between risk factors and MRSA acquisition. Second, being a single-center study, the findings may not be generalizable to other regions of Ethiopia. Third, the relatively small number of MRSA isolates ($n = 24$) might limit the statistical power of the regression analysis to detect associations with smaller effect sizes; and this resulted in wide confidence intervals. Fourth, the reliance on phenotypic methods for MRSA detection without molecular confirmation of the *mecA* gene or strain typing (e.g., via pulsed-field gel electrophoresis [PFGE] or multilocus sequence typing [MLST]) prevents a deeper understanding of the resistance mechanisms and clonal spread. Finally, the definition of wound infection was clinical and not standardized, which could introduce misclassification bias.

Conclusions

The current study showed that about 1 in 4 wound infections at WCSH were caused by *S. aureus*. About one-fourth of the *S. aureus* isolates were MRSA, and all

of them were MDR. All the *S. aureus* isolates, including the MRSA, were susceptible to linezolid, making it a suitable option for treating all types of *S. aureus* infections; while penicillin, ciprofloxacin, azithromycin, erythromycin, and co-trimoxazole showed high to moderate resistance, highlighting their limited utility in treating *S. aureus* and MRSA associated wound infections in the current study setting. Furthermore, the longer the hospital stay, the higher the likelihood of the patient contracting MRSA infections. This emphasizes the necessity of stricter infection control protocols in order to stop MRSA from spreading throughout healthcare institutions, especially for patients who will be hospitalized for a longer period of time.

It is strongly recommended that hospitals, like WCSH should implement antimicrobial stewardship programs and improve their infection prevention and control measures. Drug surveillance (the ongoing detection of drug resistance patterns) should be implemented to halt the spread of bacteria that are resistant to drugs, such as the MRSA. Additionally, healthcare practitioners should be aware about MRSA and MDR *S. aureus* strains, and should follow the standard medication prescription protocol. A longitudinal investigation across many healthcare facilities shall be undertaken in the future to support the current findings.

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Data availability statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Authors' contributions

NOK, AAK, HBK: conceptualization, research proposal, analysis, manuscript writing, and critical revision; NOK: major contributor in laboratory investigation; YAW, HMH,

MJN, BDM: data collection, manuscript writing. AAK and HBK: supervision. All authors read and approved the final manuscript.

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Conflict of interest

No conflict of interest is declared.

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