Scientific Research Publishing

Open Journal of Medical Microbiology, 2025, 15(3), 149-166
https://www.scirp.org/journal/ojmm
ISSN Online: 2165-3380
ISSN Print: 2165-3372

Prevalence and Antibiotic Susceptibility Profiles of *Staphylococcus aureus* Derived from Wound Samples of Diabetic Patients Attending the Moi Teaching and Referral Hospital, Kenya

Domnic Owuor Oguda*, Salinah J. Rono, Becky Nancy Aloo

Department of Biological Sciences, University of Eldoret, Eldoret, Kenya
Email: *dominicowuor17@gmail.com

How to cite this paper: Oguda, D.O., Rono, S.J. and Aloo, B.N. (2025) Prevalence and Antibiotic Susceptibility Profiles of *Staphylococcus aureus* Derived from Wound Samples of Diabetic Patients Attending the Moi Teaching and Referral Hospital, Kenya. *Open Journal of Medical Microbiology*, **15**, 149-166.
https://doi.org/10.4236/ojmm.2025.153012

Received: July 10, 2025
Accepted: September 5, 2025
Published: September 8, 2025

Abstract

Staphylococcus aureus is a common cause of delayed wound healing worldwide, especially among diabetic patients, due to the bacterium's resistance to antibiotics. This study aimed to investigate the prevalence, antimicrobial susceptibility patterns of *S. aureus*, and potential risk factors for its occurrence in diabetic wound infections at Moi Teaching and Referral Hospital (MTRH). A purposive sampling method was used to select 156 diabetic patients aged 13 years or older attending the diabetic clinic. Wound swabs were collected aseptically, inoculated onto blood agar, and then sub-cultured on Mannitol Salt Agar. The isolates were characterized using biochemical tests, while antimicrobial susceptibility was assessed via the agar disk diffusion technique. Results showed that 19.87% were positive for *S. aureus*, while 80.13% were negative. Among the positive isolates, 10.48% showed intermediate sensitivity, and 29.03% exhibited resistance to at least one antibiotic. More than half of the isolates were susceptible to the tested antibiotics. The highest susceptibility was observed for Cefoxitin (96.77%) and Clindamycin (80.65%), while Ampicillin demonstrated the lowest susceptibility (25.81%). The study found a 19.87% prevalence of *S. aureus* in wounds of diabetic patients at the outpatient diabetic clinic of MTRH, with most isolates showing susceptibility to Cefoxitin, Erythromycin, and Clindamycin.

Keywords

Staphylococcus aureus, Diabetes, Diabetic Wounds, Antibiotic Susceptibility

1. Introduction

Diabetes is an expensive health issue for both patients with diabetes and the

healthcare systems globally. The number of individuals with diabetes has almost doubled over the previous 40 years [1]. As reported by the International Diabetes Federation, approximately 463 million adults worldwide are impacted by diabetes, and this number is projected to rise by at least 1.5 times by 2045 [2] [3]. The worldwide incidence of diabetes among adults over 18 years of age has also grown from 4.7% in 1980 to 8.5% in 2014 [4]. Diabetes mellitus is a common chronic disease characterized by persistent hyperglycemia. One of the most serious complications of this disease is diabetic wound infections [5]. According to Hurlow [6], diabetic wound infections contribute substantially to morbidity, prolonged hospital stays, and costs of healthcare globally for diabetes mellitus patients. Approximately up to 25% of diabetics develop diabetic wound infections in their lifetime. A recent meta-analysis has shown a greater mortality rate in diabetics with diabetic wound infections (99.9 per 1000 person-year) compared to those without diabetic wound infections (41.6 per 1000 person-year) [6].

Diabetic wound infections can contain single or multiple microbes that complicate treatment [7]. *Staphylococcus aureus* is the predominant organism responsible for acute diabetic wound infections [8]. *S. aureus* has emerged as a leading causative agent due to its adaptability and multiple virulence factors, such as adhesins, that facilitate host infection [9]. Formation of biofilms, and the formation of a polysaccharide capsule and several lytic enzymes that protect it from the host immune system and antibiotics [10]-[12]. This array of virulence factors, therefore, makes the presence of *S. aureus* in diabetic wounds a big challenge in the treatment and management of diabetes. The clinical significance of the pathogen has been exacerbated by the emergence and rapid spread of multidrug resistance among its strains, which complicates treatment for people with diabetes [13]. According to Anafo [14] The rise of antibiotic-resistant strains such as methicillin-resistant *S. aureus* (MRSA) has especially exacerbated the burden of diabetic wound infections, slowing down their healing rates and commonly resulting in amputations. These resistant strains often lead to treatment failures, necessitating the use of more expensive or toxic antibiotics, thereby increasing the economic and clinical burden on healthcare systems [14].

In Kenya, the presence of *S. aureus* in diabetic wounds has previously been reported [15]-[17]. The studies have shown that *S. aureus* is a predominant pathogen in diabetic wound infections, contributing to delayed healing and increased complications. Although some reports have indicated the emergence of antibiotic resistance among these isolates, the scope of existing studies remains limited, with an insufficient focus on comprehensive antibiotic susceptibility testing and a larger patient population, in particular within the local context of Moi Teaching and Referral Hospital (MTRH). This research fills this void by offering current, site-specific insights into resistance patterns related to diabetic wound infections at MTRH. Thus, understanding the prevalence and antibiotic susceptibility patterns of *S. aureus* is crucial for tailoring effective treatment strategies and guiding antibiotic stewardship administration. The present study sought to determine the

prevalence and antibiotic susceptibility patterns of *S. aureus* in samples from diabetic wounds from patients attending the MTRH. The findings of this study can be instrumental in guiding clinical treatment protocols concerning the most effective antibiotics for managing diabetic wound infections. Furthermore, the results can offer critical insights into local antibiotic resistance patterns of *S. aureus*, thereby assisting public health authorities in refining antibiotic stewardship strategies. Ultimately, the results of this study can contribute to improving patient treatment outcomes by reducing the burden of antibiotic-resistant infections and shaping the overall management of diabetic wounds in Kenya and beyond.

2. Materials and Methods

2.1. Study Area and Design

The study was conducted at the MTRH. This is a government hospital that is located 310 km northwest of Nairobi in Uasin Gishu County (Eldoret). Several clinics are run at the hospital, and the diabetic outpatient clinic is one of these clinics. This was the means of selecting a primary unit for data collection and analysis, which was appropriate to specific research questions, hence purposive sampling was used to select patients with diabetic wound infections, the design was appropriate to the study since it helped in gathering baseline information concerning antibiotic susceptibility pattern bacterial diabetic wound infections in diabetic patients at the MTRH. Before the recruitment of participants to the study, their consent was sought through the use of Assent forms for those who were between the ages of 13 - 17, while consent forms were used for those who were 18 years and above.

2.2. Target Population and Sample Size Determination

The target population consisted of T2MD patients who developed diabetic wound infections, spanning across 13 years old and above, who visited the MTRH diabetic clinic for dressing during the study period from 22nd August 2024 to 31st January 2025. The sample size for the study was determined following Fisher [18] formula as modified by Jung [19] and determined to be 156.

2.3. Sample Collection and Processing

Data on the prevalence and antimicrobial susceptibility of *S. aureus* were collected using a laboratory request form, while socio-demographic data were gathered through a questionnaire administered to participants. Pus specimens from diabetic foot infections were collected by swabbing the wounds aseptically for *S. aureus* screening. The wounds were cleaned with sterile saline, and the swab was moistened with sterile saline before being applied to the wound in a zig-zag motion to swab the entire surface of the wound. Pus specimens from diabetic foot infections were also collected by swabbing the wounds aseptically for *S. aureus* screening. Gram staining was performed to identify the organisms present in the specimens. The samples were then inoculated onto Blood Agar (BA) plates and

incubated at 37˚C for 24 to 48 hours. Isolated colonies were sub-cultured onto Mannitol Salt Agar (MSA) and tested for free coagulase enzyme production using the tube coagulase test. All confirmed *S. aureus* strains were further tested for antimicrobial susceptibility using the agar disk diffusion method, following the Clinical and Laboratory Standards Institute (CLSI) 2020 guidelines. Antibiotics tested included; Amoxicillin (30 µg), Ampicillin (10 µg), Cefoxitin (30 µg), Ciprofloxacin (5 µg), Clindamycin (2 µg), Erythromycin (15 µg), Tetracycline (30 µg), and Trimethoprim (25 µg). All experiments were conducted in triplicate to ensure reliability. The results were shared with the participants and the attending clinicians for further management.

2.4. Ethical Considerations

The authority to conduct research was obtained from NACOSTI (license no. NACOSTI/P/24/34462). Ethical approval to research human subjects was sought from the MTRH/Moi University Institutional Ethics Review Committee (reference no: IREC/895/2024). The purpose of the study was explained to each of the participants. Informed consent was also obtained from patients who met the desired criteria and who agreed to participate in the study.

2.5. Statistical Analysis

Data from the questionnaire and laboratory results were coded and converted into numerical data, which was entered into SPSS version 20. ANOVA was used to determine inferential statistical significance between datasets at a 95% confidence level ($p \leq 0.05$) and considered to be statistically significant if the difference in antimicrobial performance between the tested isolates and the controls had p values of $p \leq 0.05$. Pearson Chi-square (χ^2) was used to determine if the risk factors were significantly associated with *S. aureus* infection of wounds from diabetic patients attending the outpatient diabetic clinic at MTRH.

3. Results

3.1. Demographic Characteristics of Participants

This study utilised a total of 156 patients' specimens collected out of which 93 (59.62%) were males and 63 (40.38%) were females. Most of the study participants were between the ages of 45 - 60 years. A majority (122) of the diabetic patients in this study period were married. 19 (12.18%) were single, while 9.62% (15) of the positive cases were from widows/widowers. 69 (44.23%) of the patients had primary school education, while 36 (23.08%) had secondary school education. 33 (21.15%) of the respondents had a tertiary school education, with only 18 (11.54%) having no school experience. More than half (56.41%) of the diabetic patients attending the outpatient diabetic clinic at the MTRH during the duration of this study had underlying conditions. A majority of the diabetic patients, 133 (85.26%), in this study also had previously been hospitalized. A total of 50 (32.05%) had used antibiotics before they enrolled in this study. The data is

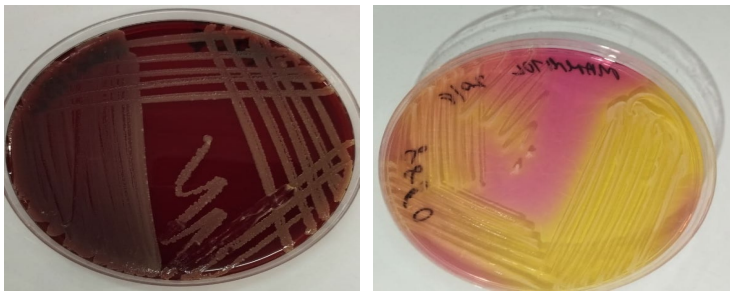
presented in Table 1.

Table 1. Demographic characteristics of participants.

Factor	Categories	Total (%)
Age Group (Years)	13 - 30	15 (9.62)
	31 - 44	26 (16.67)
	45 - 60	60 (38.46)
	>60	55 (35.25)
Sex	Female	63 (40.38)
	Male	93 (59.62)
Underlying Conditions	Yes	88 (56.41)
	No	68 (43.59)
Hospitalized	Yes	133 (85.26)
	No	23 (14.74)
Antibiotics Use	Yes	50 (32.05)
	No	106 (67.95)
Marital Status	Single	19 (12.18)
	Married	122 (78.21)
	Other	15 (9.62)
Level of Education	Primary	69 (44.23)
	Secondary	36 (23.08)
	Tertiary	33 (21.15)
	No School	18 (11.54)

3.2. Prevalence of *Staphylococcus aureus* from Diabetic Wounds of Patients

This study utilised 156 (100%) samples obtained from wounds of diabetic patients attending the outpatient diabetic clinic at the MTRH (Figure 1). The yellowish appearance of colonies on MSA indicated the presence of *S. aureus*.



(a) (b)

Figure 1. *Staphylococcus* species on Blood agar (a) and Mannitol Salt agar (b).

Further identification was obtained through Gram staining (Figure 2(a)) and

biochemical tests like the Catalase test (Figure 2(b)) and the Coagulase test (Figure 2(c))

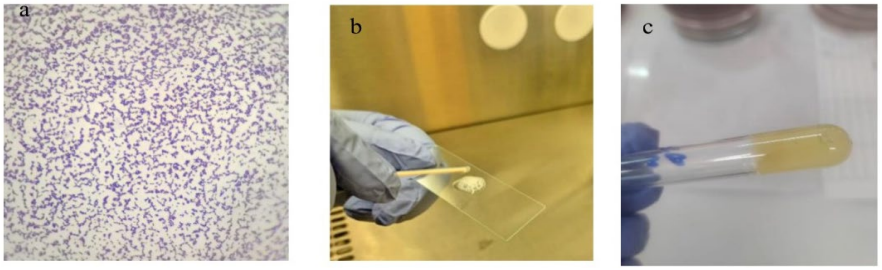


Figure 2. Identification of *S. aureus* by Gram Staining (a), Catalase test (b), and Coagulase test (c).

Upon confirmation of *S. aureus* from the samples, this study noted that 31 (19.87%) samples were positive, while 125 (80.13%) samples tested negative. This translates to a prevalence of 19.87% as shown in Table 2.

Table 2. Prevalence of *Staphylococcus aureus* from wounds of diabetic patients at MTRH.

Samples Examined	No.	Prevalence (%)
Positive	31	19.87
Negative	125	
Total	156	

3.3. Antibiotic Susceptibility Patterns of the *S. aureus* Isolates

This study assessed the antibiotic susceptibility patterns of the isolated *S. aureus* against eight (8) antibiotics of different classes/families and with different modes of action as prioritized under the MTRH protocol. The clear zones formed around the discs were recorded as zones of inhibition (Figure 3), which were measured in millimetres using Vernier callipers. *S. aureus* had varying degrees of susceptibility profiles to the antibiotics they were subjected to by the disc diffusion method (Table 3 & Figure 4). *Staphylococcus aureus* isolated in this study had at least one instance of intermediate sensitivity 26, 10.48%) and/or antibiotic resistance 72, 29.03%) to the other antibiotics. However, more than half of the isolates were susceptible to the test antibiotics, as shown in Table 3. A higher number of *S. aureus* isolates were susceptible to Cefoxitin (96.77%) and Clindamycin (80.65%), with lesser susceptibility to Ampicillin (25.81%) (Table 3).

Table 3. Susceptibility profile of *S. aureus* to tested antibiotics.

Antibiotic	Susceptible N (%)	Intermediate N (%)	Resistant N (%)
Amoxicillin	18 (58.06)	5 (16.13)	8 (25.81)
Ampicillin	8 (25.81)	11 (35.48)	12 (38.71)
Cefoxitin	30 (96.77)	-	1 (3.23)

Continued

Ciprofloxacin	16 (51.61)	2 (6.45)	13 (41.94)
Clindamycin	25 (80.65)	-	6 (19.35)
Erythromycin	20 (64.51)	1 (3.23)	10 (32.26)
Tetracycline	15 (48.39)	6 (19.35)	10 (32.26)
Trimethoprim	18 (58.06)	1 (3.23)	12 (38.71)

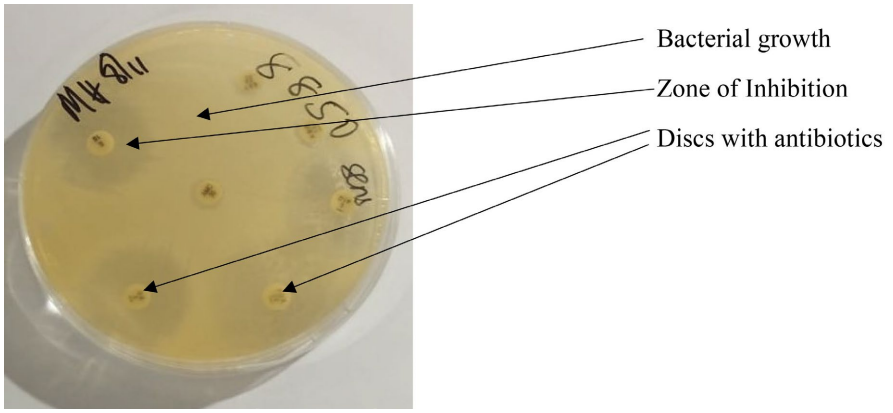


Figure 3. Antibacterial susceptibility test of *S. aureus* showing clear zones of inhibition. A display of the results of an antibiotic susceptibility test, illustrating the zones of inhibition surrounding different antibiotic discs tested against a *S. aureus* isolate on Mueller-Hinton agar.

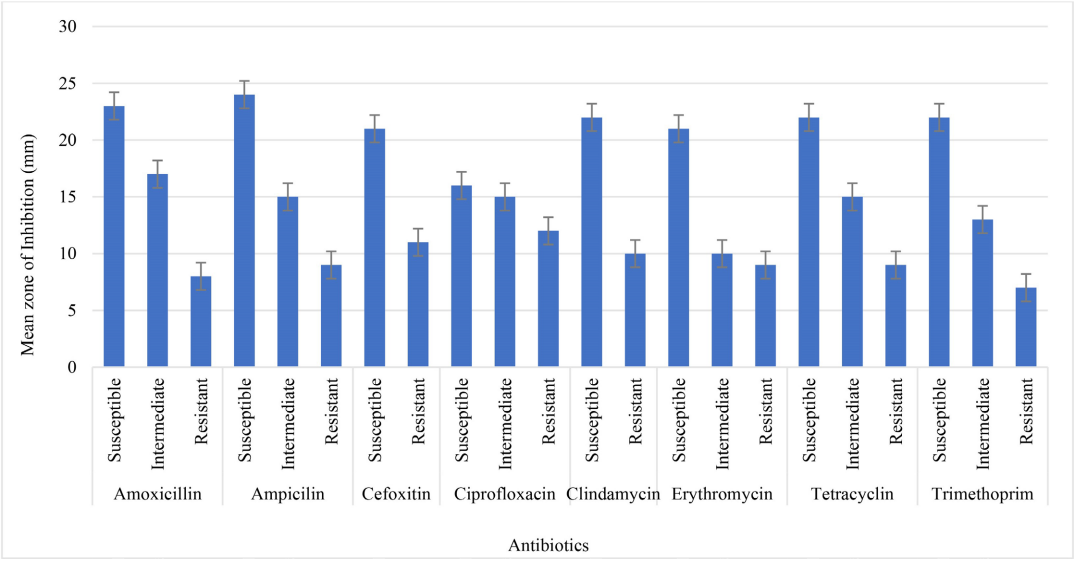


Figure 4. Antibacterial susceptibility profiles of *Staphylococcus aureus* isolates from wounds of diabetic patients attending the outpatient diabetic clinic at MTRH.

Analysis of variance was used, and a statistically significant p-value of 0.0000 at a 95% confidence level ($F = 333.72$, $p < 0.0001$) (**Table 4**) was obtained. This indicates that the mean susceptibility of the isolates varied significantly across the different antibiotics evaluated.

Table 4. ANOVA table on susceptibility of *S. aureus* isolated from diabetic wounds of patients attending outpatient diabetic clinics at MTRH.

Source of Variation	SS	Df	MS	F	p-value
Between Groups	8195.508	2	4097.754	333.7214	0.0000
Within Groups	3008.347	245	12.2789		
Total	11203.85	247			

3.4. Risk Factors Associated with the Occurrence of *S. aureus* in Diabetic Wound Infections in Diabetic Patients Attending the Outpatient Diabetic Clinic at MTRH

Out of the 31 (19.87%) positive cases for the presence of *S. aureus* in wounds of diabetic patients, the majority (13) were patients more than 60 years of age. Age groups of 13 - 30 and 31 - 44 had 4 (2.56%) positive cases each, while those aged between 45 and 60 years old were 10 (6.41%) (Table 5). Despite those aged more than 60 years returning a higher positivity rate, the statistically insignificant Chi-square test p-value of 0.6503 at a 95% confidence level indicated that the age of a diabetic patient(s) is not directly linked to the presence of *S. aureus* in their wounds (Table 5). This means that *S. aureus* is likely to be present in wounds of diabetic patients attending the outpatient diabetic clinic at MTRH, irrespective of their age.

A total of 93 (59.62%) male and 63 (40.38%) female diabetic patients attending the outpatient diabetic clinic at MTRH were enrolled in this study. Of the 31 positive cases, 13 (8.33%) were male, while 18 (11.54%) were female. The statistically significant chi-square test p-value of 0.025 at $p \leq 0.05$ means that the sex of a diabetic patient significantly influences infection with *S. aureus* (Table 5). The sex of diabetic patients, particularly those attending an outpatient diabetic clinic at the MTRH, can be linked to the existence and subsequent isolation of *S. aureus* in their wounds. This is evident from the results of this study, whereby female diabetic patients returned a significantly higher positivity rate when compared to male diabetic patients.

More than half (56.41%) of the diabetic patients attending the outpatient diabetic clinic at MTRH during the duration of this study had underlying conditions. Out of the total (31) positive cases of *S. aureus* infection, 17 (10.9%) were from diabetic patients who had underlying conditions, accounting for only 8.97% (14) of the total patients enrolled (Table 5). Using the chi-square test, the statistically insignificant p-value of 0.8437 at a 95% confidence level indicates that there was no relation between the existence of underlying conditions and the presence of *S. aureus* in wounds in this study's cohort (Table 5). That means that diabetic patients are likely to get *S. aureus* infection, whether they have underlying conditions or not.

The majority of the diabetic patients, 133 (85.26%), in this study, had previously been hospitalized for various reasons, out of which 26 (16.67%) of them returned a positive result (Table 5). Despite that, the statistically insignificant chi-square test p-value of 0.808 at a 95% confidence level indicates that there was no relation

between the existence of previous hospitalization and the presence of *S. aureus* in wounds (Table 5). This implies that those diabetic patients attending the outpatient diabetic clinic at MTRH are likely to have *S. aureus* in their wounds, irrespective of their prior hospitalization status in this study's cohort.

Table 5. Risk factors associated with the Occurrence of *S. aureus* in diabetic wound infections from diabetic patients at the MTRH.

Factor	Categories	Total (%)	Positive (%)	Negative (%)	p-value
Age Group (Years)	13 - 30	15 (9.62)	4 (2.56)	11 (7.05)	0.6503
	31 - 44	26 (16.67)	4 (2.56)	22 (14.1)	
	45 - 60	60 (38.46)	10 (6.41)	50 (32.05)	
	>60	55 (35.25)	13 (8.33)	42 (26.92)	
Sex	Female	63 (40.38)	18 (11.54)	45 (28.85)	0.025
	Male	93 (59.62)	13 (8.33)	80 (51.28)	
Underlying Conditions	YES	88 (56.41)	17 (10.9)	71 (45.51)	0.8437
	NO	68 (43.59)	14 (8.97)	54 (34.62)	
Hospitalized	YES	133 (85.26)	26 (16.67)	107 (68.59)	0.808
	NO	23 (14.74)	5 (3.21)	18 (11.54)	
Antibiotics Use	YES	50 (32.05)	9 (5.77)	41 (26.28)	0.6874
	NO	106 (67.95)	22 (14.1)	84 (53.85)	
Marital Status	Single	19 (12.18)	3 (1.92)	16 (10.26)	0.118
	Married	122 (78.21)	22 (14.1)	100 (64.1)	
	Other	15 (9.62)	6 (3.85)	9 (5.76)	
Level of Education	Primary	69 (44.23)	16 (10.26)	53 (33.97)	0.192
	Secondary	36 (23.08)	3 (1.92)	33 (21.15)	
	Tertiary	33 (21.15)	9 (5.77)	24 (15.38)	
	No School	18 (11.54)	3 (1.92)	15 (9.62)	

* Chi-Square test.

A total of 50 (32.05%) diabetic patients attending the outpatient diabetic clinic at MTRH in this study had used antibiotics before enrolment. Of the 31 (19.87%) positive cases, 9 (5.77%) diabetic patients had used antibiotics, while 41 (26.28%) had no history preceding their enrolment (Table 5). This indicated that there was no (p-value of 0.6874) relation between prior antibiotic use and the presence of *S. aureus* in the wounds of diabetic patients in this study's cohort (Table 5).

A majority (122) of the diabetic patients attending the outpatient diabetic clinic at the MTRH during this study period were married. 14.1% (22) of them returned positive results for *S. aureus* infections in their wounds. Three (1.92%) of the positive cases were from those who were single, while 3.85% (6) of the positive cases were from others (widows/widowers) (Table 5). Despite more married individuals returning a higher positivity rate, the marital status of diabetic patients (s) is

not statistically (p-value of 0.118) directly linked to the presence of *S. aureus* in their wounds (Table 5). This means that *S. aureus* is likely to be present in wounds of diabetic patients at MTRH irrespective of their marital status within this study group.

Out of the 31 (19.87%) positive cases for the presence of *S. aureus* in wounds of diabetic patients, the majority, 16 (10.26%) out of 69, had a primary school education. Those with tertiary school education were 33, with 9 (5.77%) returning positive results of *S. aureus* infections. Diabetic patients who attended the outpatient diabetic clinic at the MTRH during the duration of this study and had no school experience or had with secondary school education returned 3 (1.92%) positive cases each, from a total of 18 and 36, respectively (Table 5). Despite those who had primary school education only having a higher positivity rate, the level of education of diabetic patient (s) could not be statistically (p-value = 0.192) directly linked to the presence of *S. aureus* in their wounds (Table 5). This means that *S. aureus* is likely to be present in wounds of diabetic patients at the MTRH, irrespective of their level of education within the population studied.

4. Discussion

A total of 156 samples were obtained from wounds of diabetic patients attending the outpatient diabetic clinic at the MTRH during the study period. 31 samples were positive, while 125 samples tested negative. This translates to a prevalence of 19.87%. The prevalence result of this study is lower when compared to similar studies conducted at Vihiga County Referral Hospital [15]. That study established an overall 60.3% prevalence of *S. aureus* infection among diabetes mellitus patients. Similar studies in Ethiopia also recorded higher prevalence of 31.1% [20] and 25.19% [21]. Mutonga [16] recorded 98% prevalence while Amini [22] reported 87% prevalence. The difference can not only be attributed to the differences in periods and settings in which the studies were conducted, but also to the fact that these studies focused on foot ulcers. According to Mutonga [16], it is estimated that 10 - 15% of diabetic patients will develop DFUs at some point in their lives. Tuvei [15] also documents that foot ulcers are more prone to infections than other wounds. These high prevalences can be attributed to the fact that most often, *S. aureus* colonizes skin or mucosal surfaces. However, it has been documented that children, HIV or diabetic patients are more prone to *S. aureus* colonization if they have wounds [23]. They also have the potential to cause serious infections if not treated early. Even when the virulence and invasive capability of *S. aureus* strains recovered from diabetes patients' wounds are lower than those of strains typically seen in infections, they nevertheless retain the ability to cause and sustain invasive and deep tissue infections [24].

The results of this study indicate that antibiotic resistance is not widespread among diabetic patients, which has also been reported by other authors before [15] [16] [20]-[22]. These findings differ from those of Amini [22] Reported 63.9% resistance by *S. aureus* isolates to Clindamycin. Atlaw [21] Also documented a

high level of resistance of *S. aureus* to erythromycin and trimethoprim, unlike in the current study. The authors, however, reported that the *S. aureus* isolates were sensitive to clindamycin, just like in the current study. These also concur with the findings of Fawad. [25] who documented that the *S. aureus* they isolated showed high sensitivity to Cefoxitin and Clindamycin. Bhat [26] Also documented that *S. aureus* presented better susceptibility to commonly used antibiotics like Erythromycin, ceftriaxone, and clindamycin. *S. aureus* isolates showed high rates of resistance to oxacillin (95.2%), clindamycin (68.7%), and erythromycin (65.6%) according to Owais [27] the spread of antibiotic-resistant *S. aureus* complicates therapy, underscoring the need for robust infection control measures, such as enhanced hygiene, and the development of novel therapeutic approaches. Given the variability in antibiotic resistance patterns, personalized treatment plans based on susceptibility testing are essential for effective management.

The findings of this study regarding the influence of age group on the prevalence of *S. aureus* concur with those of earlier studies. Tuvei [15] reported an even higher prevalence rate among those in the 60 years and older age group at 63.8%. Amini [22] also documented that more than half (51/90) were more than 60 years old. This was similar to Rashid. [28], who established a higher prevalence for those aged over 50 years. This observation could be attributed to this group of patients having other pre-existing medical conditions like hypertension, reduced mobility, and rare visits to the diabetic clinic. The danger of T2D is at its peak with an increase in age, especially after 45 years, due to less exercise, and thus gaining weight [29]. Therefore, aging may augment T2DM risk through pathophysiological mechanisms independent of obesity. As has been reported by other authors before, as people age, their immune systems become less effective at fighting off infections. Older individuals often have reduced neutrophil function and other immune impairments, making them more susceptible to infections like *S. aureus.* [30].

The sex of a diabetic patient significantly ($p = 0.025$) influenced infection with *S. aureus* in this study cohort. The sex of diabetic patients, particularly those attending the outpatient diabetic clinic at MTRH, can be linked to the existence and subsequent isolation of *S. aureus* in their wounds. This is evident from the results of this study, whereby female diabetic patients returned a significantly higher positivity rate (11.54%) when compared to male diabetic patients. The highest prevalence of *S. aureus* infections in diabetic wounds in females could be attributed to the kind of chores traditionally female-dominated. Most studies have not explored the influence of sex in the occurrence of diabetes. That is despite an estimated 17.7 million more men than women worldwide suffering from diabetes mellitus. However, when type 2 diabetes is diagnosed, women seem to have a higher load of risk factors. Most studies have also not explored the influence of sex in the occurrence of diabetes. Women experience greater hormonal fluctuations throughout their lives, particularly during pregnancy and menopause, which can affect glucose metabolism and increase the risk of developing diabetes [31]. The influence of sex is therefore inconclusive, as some studies demonstrated male gender as a risk factor,

some female gender as a risk factor, while other studies have shown no difference. Amini [22] reported equal proportions of infections in both sexes. Tuvei [15] reported that females had a higher prevalence of 57.4% as compared to their male counterparts at 42.6% just as was in this study also shared the same view [28] [32] [33]. However, this study's results contradicted those of other studies reporting a higher prevalence in males than in females [21] [34]-[37].

More than half (56.41%) of the diabetic patients attending the outpatient diabetic clinic at MTRH during the duration of this study had underlying conditions. The most frequent was hypertension, followed by heart disease and kidney disease. Just like other studies before, this study found that underlying conditions raise diabetes risk by altering metabolic health, causing insulin resistance, and complicating the care of modifiable risk factors. The higher positivity rate can be attributed to the already low immune systems among most diabetic patients. Underlying conditions weaken the patient's immune system, rendering them highly susceptible to other infections. Reveles [35] they are of the same opinion, with their findings comparable to those from this study. According to the authors, hypertension (76%), dyslipidaemia (52%), obesity (49%), peripheral vascular disease (37%), and kidney disease (12%) significantly predispose diabetic patients to *S. aureus* infection.

A majority of the diabetic patients, 133 (85.26%) in this study, had previously been hospitalized for various reasons, out of which 26 (16.67%) of them returned a positive result. This is slightly lower than the findings of Reveles [35]. The authors documented a prevalence of 19% among patients with a history of recent hospitalization. This suggests that it is possible that *S. aureus* infection among diabetic patients in this and other studies could be due to nosocomial risk. The use of improperly sterilized equipment as well as contaminated fomites in hospitals could be the main reason.

The present study identified previous hospitalization as an independent risk factor for *S. aureus* infection. Hospital-acquired infection is one of the most common causes of microbial infections [38]. According to Liu [39] the occurrence of hospital-acquired infections is mainly due to the poor ward environment and the inadequate implementation of isolation measures for patients.

Another 50 (32.05%) diabetic patients attending the outpatient diabetic clinic at MTRH in this study had used antibiotics before enrolment. Of the 31 (19.87%) positive cases, 9 (5.77%) diabetic patients had used antibiotics. The statistically insignificant chi-square test p-value of 0.6874 at a 95% confidence level indicates that there was no relation between prior antibiotic use and the presence of *S. aureus* in the wounds of diabetic patients. This means that the *S. aureus* isolates could not be directly labelled as resistant to the antibiotics used by the patients before this study. That means they may have been contracted after completion of the prescribed dosage. However, that contradicts the findings from Amini. [22] who reported that 55.4% of the positive cases had a history of recent antibiotic therapy in the last few days. Reveles [35] also holds the same view with a 43%

positivity rate documented by the authors. According to Yuan [40] antibiotics can raise the risk of diabetes by altering the gut microbiota and impacting metabolic health. Additionally, the risk may be confounded by underlying diseases that require the use of antibiotics.

A majority (122) of the diabetic patients attending the outpatient diabetic clinic at MTRH during this study period were married. 14.1% (22) of them returned positive results for *S. aureus* infections in their wounds. 1.92% (3) of the positive cases were from those who were single, while 3.85% (6) of the positive cases were from others (widows/widowers). Similar findings have also been documented by earlier studies. Tuvei [15] noted that those married had a higher prevalence of 84.0%. Aedh [34] also documented similar findings. According to Karimi [41], divorced people are less likely to have T2DM, widowed people are less likely to have T2DM, and single people are more likely to have it. It has also been documented that single men may have a higher risk of diabetes compared to married men, while the impact on women can be different depending on the specific marital status. Social support, which is frequently provided by marriage, has a favourable impact on health-related behaviours, including diet, exercise, and treatment compliance. Regarding the effect of marital status on *S. aureus* infection rates, the majority of studies have produced conflicting findings, with the majority suggesting that married participants had higher rates [42]. This can be attributed to increased exposure and transmission opportunities within households.

Out of the 31 (19.87%) positive cases for the presence of *S. aureus* in wounds of diabetic patients, the majority, 16 (10.26%) out of 69, had a primary school education. Those with tertiary school education were 33, with 9 (5.77%) returning positive results of *S. aureus* infections. Diabetic patients who attended the outpatient diabetic clinic at MTRH during the duration of this study and had no school experience or had with secondary school education returned 3 (1.92%) positive cases each, from a total of 18 and 36, respectively. Tuvei [15] Conducted an education level analysis from their data and noted that those with primary level education had the highest prevalence rate at 51.1% just like in the current study. Aedh [34] also reported similar findings. Reduced socioeconomic status is frequently associated with lower education levels, which can result in more exposure to cramped living arrangements, unsanitary environments, and restricted access to medical treatment. Low levels of education may also contribute to poor dressing of their wounds, as most do not acquire sanitary techniques. Highly educated people may have easier access to early detection and treatment, which lowers the risk of severe infections [43]. These factors can increase the risk of diabetes and/or *S. aureus* infections.

5. Conclusion

The study reports an *S. aureus* prevalence of 19.87% from diabetic wounds of patients attending MTRH. The majority of the *S. aureus* isolates were susceptible to

Cefoxitin, Erythromycin, and Clindamycin, with lesser susceptibility to Ampicillin. With other antibiotics having at least instances of intermediate sensitivity and/or antibiotic resistance by the isolates. Sex influences the occurrence of *S. aureus* in diabetic wounds of patients attending the diabetic clinic at MTRH. Age, underlying conditions, previous hospitalization, previous antibiotic use, marital status, and level of education do not significantly predispose the occurrence of S. *aureus* in diabetic wound patients. The study recommends Surveillance and early screening to detect any presence of *S. aureus* in diabetic wounds at MTRH to track the development of resistance trends and guide empirical treatment recommendations, as well as to inform early management measures. Considering the detected patterns of antimicrobial susceptibility, the study suggests that MTRH's local empirical treatment protocols for infections related to diabetic wounds should favor Cefoxitin and Clindamycin, while reevaluating the standard use of Ampicillin due to elevated resistance levels. Female diabetic patients should be more cautious to prevent any traumatic injury, which could lead to diabetic wound infections.

Data Availability

All data generated or analyzed during this study are included in this published article.

Consent to Participate

Written informed consent was obtained from all participants before the commencement of the study.

Ethics Approval

The study was carried out with approval obtained from NACOSTI (license no: NACOSTI/P/24/34462) as well as the Institutional Research and Ethics Committee (IREC) of Moi MTRH and Moi University School of Medicine, and permission to conduct the study from MTRH management (Approval No: 0004852).

Authors' Contributions

The authors contributed equally to the development of the research concept. DOO researched while RS and ABN supervised the work. DOO analysed the data and developed the draft manuscript. RS and ABN reviewed the manuscript and data analysis.

Acknowledgements

The authors would like to thank the staff at Moi Teaching and Referral Hospital's diabetic clinic and Laboratory Directorate, as well as the entire management, for the opportunity to conduct our research within the facility, along with their kind cooperation and encouragement.

Conflicts of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

References

[1] Standl, E., Khunti, K., Hansen, T.B. and Schnell, O. (2019) The Global Epidemics of Diabetes in the 21st Century: Current Situation and Perspectives. *European Journal of Preventive Cardiology*, **26**, 7-14. https://doi.org/10.1177/2047487319881021

[2] Ogurtsova, K., Guariguata, L., Barengo, N.C., Ruiz, P.L., Sacre, J.W., Karuranga, S., *et al.* (2022) IDF Diabetes Atlas: Global Estimates of Undiagnosed Diabetes in Adults for 2021. *Diabetes Research and Clinical Practice*, **183**, Article 109118. https://doi.org/10.1016/j.diabres.2021.109118

[3] Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., *et al.* (2019) Global and Regional Diabetes Prevalence Estimates for 2019 and Projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th Edition. *Diabetes Research and Clinical Practice*, **157**, Article 107843. https://doi.org/10.1016/j.diabres.2019.107843

[4] Al-Khaledi, M., Al-Dousari, H., Al-Dhufairi, S., Al-Mousawi, T., Al-Azemi, R., Al-Azimi, F., *et al.* (2018) Diabetes Self-Management: A Key to Better Health-Related Quality of Life in Patients with Diabetes. *Medical Principles and Practice*, **27**, 323-331. https://doi.org/10.1159/000489310

[5] Inzucchi, S.E., Bergenstal, R.M., Buse, J.B., Diamant, M., Ferrannini, E., Nauck, M., *et al.* (2014) Management of Hyperglycemia in Type 2 Diabetes, 2015: A Patient-Centered Approach: Update to a Position Statement of the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care*, **38**, 140-149. https://doi.org/10.2337/dc14-2441

[6] Hurlow, J.J., Humphreys, G.J., Bowling, F.L. and McBain, A.J. (2018) Diabetic Foot Infection: A Critical Complication. *International Wound Journal*, **15**, 814-821. https://doi.org/10.1111/iwj.12932

[7] Hinojosa, C.A., Boyer-Duck, E., Anaya-Ayala, J.E., Núñez-Salgado, A.E., Laparra-Escareno, H. and Lizola, R. (2018) Impact of Revascularization and Factors Associated with Limb Salvage in Patients with Diabetic Foot. *Gaceta Médica de México*, **154**, 146-152. https://doi.org/10.24875/gmm.18002772

[8] Anwar, K., Hussein, D. and Salih, J. (2020) Antimicrobial Susceptibility Testing and Phenotypic Detection of MRSA Isolated from Diabetic Foot Infection. *International Journal of General Medicine*, **13**, 1349-1357. https://doi.org/10.2147/ijgm.s278574

[9] Foster, T.J. (2019) Surface Proteins of *Staphylococcus aureus*. *Microbiology Spectrum*, **7**, 1-22. https://doi.org/10.1128/microbiolspec.gpp3-0046-2018

[10] Lister, J.L. and Horswill, A.R. (2014) *Staphylococcus aureus* Biofilms: Recent Developments in Biofilm Dispersal. *Frontiers in Cellular and Infection Microbiology*, **4**, Article ID: 178. https://doi.org/10.3389/fcimb.2014.00178

[11] Thomas, S., Liu, W., Arora, S., Ganesh, V., Ko, Y. and Höök, M. (2019) The Complex Fibrinogen Interactions of the *Staphylococcus aureus* Coagulases. *Frontiers in Cellular and Infection Microbiology*, **9**, Article ID: 106. https://doi.org/10.3389/fcimb.2019.00106

[12] Visansirikul, S., Kolodziej, S.A. and Demchenko, A.V. (2020) *Staphylococcus aureus* Capsular Polysaccharides: A Structural and Synthetic Perspective. *Organic & Biomolecular Chemistry*, **18**, 783-798. https://doi.org/10.1039/c9ob02546d

[13] Bashabsheh, R.H.F., AL-Fawares, O., Natsheh, I., Bdeir, R., Al-Khreshieh, R.O. and Bashabsheh, H.H.F. (2023) *Staphylococcus aureus* Epidemiology, Pathophysiology, Clinical Manifestations and Application of Nano-Therapeutics as a Promising Approach to Combat Methicillin Resistant *Staphylococcus aureus*. *Pathogens and Global Health*, **118**, 209-231. https://doi.org/10.1080/20477724.2023.2285187

[14] Anafo, R.B., Atiase, Y., Dayie, N.T.K.D., Kotey, F.C.N., Tetteh-Quarcoo, P.B., Duodu, S., *et al.* (2021) Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infection of Diabetic Foot Ulcers at a Tertiary Care Hospital in Accra, Ghana. *Pathogens*, **10**, Article 937. https://doi.org/10.3390/pathogens10080937

[15] Tuvei, S.M. (2017) 'Prevalence and Antimicrobial Susceptibility of *Staphylococcus aureus* Isolated from Diabetes Mellitus Patients with Foot Ulcers at Vihiga County Referral Hospital, Kenya. Doctoral Dissertation, Maseno University.

[16] Mutonga, D.M. (2018) Isolation, Sensitivity Patterns, and Molecular Characterization of Bacterial Isolates from Infected Diabetic Foot Ulcers in Patients at Kenyatta National Hospital. Master's Thesis, University of Nairobi.

[17] Kisoi, S.K. (2021) The Prevalence and Antimicrobial Susceptibility Patterns of Bacteria That Cause Chronic Wound Infections among Patients at Kenyatta National Hospital. Master's Thesis, University of Nairobi.

[18] Fisher, A.A., Laing, J.E., Stoeckel, J.E. and Townsend, J. (1991) Handbook for Family Planning Operations Research Design. 2nd ed. Population Council. https://doi.org/10.31899/rh10.1039

[19] Jung, S. (2013) Stratified Fisher's Exact Test and Its Sample Size Calculation. *Biometrical Journal*, **56**, 129-140. https://doi.org/10.1002/bimj.201300048

[20] Mariam, T.G., Alemayehu, A., Tesfaye, E., Mequannt, W., Temesgen, K., Yetwale, F., *et al.* (2017) Prevalence of Diabetic Foot Ulcer and Associated Factors among Adult Diabetic Patients Who Attend the Diabetic Follow-Up Clinic at the University of Gondar Referral Hospital, North West Ethiopia, 2016: Institutional-Based Cross-Sectional Study. *Journal of Diabetes Research*, **2017**, Article ID: 2879249. https://doi.org/10.1155/2017/2879249

[21] Atlaw, A., Kebede, H.B., Abdela, A.A. and Woldeamanuel, Y. (2022) Bacterial Isolates from Diabetic Foot Ulcers and Their Antimicrobial Resistance Profile from Selected Hospitals in Addis Ababa, Ethiopia. *Frontiers in Endocrinology*, **13**, Article ID: 987487. https://doi.org/10.3389/fendo.2022.987487

[22] Amini, M., Davati, A. and Piri, M. (2013) Determination of the Resistance Pattern of Prevalent Aerobic Bacterial Infections of Diabetic Foot Ulcer. I*ranian Journal of Pathology*, **8**, 21-26. https://ijp.iranpath.org/article_8328.html

[23] Shettigar, K. and Murali, T.S. (2020) Virulence Factors and Clonal Diversity of *Staphylococcus aureus* in Colonization and Wound Infection with Emphasis on Diabetic Foot Infection. *European Journal of Clinical Microbiology & Infectious Diseases*, **39**, 2235-2246. https://doi.org/10.1007/s10096-020-03984-8

[24] Tuchscherr, L., Korpos, È., van de Vyver, H., Findeisen, C., Kherkheulidze, S., Siegmund, A., *et al.* (2018) *Staphylococcus aureus* Requires Less Virulence to Establish an Infection in Diabetic Hosts. *International Journal of Medical Microbiology*, **308**, 761-769. https://doi.org/10.1016/j.ijmm.2018.05.004

[25] Fawad, U. (2022) Bacteriological Spectrum and Antibiotic Susceptibility on Blood Culture in Newly Diagnosed Pediatric Patients with Acute Lymphoblastic Leukemia during the Induction Phase. *Cureus*, **14**, e25470. https://doi.org/10.7759/cureus.25470

[26] Bhat Y, R., Lewis, L. and KE, V. (2011) Bacterial Isolates of Early-Onset Neonatal

Sepsis and Their Antibiotic Susceptibility Pattern between 1998 and 2004: An Audit from a Center in India. *Italian Journal of Pediatrics*, **37**, Article No. 32. https://doi.org/10.1186/1824-7288-37-32

[27] Owais, D., Al-Groom, R.M., AlRamadneh, T.N., Alsawalha, L., Ahmad Khan, M.S., Yousef, O.H., *et al.* (2024) Antibiotic Susceptibility and Biofilm Forming Ability of Staphylococcus Aureus Isolated from Jordanian Patients with Diabetic Foot Ulcer. *Iranian Journal of Microbiology*, **16**, 450-458. https://doi.org/10.18502/ijm.v16i4.16303

[28] Rashid, Z., Farzana, K., Sattar, A. and Murtaza, G. (2012) Prevalence of Nasal *Staphylococcus aureus* and Methicillin-Resistant *Staphylococcus aureus* in Hospital Personnel and Associated Risk Factors. *Acta Poloniae Pharmaceutica*, **69**, 985-991.

[29] Amanat, S., Ghahri, S., Dianatinasab, A., Fararouei, M. and Dianatinasab, M. (2020) Exercise and Type 2 Diabetes. *Advances in Experimental Medicine and Biology*, Springer Nature, 91-105. https://doi.org/10.1007/978-981-15-1792-1_6

[30] Thorlacius-Ussing, L., Sandholdt, H., Larsen, A.R., Petersen, A. and Benfield, T. (2019) Age-Dependent Increase in Incidence of *Staphylococcus aureus* Bacteremia, Denmark, 2008-2015. *Emerging Infectious Diseases*, **25**, 875-882. https://doi.org/10.3201/eid2505.181773

[31] Kautzky-Willer, A., Leutner, M. and Harreiter, J. (2023) Sex Differences in Type 2 Diabetes. *Diabetologia*, **66**, 986-1002. https://doi.org/10.1007/s00125-023-05891-x

[32] Gebremedhn, G., Gebremariam, T.T., Wasihun, A.G., Dejene, T.A. and Saravanan, M. (2016) Prevalence and Risk Factors of Methicillin-Resistant *Staphylococcus aureus* Colonization among HIV Patients in Mekelle, Northern Ethiopia. *SpringerPlus*, **5**, Article No. 877. https://doi.org/10.1186/s40064-016-2613-7

[33] Simkhada, R. (2013) Urinary Tract Infection and Antibiotic Sensitivity Pattern among Diabetics. *Nepal Medical College Journal*, **15**, 1-4.

[34] Aedh, A.I. (2016) Methicillin-Resistant *Staphylococcus aureus* Prevalence, Response and Resistance to Antimicrobial Agents at King Khaled Hospital in Najran (KSA). *Journal of Medical and Dental Science Research*, **4**, 14-20.

[35] Reveles, K.R., Duhon, B.M., Moore, R.J., Hand, E.O. and Howell, C.K. (2016) Epidemiology of Methicillin-Resistant *Staphylococcus aureus* Diabetic Foot Infections in a Large Academic Hospital: Implications for Antimicrobial Stewardship. *PLOS ONE*, **11**, e0161658. https://doi.org/10.1371/journal.pone.0161658

[36] Oguzkaya-Artan, M., Artan, C. and Baykan, Z. (2016) Prevalence and Risk Factors for *Staphylococcus aureus* and Methicillin-Resistant *Staphylococcus aureus* Nasal Carriage Inpatients in a Tertiary Care Hospital's Chest Clinic in Turkey. *Nigerian Journal of Clinical Practice*, **19**, 313-317. https://doi.org/10.4103/1119-3077.179285

[37] Sekhar, S., Vyas, N., Unnikrishnan, M., Rodrigues, G. and Mukhopadhyay, C. (2014) Antimicrobial Susceptibility Pattern in Diabetic Foot Ulcer: A Pilot Study. *Annals of Medical and Health Sciences Research*, **4**, 742-745.

[38] Neubeiser, A., Bonsignore, M., Tafelski, S., Alefelder, C., Schwegmann, K., Rüden, H., *et al.* (2020) Mortality Attributable to Hospital Acquired Infections with Multidrug-Resistant Bacteria in a Large Group of German Hospitals. *Journal of Infection and Public Health*, **13**, 204-210. https://doi.org/10.1016/j.jiph.2019.07.025

[39] Liu, X., Ren, Q., Zhai, Y., Kong, Y., Chen, D. and Chang, B. (2022) Risk Factors for Multidrug-Resistant Organisms Infection in Diabetic Foot Ulcer. *Infection and Drug Resistance*, **15**, 1627-1635. https://doi.org/10.2147/idr.s359157

[40] Yuan, J., Hu, Y.J., Zheng, J., Kim, J.H., Sumerlin, T., Chen, Y., *et al.* (2020) Long-Term Use of Antibiotics and Risk of Type 2 Diabetes in Women: A Prospective Co-

hort Study. *International Journal of Epidemiology*, **49**, 1572-1581. https://doi.org/10.1093/ije/dyaa122

[41] Karimi, M.A., Binaei, S., Hashemi, S.H., Refahi, P., Olama, E., Olama, E., *et al.* (2025) Marital Status and Risk of Type 2 Diabetes among Middle-Aged and Elderly Population: A Systematic Review and Meta-analysis. *Frontiers in Medicine*, **11**, Article ID: 1485490. https://doi.org/10.3389/fmed.2024.1485490

[42] Adeiza, S.S., Ademola Onaolapo, J. and Olalekan Olayinka, B. (2020) Prevalence, Risk Factors and Antimicrobial Susceptibility Profile of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Obtained from Nares of Patients and Staff of Sokoto State-Owned Hospitals in Nigeria. *GMS Hygiene and Infection Control*, **15**, Doc25.

[43] Early, G.J. and Seifried, S.E. (2012) Risk Factors for Community-Associated *Staphylococcus aureus* Skin Infection in Children of Maui. *Hawai'i Journal of Medicine and Public Health*, **71**, 218-223.