

**Original Research Article**  
**Phenotypic Profiling of Selected Bacterial  
Microbes Isolated from Wounds of Diabetic  
Patients at Jaramogi Oginga Odinga Teaching  
& Referral Hospital, Kenya**

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**ABSTRACT**

**Aims:** To phenotypically profile selected bacteria microbes, determine antimicrobial resistance patterns and genetic diversity of resistant genes encoding extended spectrum  $\beta$ -lactamases in bacteria isolated from wounds of diabetes mellitus patients at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), Kenya.

**Study design:** A hospital based cross sectional study design

**Place and Duration of Study:** Jaramogi Oginga Odinga Teaching and Referral Hospital, Kenya between September, 2019 and February, 2020.

**Methodology:** Pus swabs were collected for isolation of bacteria using conventional techniques and serology involving 117 patients. Samples collected were inoculated onto Mac-Conkey agar, pseudomonas agar media (cetrimide) and blood agar plates then incubated aerobically at 37°C for 18hours to 24hours. Inoculated plates were examined for growth after 24-48 hours. After attaining pure colonies, gram staining, colony morphology, and biochemical testing were done. Biochemical tests were done to identify specific bacterial species. Biochemical tests involving Catalase, Coagulase, indole, Oxidase, urease citrate utilization tests were done according to microbiological standard procedures.

**Results:** The results of analysis showed that the prevalence of Gram positive cocci isolated from diabetic wounds was 34.2% while the prevalence for Gram negative rods was 65.8%. The biochemically profiled bacterial microbes were *S.aureus*, *E.coli*, *P.aeruginosa*, *K. pneumoniae* and *Proteus* species. *S.aureus* was the most commonly isolated bacteria with a prevalence of 34.2%. *P.aeruginosa* had a prevalence of 24(20.5%), *K. pneumoniae* 22(18.8%), *Proteus* species 18(15.4 %) and *E.coli* 13(11.1%). More importantly, the prevalence basing on chi-square results was significantly associated with education level, age, smoking habit, patient setting, drug uptake and hospital visit at 5% level of significance ( $p < 0.05$ ).

**Conclusion:** Diabetic patients with wounds at JOOTRH, Kenya are more exposed to gram negative rods infection. The most prevalent gram negative rod was *P. aeruginosa* with its prevalence associated with the patient's education level, smoking habit, patient setting, irregular hospital visit and adherence to taking of prescribe antibiotics regularly. Therefore, JOOTRH, Kenya healthcare providers to initiate wound infection preventive measures that may include awareness campaigns on the importance of wound management, regular hospital visits, stopping to smoke and regular uptake of prescribed drugs.

**Keywords:** [Phenotypic Profiling, Selected Bacterial Microbes, Diabetic Patients]

**1. INTRODUCTION**

Diabetes mellitus (DM) is a chronic metabolic ailment having numerous causes characterized by increased blood sugar with instabilities of carbohydrates, fats and proteins absorption that occur due to deficiencies in the secretion and action of insulin (Ibrahim *et al.*,2016). Diabetes has emerged as the new global epidemic, particularly the developing world, in which individuals living with the disease continues to increase at a startling rate in

comparison to the high income countries [22]. Diabetic patient's world over in 2013 stood at 382 million, which is estimated to rise to nearly 592 million by 2035 [21]. The estimated prevalence of diabetes in adults aged 20–79 years has more than tripled, from an estimated 151 million (4.6% of the global population) to 537 million (10.5%) in 2021 and without sufficient action to address the situation, it is predicted that 783 million people will have diabetes by 2045 (12.2% of the population) [10]. Like other parts of the world, Africa has a rising prevalence of diabetes besides other non-communicable diseases. For example, in the year 2010, more than 12 million persons were projected as being diabetic in Africa while the number is estimated to rise to 23.9 million in the year 2030 [8]. In 2021 according to [10], the prevalence of diabetes in Africa among adults aged 20 –79 years was 23.6 million (4.5%) and without sufficient action to address the situation, it is predicted that 54.9 million people will have diabetes by 2045, a prevalence of 5.2%.

More than half of admissions and death in Kenyan hospitals are attributed to non –communicable diseases with diabetic patients being the majority [21]. In the year 2021, occurrence of diabetes in Kenya stood at 3.0% a rise from 750,000 individuals in 2015 to 821,500 adults in 2021 [21, 22]. Statistics from the Public Health directorate in Kenya as stated by [15] specified that, the number of Kenyans with diabetes is projected to increase to 1.5 million (4.5 % of inhabitants) by 2025. Jaramogi Oginga Odinga Teaching & Referral Hospital (JOOTRH) is one of the high volume hospitals located in the western part of Kenya that has over 5 million persons [22]. County Government of Kisumu ranks diabetes amongst the top most cause of death with about 10 diabetic patients with wounds visiting the referral hospital on a daily basis. The rising incidence of diabetes exposes patients to long term problems such as wounds, cardiac and kidney difficulties [21]. The development of wounds is a serious complication for patients with diabetes [3]. The likelihood of a diabetic individual having a wound can be more than 25 % [1, 25, 29]. Prevalence of diabetic wounds has been estimated at 20.4 % in Netherlands, 4.10 % in America and about 4.7 % among the Kenyan population [6]. The prevalence of *S. aureus* in diabetic wounds in Vihiga County is estimated at 62.3% [28].

Amputations in diabetics is normally triggered by long-lasting wounds, well-defined according to [19] as a wound which does not show 20 % to 40 % reduced size after two to four weeks of optimum management. Infections of these wounds are often polymicrobial where Gram positive bacteria coexist with Gram negative organisms which complicate the long-standing ulcers making them extremely difficult to heal [7, 13]. Although phenotypic profiling varies in different areas, common bacteria identified include *S. aureus*, Enterobacteriaceae and *P. aeruginosa* which have proved to be multidrug resistant [6, 9, 21].

Several studies phenotypically profiling bacterial microbes colonizing diabetic wounds have been conducted world over which include [1, 9, 11, 18, 21] among others. Majority, of these studies established that gram negative bacteria as the most occurring than gram positive bacteria. [6, 9] indicated *Staphylococcus aureus* to be the most predominant pathogen, [21] noted *Enterococcus faecalis* and *Escherichia coli* as the predominant pathogens while [1, 18] indicated *Pseudomonas aeruginosa* as the most predominant pathogen. It is also noted that studies conducted in Kenya like [6,12, 20] focused on diabetes management education and foot problems among diabetic patients. This implies uncertainty with regard to the most predominant bacterial microbe colonizing diabetic patient's wounds which might be complicating treatment of diabetic wounds due to inaccurate diagnosis of the predominant pathogens justifying the study.

### **1.1 Statement of the Problem and Justification**

Wound colonization is more often polymicrobial, encompassing many microorganisms that are possibly pathogenic increasing the risk of wound infection that prolongs healing [24]. To reduce the burden of diabetes mellitus complications which pose severe threats to health

security an understanding of the predominant bacterial microbe isolated from wounds of diabetes mellitus patients is necessary. Several studies to identify the prevalence have been carried out, however, it has been noted that the studies including those conducted in Kenya showed contradicting views with regard to most phenotypically profiled bacteria colonizing wounds. This makes it impossible to single out the most prevalent bacterial microbe thus calling for continued research. This then justified a study to phenotypically profile selected bacterial microbes isolated from wounds of diabetic patients at Jaramogi Oginga Odinga Teaching & Referral Hospital, Kenya.

## 1.2 Literature Review

Vulnerability to infections by diabetic patients is as a result of higher sugar levels, reduced immune response as well as diminished blood movement to extremities that cause slow wound healing process [5, 27]. For example, 25 % of diabetic patients with wounds get contagions, regularly with antibiotic resistant bacteria, which dictate amputations [27]. Infections and serious metabolic problems are the major causes of death in Africa where for example, Diabetic ketoacidosis (DKA) accounted for 8 % of hospital admission at Kenyatta National Hospital, 30 % of patients passed on in 48 hours of presentation [26]. Diabetic wounds are observed regularly at tertiary clinics in Kenya and are linked with poor glycemic control, infections, hypertension and dyslipidemia [26].

To isolate the predominant organisms colonizing wounds, [9] in his study conducted in Western India by focusing on diabetic foot ulcers indicated that various gram positive and negative bacteria were isolated which included *Staphylococcus aureus* (21.8%), *Enterococcus faecalis* (4.6%), *Pseudomonas aeruginosa* (18.2%), *Escherichia coli* (13.6%), *Proteus spp* (9.1%), and *Acinetobacter baumannii* (7.3%), *Klebsiella pneumoniae* (6.4%). It was noted that although gram negative rods were the most prevalent than gram positive organisms, *Staphylococcus aureus* remained a predominant pathogen. [21], in their study in South India on pathogens colonizing diabetic foot ulcers established that 54.9% of pathogens isolated were gram negative bacteria while 38.1% were gram positive bacteria with *Enterococcus faecalis* and *Escherichia coli* as the most common pathogens isolated at 12.1% each. Unlike [9, 18, 21] in their studies to isolate the most common bacteria in India found out that *Pseudomonas aeruginosa* and *Klebsiella pneumonia* as the major pathogens respectively. Although the studies focused on the same target population, country they did not consent on which specific gram positive or negative pathogen that was most predominant. This might be ascribed to the dissimilarity in environmental distribution.

Studies singled out from Iraq such as [1, 11] to understand diabetic foot contaminations indicated in the findings that *Pseudomonas aeruginosa* and *Staphylococcus aureus* as the leading microorganism in occurrence respectively. A keen observations of the studies showed that the groups were from different localities that is urban and rural which begs the question whether the place one resides determines the microorganism that can colonize his/her wound.

There is continued debate on the predominance of bacteria colonizing wounds in Africa. Different studies outline conflicting views on the most occurring microorganism. For instance, [2, 15, 16] who researched in Nigeria, Libya and Ethiopia respectively found gram positive cocci, specifically *Staphylococcus aureus* to be the most frequent. On the other hand, [17] in Sudan found gram negative rods and specifically *Pseudomonas aeruginosa* as the pathogen that most commonly inhabit wounds. The divergent results in the different African countries indicate the uncertainty in making conclusions to which pathogen is most prevalent. Thus the need for similar studies in Kenya to establish predominant pathogens isolated from wounds of diabetic patients.

Studies done in Kenya by [4, 6, 20] at Kenyatta National Hospital show some evidence of pathogens colonizing wounds. For instance, [6] found *Proteus* to be the most common gram negative, [4] identified *Staphylococcus aureus* to be predominant while [20] got *Pseudomonas* spp as the leading bacteria. Although the research focused on KNH, the differences may be a pointer to other underlying factors that determine the spread of bacteria making it difficult to generalize the results to diabetic patients with wounds at JOOTRH.

From the reviews, several studies to classify the prevalence of gram positive and negative bacteria colonizing wounds have been undertaken world over. Majority concluded that gram positive pathogens were most predominant as compared to gram negative pathogens. Studies conducted in Kenya showed divergent views indicating uncertainty in relation to the most common bacteria colonizing wounds. This makes it difficult to make a conclusion as to whether gram positive or negative bacteria are the most prevalent among diabetic patients with wounds at JOOTRH thus a justification for the study to identify selected gram positive and negative bacteria isolated from wounds of diabetic patients at Jaramogi Oginga Odinga Teaching & Referral Hospital, Kenya.

## 2. MATERIAL AND METHODS

Swab samples collected were inoculated onto Mac-Conkey agar, pseudomonas agar media (cetrimide) and blood agar plates then incubated aerobically at 37°C for 18hours to 24hours. All the inoculated plates were examined for growth after 24 hours to 48 hours. The inoculated plates before and after growth are shown in Figures 1 and 2 respectively.

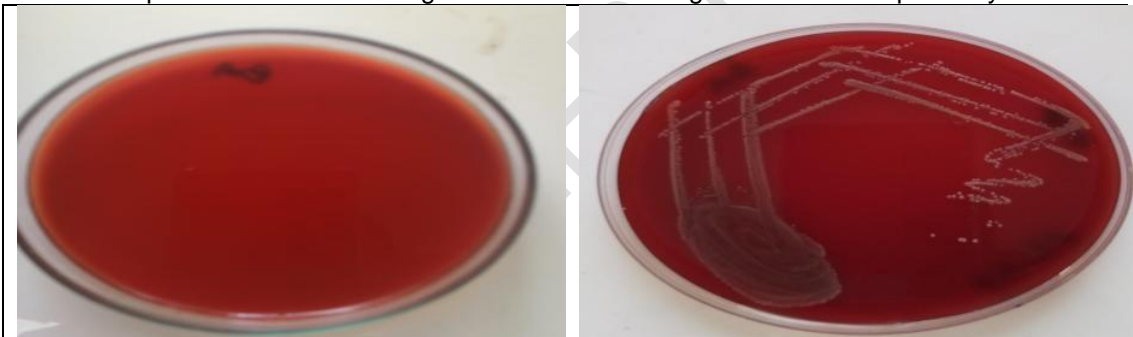


Figure 1: Inoculated plate before growth

Figure 2: Inoculated plate after growth

After attaining pure colonies, more procedures were performed by means of the standard microbiological practices, which included gram staining, colony morphology, and biochemical testing. Biochemical tests were done to identify specific bacterial species. Biochemical tests involving Catalase, Coagulase, indole, Oxidase, urease citrate utilization tests were done according to microbiological standard procedures.

### 2.1 Catalase test

The test involved emulsification of Gram positive colonies in two drops of hydrogen peroxide on a microscope slide. Presence of effervescence as in Figure 1 indicated colonies for *Staphylococcus*.

### 2.2 Coagulase test

The test distinguished pathogenic *S. aureus* from other *Staphylococcus* species. 0.3 milliliters of citrated rabbit plasma was put into two test tubes and labeled as control and sample. Tube labeled as sample was inoculated with a colony of Gram positive cocci and mixed by shaking to make a cloudy suspension. On the other hand, the control tube was

inoculated with *S. aureus* ATCC 25923 and both tubes incubated at 37°C for 1 hour to 4 hours. A clot as depicted in Figure 3 represented a positive coagulase test.



Figure 3: A positive coagulase test

### 2.3 Sugar fermentation test

The test was employed to confirm all the Enterobacteriaceae isolates. An inoculum from the pure culture was moved to a sterile tube having phenol red mannitol broth and incubated at 35-37°C for 18 hours to 24 hrs. Presence of enterobacteriaceae altered the colour of the broth from red to yellow, showing acid-gas production.

### 2.4 Indole test

To test the ability of the organism to degrade the amino acid tryptophan and produce indole, motility indole urea medium was inoculated with a small amount of a gram negative pure culture, incubated at 37°C for 24 to 48 hours using *Escherichia coli* ATCC 35218 indole as a positive control. 1ml of Kovac's reagent was added to the overnight growth. A positive indole test as in Figure 4 was indicated by the formation of a cherry red ring on top of the medium in 2 to 10 minutes.

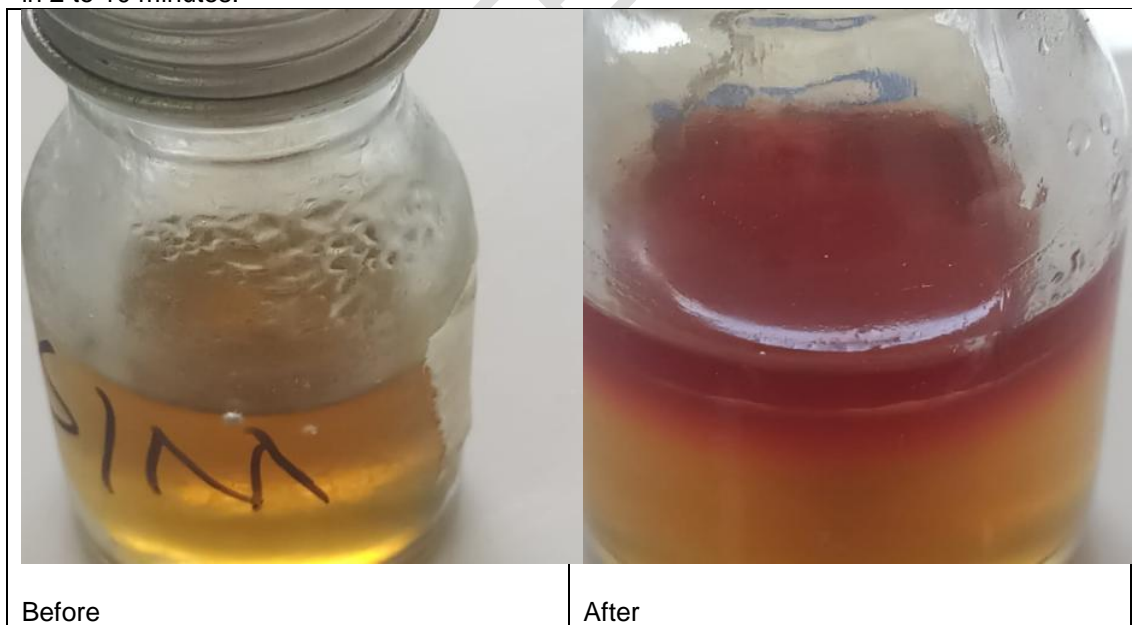


Figure 4: Indole test (Before and after addition of Kovac's reagent)

### 2.5 Citrate utilization Test

The test is used to identify *Klebsiella pneumoniae* that can utilize citrate as the sole carbon and energy source when inoculated on Simmons citrate medium. *Klebsiella pneumoniae* ATCC 700603 was used as positive control. Using a needle, a fresh 16 to 18 hour pure

culture was used as an inoculation source. A single isolated colony was picked and lightly streaked on the surface of the slant of Simmons citrate agar, and incubated at 37°C for 18 to 48 hours. Citrate positive growth visible on the slant surface of the medium with an intense Prussian blue indicated the presence of *Klebsiella pneumoniae* as in Figure 5 while a negative citrate test was shown by no colour change as depicted in Figure 6.

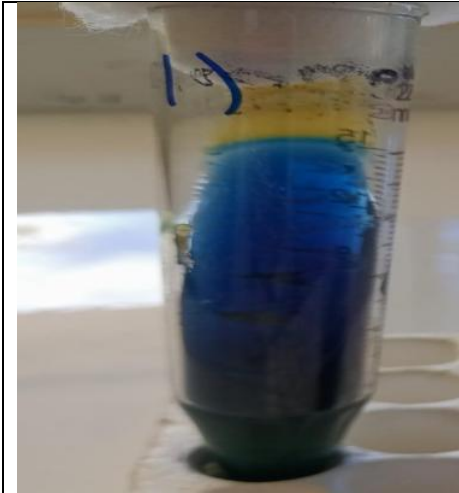


Figure 5: Citrate utilization positive test



Figure 6: Citrate utilization negative test

## 2.6 Urease Test

*Proteus species* hydrolyzes urea to produce ammonia and CO<sub>2</sub>. Ammonia changes the color of Christensen's urea agar slant from light orange to pink. *Proteus mirabilis* ATCC 29906 was used as positive control. An inoculum from an 18 to 24 hour pure culture, was inoculated on the slant surface of Christensen's urea agar and incubated at 37°C. The color change on the slant was observed after 6 hours to 24 hours. Urease positive and negative results were shown by a bright pink color and no colour change on the slant as in Figures 7 and 8 respectively.

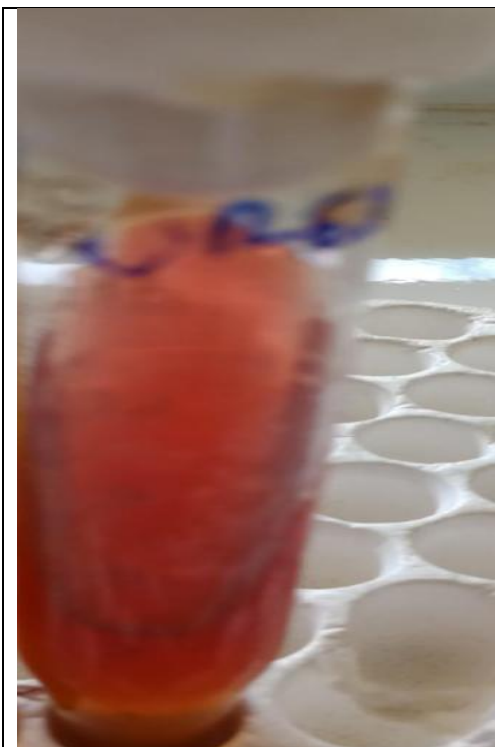


Figure 7: Urease positive

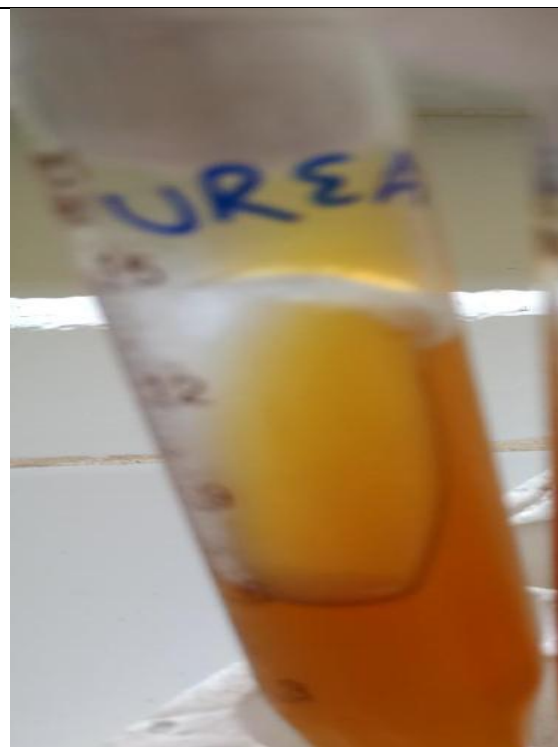


Figure 8: Urease negative

### 2.7 Oxidase Test

This test is used in identification of *Pseudomonas aeruginosa* which has oxidase enzyme that catalyzes oxidation of cytochrome c, thus turning the impregnated oxidase filter paper from white to deep purple. *Pseudomonas* ATCC 27853 was used as a positive control. Using a loop, a well-isolated colony was picked from a fresh 18 to 24 hour culture bacterial plate and rubbed onto oxidase filter paper for colour change observation. Oxidase positive was shown by colour change from white to dark purple within 5 to 10 seconds as in Figure 9.



Figure 9: Oxidase positive

## 3. RESULTS AND DISCUSSION

### 3.1 Demographic and Clinical Characteristics

The study analyzed the distribution of patient's based on gender, marital status, level of education and age. The results of analysis as depicted in Table 4 show that out of a Total 117 sampled patients, 58 (49.6%) were male, 59 (50.4%) female, 3 (2.6%) single, 99 (84.6 %) married, 15 (12.8%) widowed, 11 (9.4%) had no education, 50 (42.7%) primary level education, 38 (32.5%) secondary level education and 18 (15.4%) had college/university

education. This was an indication that females, married and those patients with none or primary level of education are at a greater risk of developing wounds.

The results of analysis on smoking, drinking, patient setting, sample testing, terminal illness and hospital visit as in Table 1 show that out of a total of 117, non-smokers were 87 (74.4%), smokers 30 (25.6%), non-drinkers 85 (72.6%), alcohol drinkers 32 (27.4%), inpatient 68 (58.1%), outpatient 49 (41.9%), samples not tested 106 (90.6%), samples tested 11 (9.4%), no terminal illness 50 (42.7%), terminal illness 67 (57.3%) where 12 (10.3%) had asthma while 55 (47.0%) had hypertension. 55 (47.0%) do not visit the hospital regularly whereas 62 (53.0%) visit the hospital regularly as prescribed. Test results on duration with diabetes as in Table 2 showed a minimum of 1 year, a maximum of 14 years, a mean of 4.46 years with a standard deviation of 3.29 years while for the period a patient had been on antibiotics since developing a wound had a minimum of 0.1 months, a maximum of 36 months, a mean of 9.99 months and a standard deviation of 8.84. Based on the mean, diabetic patients with wounds have had diabetes for approximately 4.5 years and have been on antibiotics for an average period of approximately 10 months.

The study also computed the measures of central tendency to summarize data for the age variable and measures of dispersion to understand the variability of scores for the patient's age. Results of analysis as depicted in Table 2 showed a minimum age of 22 years and a maximum of 67 years having a mean of 54.41 years and a standard deviation of 8.828. From the mean, it is evident that the average age for diabetic patients with wounds is 54.41 years. However, younger persons are also diabetic with wounds given the minimum age of 22 years. A large standard deviation value shows large variance in the ages of the patients.

Table 1: Demographic and Clinical Characteristics of Study Participants (Categorical Data)

Characteristic	Frequency (n)	Percent (%)
<b>Gender</b>		
Male	58	49.6
Female	59	50.4
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Marital Status</b>		
Single	3	2.6
Married	99	84.6
Widowed	15	12.8
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Level of Education</b>		
None	11	9.4
Primary	50	42.7
Secondary	38	32.5
College/University	18	15.4
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Smoking</b>		
Yes	30	25.6
No	87	74.4
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Drinking</b>		
Yes	32	27.4
No	85	72.6
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Patient Setting</b>		
In patient	68	58.1
Out patient	49	41.9
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Sample Testing</b>		
Yes	11	9.4
No	106	90.6
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Terminal Illness</b>		
Yes	67	57.3
No	50	42.7
<b>Specific Terminal Illness</b>		
Asthma	12	10.3
Hypertension	55	47.0
None	50	42.7
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>
<b>Regular Hospital Visit</b>		
Yes	62	53.0
No	55	47.0
<b>Total (N)</b>	<b>117</b>	<b>100.0</b>

Table 2: Clinico-demographic Characteristics (Continuous Data)

Characteristic	N	Minimum	Maximum	Mean	Std. Deviation
Age	117	22	67	54.41	8.828
Years with Diabetes	117	1	14	4.46	3.29
Months with Wound	117	1	60	13.00	13.14
Months on Antibiotics	117	0.1	36.0	9.99	8.84

### 3.2 Selected bacterial microbes isolated from wounds of diabetic patients

#### 3.2.1 Morphological profiling of bacterial microbe isolated from diabetic wounds

Descriptive statistics analysis was conducted to phenotypically profile the selected bacterial microbe. The results of analysis as depicted in Table 3 from a total of 117 samples, Gram positive cocci were 40 (34.2%) and Gram negative rods 77 (65.8%). This was an indication that the prevalence of Gram positive cocci isolated from diabetic wounds was 34.2% while the prevalence for Gram negative rods was 65.8%.

Table 3: Morphological profiling of bacterial microbe isolated from diabetic wounds

Cell Shape	Cell Colour	Gram Stain Reaction	Frequency (n)	Percent (%)
Cocci	Purple/Blue	Positive	40	34.2
Rods	Red/Pink	Negative	77	65.8
<b>Total (N)</b>			<b>117</b>	<b>100.0</b>

#### 3.2.2 Biochemical profiling of bacterial microbe isolated from diabetic wounds

The biochemically profiled bacterial microbes as depicted in Table 4, were *S.aureus*, *E.coli*, *P.aeruginosa*, *K. pneumoniae* and *Proteus* species. *S.aureus* was the most commonly isolated bacteria with a prevalence of 40(34.2%). *P.aeruginosa* had a prevalence of 24(20.5%), *K. pneumoniae* 22(18.8%), *Proteus* species 18(15.4 %) and *E.coli* 13(11.1%).

Table 4: Biochemical profiling of bacterial microbe isolated from diabetic wounds

Test	Inference	Bacterial Microbe	Frequency (n)	Percent (%)
Coagulase	Clot formation	<i>S. aureus</i>	40	34.2
Indole	Cherry red ring on top surface	<i>E. coli</i>	13	11.1
Citrate Utilization	Intense Prussian blue colour	<i>K. pneumoniae</i>	22	18.8
Urease	Bright pink colour	<i>Proteus</i> species	18	15.4
Oxidase	Dark purple colour	<i>P.aeruginosa</i>	24	20.5
<b>Total (N)</b>			<b>117</b>	<b>100.0</b>

More importantly, the prevalence basing on chi-square results in Table 5 was significantly associated with education level, age, smoking habit, patient setting, drug uptake and hospital visit at 5% level of significance ( $p < 0.05$ ). Patients with lower level of education, those aged between 40-59 years, non-smokers, those on outpatient setting, irregular hospital visits and drug uptake were more exposed to bacterial infection. Out of the 40 patients from whom Gram positive cocci were isolated, 23(57.5%) had primary level education, 11(27.5%) secondary level education, 6(15.0%) college/university education, 3(7.5%) were aged below 40 years, 25(62.5%) between 40-59 years, 12(30.0%) had 60 and above years. 5(12.5%) were smokers, 35(87.5%) non-smokers, 19(47.5%) inpatient, 21(52.5%) outpatient, 16(40.0%) visited the hospital regularly, 24(60.0%) visited the hospital irregularly, 8(20.0%) took prescribed drugs irregularly and 32(80.0%) took prescribed drugs irregularly.

On the other hand, out of the 77 patients from whom Gram negative rods were isolated, 11(14.3%) had no education at all, 27(35.1%) primary level education, 27(35.1%) secondary

level education, 12(15.6%) college/university education, 0(0.0%) were aged below 40 years, 49(63.6%) between 40-59 years, 28(36.4%) had 60 and above years, 25(32.5%) smokers, 52(67.5%) non-smokers, 49(63.6%) inpatient, 28(36.4%) outpatient, 38(49.4%) visited the hospital regularly, 39(50.6%) visited the hospital irregularly, 29(37.7%) took prescribed drugs irregularly and 48(62.3%) took prescribed drugs irregularly. This implied that Gram negative rods were mostly isolated from non-smokers, those admitted, patients visiting the hospital and taking prescribed drugs irregularly against the doctor's recommendation.

The finding that Gram negative rods were most prevalent than the Gram positive cocci which was associated with education level, smoking habit, patient setting, hospital visit and adherence to taking of prescribed antibiotics regularly with *S.aureus* as the most prevalent pathogen followed by *P. aeruginosa*, *K. pneumonia*, *Proteus* spp and *E.coli* conforms to the findings of [9], [21], Mukhtar and Saeed (2011) in their studies conducted in Western India, South India and Sudan respectively.

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Table 5: Prevalence of gram positive cocci (GP) and gram negative rods (GN)

	Gender (n)		Marital Status (n)				Education (n)			Age (n)			Total (N)	
	Male	Female	Single	Married	Widowed	Divorced/Seperated	None	Primary	Secondary	College/University	Below 40	41-59		60 and above
<b>GP(n)</b>	19(47.5%)	21(52.5%)	3(7.5%)	32(80.0%)	5(12.5%)	0(0.0%)	0(0.0%)	23(57.5%)	11(27.5%)	6(15.0%)	3(7.5%)	25(62.5%)	12(30.0%)	<b>40(34.2%)</b>
<b>GN(n)</b>	39(50.6%)	38(49.4%)	0(0.0%)	67(87.0%)	10(13.0%)	0(0.0%)	11(14.3%)	27(35.0%)	27(35.0%)	12(15.6%)	0(0.0%)	49(63.0%)	28(36.0%)	<b>77(65.8%)</b>
<b>Chi - sq [P-value]</b>	<b>0.104[0.75]</b>		<b>5.933[0.06]</b>				<b>9.285 [0.03]*</b>			<b>6.092 [0.04]*</b>				
	Smoking (n)		Alcohol (n)		Patient Setting (n)		Hospital Visit (n)		Drug Uptake (n)		Total (N)			
	Yes	No	Yes	No	Inpatient	Outpatient	Regular	Irregular	Regular	Irregular				
<b>GP(n)</b>	5(12.5%)	35(87.5%)	11(27.5%)	29(72.5%)	19(47.5%)	21(52.5%)	16(40.0%)	24(60.0%)	8(20.0%)	32(80.0%)	<b>40(34.2%)</b>			
<b>GN(n)</b>	25(32.5%)	52(67.5%)	21(27.3%)	56(72.7%)	49(63.6%)	28(36.4%)	38(49.4%)	39(50.6%)	29(37.3%)	48(62.7%)	<b>77(65.8%)</b>			
<b>Chi - sq [P-value]</b>	<b>5.505 [0.02]*</b>		<b>0.001[0.10]</b>		<b>3.916 [0.04]*</b>		<b>4.746 [0.02]*</b>		<b>12.642 [0.00]*</b>					
<b>Total</b>											<b>117(100.0%)</b>			

**Note.** n refers to total diabetes mellitus patients with wounds infected with bacteria. \* indicates significance at 5% level significance

#### 4. CONCLUSION

The prevalence of gram negative rods isolated from diabetic wounds was 65.8% and gram positive cocci 34.2% while the prevalence for gram negative rods was 65.8%. *Staphylococcus aureus* was the only gram positive bacteria isolated and it accounted for 34.2% prevalence followed by *P. aeruginosa* gram negative at 20.5%. In conclusion, diabetic patients with wounds at JOOTRH, Kenya are more exposed to gram negative rods infection. The most prevalent gram negative rod was *P. aeruginosa*. Its prevalence was associated with the patient's education level, smoking habit, patient setting, irregular hospital visit and adherence to taking of prescribe antibiotics regularly. Therefore, JOOTRH, Kenya healthcare providers to initiate wound infection preventive measures that may include awareness campaigns on the importance of wound management, regular hospital visits, stopping to smoke and regular uptake of prescribed drugs.

#### CONSENT (WHERE EVER APPLICABLE)

"All authors declare that 'written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal."

#### ETHICAL APPROVAL (WHERE EVER APPLICABLE)

"All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki."

#### REFERENCES

1. Al- Shabaki, J. F. (2014). Bacteriological evaluation of diabetic foot infections of patients in Al- Salam Hospital in Mosul city/ Iraq and antibiotic sensitivity pattern. *International Journal of Advanced Research* , 2 (5), 614-623.
2. Alsadig, M. A., Elzen, A. A., Alshahed, A., Gurfa, A. A., Aziza, H. M., Gaeidaa, A. M., et al. (2015). Identification and determination of antibiotic resistance of pathogenic bacteria isolated from septic wounds. *Journal of Advanced Laboratory Research in Biology* , 6 (5), 97-101.
3. Alsaimary, I. E. (2010). Bacterial wound infections in diabetic patients and their therapeutic implications. *Medical Practice and Review* , 1 (2), 12-15.
4. Elamenya, L. K. (2013). *Antimicrobial susceptibility of bacteria that cause wound sepsis in the peadiatric surgical pasienys at Kenyatta National hospital (master's dissertation)*. Nairobi, Kenya: University of Nairobi.
5. Enoch, S., Williams, D., Price, P., Harding, P., Moloney, M. C., & Burke, P. E. (2003). Randomized clinical trial and economic analysis of four-layer compression bandaging for venous ulcer. *British Journal of Surgery* , 7, 794-798.
6. Gichuki, H. K. (2016). *Prevalence and bacterial sensitivity patterns of antimicrobial agents for diabetic foot infections at Kenyatta National Hospital (master's dissertation)*. Nairobi: University of Nairobi.
7. Haldar, J., Mukherjee, P., Mukhopadhyay, S., & Maiti, P. K. (2017). Isolation of bacteria from diabetic foot ulcers with special reference to anaerobe isolation by simple two-step combustion technique in candle jar. *Indian Journal of Medical Research* , 145, 97-101.

8. Hall, V., Thomsen, R. W., Henriksen, O., & Lohse, N. (2011). Diabetes in sub-saharan africa 1999-2011: Epidemiology and public health implicatio, a systematic review. *Biomed Central public Health* , 11 (564), 1-12.
9. Ibrahim, A. A., Bhatawadekar, M. S., Peerzada, B. Y., Modak, M. M., & Lahiri, K. K. (2016). Bacterial profile of diabetic foot ulcer- Study from Western India. *International Journal of Health Sciences and Research* , 6 (5), 65-71.
10. IDF. (2021). *IDF diabetes atlas* (10th ed.). Brussels, Belgium: International Diabetes Federation. ISBN: 978-2-930229-98-0.
11. Jeber, M. A., & Saeed, E. A. (2013). Isolation and identification of bacterial causes from diabetic foot ulcers. *Tikrit Journal of Pure Science* , 18 (3), 6-9.
12. Kavinguha, L. K. (2017). *Diabetes self management knowledge and foot complications among type 2 diabetes patients at Jaramogi Oginga Odinga Teaching & Referral Hospital, Kisumu County, Kenya (master's thesis)*. Kakamega, Kenya: Masinde Muliro University of Science and Technology.
13. Lipsky, B. A., Pecoraro, R. E., & Wheat, L. J. (1990). The diabetic foot: Soft tissue and bone infection. *Journal of Infectious Disieases* , 4, 409-432.
14. Mengesha, R. E., Kasa, B. G.-S., Saravanan, M., Berhe, D. F., & Wasihun, A. G. (2014). Aerobic bacteria in post surgical wound infections and pattern of their antimicrobial susceptibility in Ayder Teaching and Referral Hospital, Mekelle, Ethiopia. *Biomedical Research Central* , 7 (575), 1-6.
15. McFerran, L. (2008). Obstacles to diabetes care in Kenya. *Medical Journal of Therapeutics Africa* , 2 (2), 127-129.
16. Muhammad, U. K., Adamu, T. M., Binji, Z., & Isa, M. A. (2014). Prevalence of pathogenic bacteria isolated from surgical site and wound infection among patients admitted in some selected hospitals in Sokoto metropolis, Nigeria. *International Journal of Environment* , 3 (3), 89-103.
17. Mukhtar, A. M., & Saeed, H. A. (2011). Profile of antibiotic sensitivity and resistance of some pathogenic bacteria isolated from clinical specimens in Sudan. *Journal of Science and Technology* , 12 (1), 14-19.
18. Nagaraju, V. E., & Divakar, G. (2012). Antibiotic susceptibility of bacterial strains isolated from diabetic patients. *International Journal of Advances in Pharmacy, Biology and Chemistry* , 1 (4), 546-550.
19. Pai, D. R., & Madan, S. S. (2013). Techniques in chronic wound management: Review of the literature and recent concepts. *Journal of Novel Physiotherapies* , 3 (2), 1-7.
20. Ratemo, N. K. (2014). *Antimicrobial susceptibility pattern of bacterial isolates from pus samples at Kenyatta National Hospital, Kenya (master's dissertation)*. Nairobi, Kenya: University of Nairobi.
21. Reghu, R., Padma, U. D., Sasankan, V., Puthur, S., & Jose, J. (2016). A microbiological study of diabetic foot ulcer in a South Indian Tertiary care hospital. *International Journal of Pharmaceutical Sciences Review and Research* , 37 (1), 167-170.
22. Republic of Kenya. (2015). *Kenya national strategy for the prevention and control of non-communicable diseases 2015-2020*. Nairobi: Ministry of Health.
23. Repulic of Kenya. (2016). *Jaramogi Oginga Odinga Teaching & Referral hospital strategic plan: 2016-2021*. Nairobi: Government Printer.
24. Sawdekar, H., Sawdekar, R., & Wasnik, V. R. (2015). Antimicrobial susceptibility pattern of bacterial isolates from wound infection and their sensitivity to antibiotic agents at super specialty hospital, Amravati city, India. *International Journal of Research in Medical Sciences* , 3 (2), 433-439.
25. Singh, N., Armstrong, D. G., & Lipsky, B. A. (2005). Preventing foot ulcers in patients with diabetes. *J Am Med Assoc* , 293, 217–228.

26. Tiffany, J. L. (2013). Diabetes mellitus: the increasing burden of disease in Kenya. *South Sudan Medical Journal* , 6 (3), 60-64.
27. Trivedi, U., Parameswaran, S., Armstrong, A., Burgueno-Vega, D., Griswold, J., Dissanaik, S., et al. (2014). Prevalence of multiple antibiotic resistant infections in diabetic versus non diabetic wounds. *Journal of Pathogens* , 1, 1-6.
28. Tuvei, S. M. (2017). *Prevalence and antimicrobial susceptibility of S. aureus isolated from diabetes mellitus patients with foot ulcers at Vihiga County Referral Hospital, Vihiga County Kenya (master's thesis)*. Maseno, Kenya: Maseno University.
29. Wahab, N. H., Samsudin, I. N., Nordin, S. A., Ahmad, Z. M., Noor, M. A., & Devnani, A. S. (2015). Clinical presentation and microorganisms sensitivity profile for diabetic foot ulcers: a pilot study. *Medical Journal of Malaysia* , 70 (3), 182-187.

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