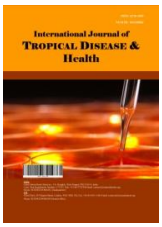

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Bacteriological Profiles of Pyogenic Wound Infection among Adults with Antibiotic Susceptibility Pattern at a Tertiary Hospital in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author IAO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author PCM managed the literature searches and performed the statistical analysis. Author AOO managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: A wide variety of aerobic and anaerobic bacteria either singly or in combination has been implicated in pyogenic wound infection and this has been associated with treatment failures due to antibiotic resistance. This study aims at investigating the agents of pyogenic wound infection and their antibiotic susceptibility.
Study Design: A descriptive cross-sectional study conducted at the only tertiary Teaching Hospital in Uyo, Nigeria and carried out on 136 wound samples.
Place and Duration of Study: University of Uyo Teaching Hospital, Uyo, Nigeria, between April and October, 2018.
Methodology: Aspirated pus or wound swab samples were collected and inoculated on two separate agar plates containing 25% Sheep Blood and incubated aerobically and anaerobically at 37°C for 48 – 72 hours. Identification of isolates was performed following standard procedures. Data obtained were analyzed using SPSS software.

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Results: Of the 136 collected wound samples from 76 (55.9%) males and 60 (44.1%) females patients from ages 20 to 70 years and above, 127 (93.4%) had growth of different bacterial isolates totaling 214 in number. Among these were aerobes 132 (61.6%) anaerobes 82 (38.4%). The Gram-negative aerobes had the highest prevalence 81 (37.9%), while the Gram-positive anaerobes 20 (9.4%) was the least prevalent. *Staphylococcus aureus,* 44 (86.3%) and *Pseudomonas aeruginosa*, 24 (29.6%), were the predominant Gram-positive and Gram-negative aerobes respectively. *Peptococci* spp. 8 (40%) *and Bacteriodes fragilis* 28 (54.9%) were the predominant Gram-positive and Gram-negative anaerobes respectively. Some rarely reported pathogens revealed include *Acinetobacter iwoffi*, *Enterobacter cloacae* and *Stenotrophomonas maltophilia* 1(1.2%) and they showed 100% resistance to all tested antibiotics. The majority of the Gram-positive aerobes 29 (56.9%) were Vancomycin resistant and there was also an increasing prevalence of Methicillin resistant *Staphylococcus aureus* (45%).
Conclusion: The bacterial agents causing pyogenic wound infection in Uyo comprised of 61.6% aerobes and 38.4% anaerobes. Some rarely reported bacteria such as *Enterobacter cloacae* and *A. iwofii* implicated in the infections were resistant to all commonly used antibiotics including Imipenem, a reserved antibiotic. *Staphylococcus aureus* was the commonest cause of pyogenic wound infection and up to 45% of them were Methicillin resistant.

Keywords: Bacteriological profile; pyogenic wound; antibiotic susceptibility; tertiary hospital.

1. INTRODUCTION

Pyogenic wound infection is one of the common hospital infections which may occur following accidental or intentional trauma of the skin or other tissues [1,2]. The infection results from the presence and growth of microorganism in wound with the formation of pus [3,4,5] consequent upon series of local and systemic host responses. While acute wounds are caused by external damage to intact skin, chronic wound develops when an acute wound fails to heal in the expected time frame for that type of wound, which might be a couple of weeks or up to six weeks in some cases [6,7]. This notwithstanding, chronic wounds are most frequently caused by endogenous mechanisms associated with a predisposing condition that ultimately compromises the integrity of dermal and epidermal tissues [6]. The various types of acute wound include surgical wounds, bites, burns, minor cuts and abrasions, severe traumatic wounds such as lacerations and those caused by crush or gunshot injuries. Some of the most common types of chronic wounds in patients include diabetic wounds, venous and pressure ulcers [8].

A wide variety of aerobic and anaerobic bacteria have been implicated in wound infections either singly or in combination. The most predominant aerobic pyogenic bacteria are *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pneumonococcus* and *Coliform bacilli* such as *Escherichia coli, Proteus species* and *Pseudomonas aeruginosa*. Anaerobic organisms involved, are mainly *Clostridium perfringens* and other *Clostridia*, *Bacteroides species* and anaerobic cocci [9,10].

Proper diagnosis of pyogenic wounds which mostly will involve both clinical and laboratory assessments is important for effective treatment. It is now generally accepted that systemic antibiotics are essential for the treatment of clinically infected wounds. The available antimicrobials for most infections include metronidazole, clindamycin, chloramphenicol, cefoxitin, a penicillin (i.e. ticarcillin, ampicillin, piperacillin) and a beta-lactamase inhibitor (i.e. clavulanic acid, sulbactam, tazobactam), and a carbapenem (imipenem, meropenem, doripenem, ertapenem) [11]. However, antibiotic resistance poses a big challenge as increasing prevalence of resistance by pathogens towards these antibiotic agents has been reported over the years in different regions of the world including developing countries [12]. This has been attributed to changing microbial characteristics, selective pressures of antimicrobial use, societal and technological changes that enhance the development and transmission of drug-resistant organisms [13].

The emergence of resistant strains is becoming a threat and has increased morbidity and mortality rates associated with wound infection [14,15]. Currently, multidrug-resistant Gram-negative bacterial strains such as *Acinetobacter baumannii, E. coli, Klebsiella pneumoniae, Pseudomonas aeruginosa* and Gram-positive Methicillin Resistant *Staphylococcus aureus*

(MRSA) are increasingly associated with pus infections [16,17]. However, resistance is also seen among anaerobes that were previously considered to be highly susceptible to antibiotics, raising concerns about appropriate empirical therapy. Although resistance trends of aerobes have been monitored and reported predominantly through national and local surveys, [10] identification and susceptibility testing of anaerobic bacteria at individual hospitals is usually uncommon. Therefore, this study was conducted in the University of Uyo Teaching Hospital to investigate the bacterial pathogens causing pyogenic wound infection and their antimicrobial susceptibilities amidst the high treatment failures recorded.

2. METHODOLOGY

2.1 Study Design

A descriptive cross-sectional hospital based study of patients with pyogenic wound infections at the University of Uyo Teaching Hospital (UUTH), Uyo. The study was carried out at the University of Uyo Teaching Hospital between April to October, 2017. Uyo is located South-South region of Nigeria and UUTH is the only Federal tertiary health institution in Akwa Ibom State.

2.2 Sample Size

The study involved 136 wound samples from adult patients with pyogenic infections which was calculated by using a prevalence rate of 8.8% as obtained from a related study at the University of Uyo Teaching Hospital, Uyo [18]. Only wound/pus samples from various body sites of adult patients who were on admission or seen on out-patient basis were included. Results of positive cultures were sent to the attendant medical specialists for further management of the patients.

2.3 Sample Processing

2.3.1 For aerobes

Two swab samples were taken from the floor of the wound (or aspirates where applicable), for both culture and Gram stain. The swab specimens and aspirates were inoculated on Blood and MacConkey agar plates and incubated at 37°C aerobically for 18-24 hours [9]. Bacteria from positive cultures were Gram stained to differentiate Gram-positive bacteria from Gram-negative ones [19,20]. Microscopy using Gram stain was performed by making a smear on a clean grease free slide which was heat fixed by passing it over a flame 2-3 times, then flooded with crystal violet and allowed to stand for one minute. It was washed off by placing the slide in a slow running tap, then flooded with lugol's iodine and allowed to stand for one minute. The iodine was washed off and decolourisation done by flooding the slide with acetone and washed immediately. The smear was counterstained by flooding the slide with safranin which was allowed to stand for 30 seconds. The back of the slide was wiped clean and placed on a draining rack for the smear to air dry before being examined microscopically using the x100 oil immersion objective lens. The Gram-positive and Gram-negative bacteria appeared purple and pinkish respectively [20].

Further identification of isolates were done biochemically using Microbact 24E (MB24E) (Oxoid, UK) system for Gram-negative bacteria while other various standard conventional methods including Catalase and Coagulase tests, DNase detection test, Mannitol test, Salt tolerance and Bile Esculin tests for detection of Enterococci species were used in identifying Gram-positive aerobes [19,20].

Antibiotic susceptibility test was performed on a Muller Hinton Agar, using the Kirby Bauer disc diffusion method according to the Clinical and Laboratory Standard Institute guidelines [19]. The following standard antimicrobial agents (Oxoid, UK) were used for Gram-positive isolates; Penicillin (10 µg), Ampicillin (10 µg), Vancomycin (30 µg), Ciprofloxacin (5 µg), Gentamicin (30 µg) and Cefotaxime (30 µg). While Gentamicin (30 µg), Ceftaxidime (30 µg), Imipenem (10 µg), Amoxillin-clavulanate (30 µg) and Ampicillin (10 µg) were used for Gram-negative isolates.

2.3.2 For anaerobes

The specimens for anaerobic culture were inoculated onto fresh 25% Sheep Blood Agar plate and incubated in anaerobic jar containing anaerobic indicator and Gas-pak at 37°C for 48 – 72 hours [9]. Isolates were inoculated onto Thioglycollate broth (for storage) and Blood Agar plates and incubated aerobically for confirmations of obligate anaerobes which do not grow when cultured aerobically [20]. Further

identification were performed on isolates using conventional methods such as 20% Bile-inhibition test (Bacteroides Bile Esculin Test) for the preliminary identifications of *Bacteroides fragilis* and the Egg Yolk Base Agar Test for the differentiation of *Clostridium* species and other relevant anaerobic organisms based on lecithinase and lipase activity [20].

The Antibiotic Agar Presumptive Disk Identification system for Anaerobes was used both for identification and susceptibility by the Modified Kirby Bauer's Disc Diffusion Method on Mueller Hinton Agar containing 5% sheep blood at 0.5 MacFarland Turbidity Standard [19]. The standard antimicrobial agents used were, Kanamycin (1000 µg), Penicillin (2 µg), Erythromycin (60 µg), Clindamycin (30 µg) and Vancomycin (5 µg) (Oxoid, UK).

All wound samples were transported to Department of Medical Micrbiology laboratory where they were standardly processed.

2.4 Statistical Analysis of Data

The data from the processed wound samples were collated using computer applications and software. Data analysis was done by using SPSS (Statistical Package for Social Sciences) Version 21 and Mini TaB Version 17.

3. RESULTS

One hundred and thirty six (136) patients with pyogenic infections included in this study comprised of adults from the age of 20 to 70 years and above. There were 76 (55.9%) males and 60 (44.1%) females. The age range 30–39 had the highest infection rate of 25% (34) while those 70 years and above, were the least infected at 9.6% (13) The social characteristics of participants in this study, revealed that majority of them had basic secondary school education 45 (33.1%). Although many had no employment 33 (24.3%), majority 38 (27.9%) had employment (Table 1).

Table 1. Socio-demographic characteristics of study participants with pyogenic infections

Variables	Category	Frequency	Percentage
Gender	Male	76	55.9
	Female	60	44.1
	Total	**136**	**100**
Age	20-29	30	22.1
	30-39	34	25.0
	40-49	19	14.0
	50-59	21	15.4
	60-69	19	14.0
	70 above	13	9.6
	Total	**136**	**100**
Education	No formal Education	19	14.0
	Primary	31	22.8
	Secondary	45	33.1
	Tertiary	41	30.1
	Total	**136**	**100**
Occupation	Unemployed	33	24.3
	Business	39	28.7
	Employ	38	27.9
	Retired	8	05.9
	Student	18	13.2
	Total	**136**	**100**
Residence	Urban	88	64.7
	Rural	48	35.3
	Total	**136**	**100**

There was growth of pathogens in 127 (93.4%) of the 136 samples analysed. There were either pure growths of one organism or combined growths of the bacterial isolates. The combined growth of both Gram Negative Aerobes (GNA) and Gram Negative Anaerobes (GNAn) 36 (26.5%) from same sample, was the highest recorded (Fig. 1).

A total of 214 different bacterial pathogens were isolated comprising Gram-positive aerobes 51 (23.7%), Gram-negative aerobes 81 (37.9%), Gram-positive anaerobes 20 (9.4%) and Gram-negative anaerobe 62 (29.0%). *Staphylococcus aureus,* 44 (86.3%), was the predominant Gram Positive Aerobes (GPA) isolated while *Pseudomonas aeruginosa*, 24 (29.6%), was the predominant Gram-negative aerobe followed by *E. coli* 16 (19.8%). The least predominant isolates which have not been reported before in the study area was *Acinetobacter iwoffi*, *Enterobacter cloacae* and *Stenotrophomonas maltophilia* 1(1.2%) each (Table 2). *Peptococci* spp. 8 (40%), *and Bacteriodes fragilis* 28 (54.9%) were among the most predominant Gram-positive anaerobes (GPAn) and Gram-negative anaerobes (GNAn) respectively (Table 2).

The distribution of Gram-positive anaerobes (GPAn) as well as Gram-negative anaerobes (GNAn) by their presumptive antibiotic susceptibility pattern revealed *Clostridium perfringens* (3) by their absolute (100%) susceptibility to Kanamycin, Penicillin and Erythromycin and absolute resistance to Clindamycin and Colistin. *Peptostrepcocci* spp. (8), by their absolute susceptibility to kanamycin, Penicillin, Erythromycin and Vancomycin but absolute resistance to Penicillin, Clindamycin and Colistin. Also *Peptococci* spp. (6) their absolute resistance to Erythromycin and *Colistin* and absolute susceptibility to Penicillin and Vancomycin (Table 3).

The GNAn, *B. fragilis* (26) also by its absolute resistance to Kanamycin, Penicillin, Vancomycin and Colistin. *Fusobacterium* spp., (23) with absolute sensitivity to Kanamycin, Penicillin and *P. Melaninogenica* (11) with absolute resistance to Kanamycin and Vancomycin (Table 3).

The antibiotic susceptibility pattern of the aerobic bacteria revealed that the Gram-negative pathogenic aerobes were highly resistant to Ampicillin 75 (92.6%); Amoxicillin-clavulanate 54 (66.7%); Gentamicin 51 (63%) and Ciprofloxacin, 48(59.3%). Some isolates including *A. iwofii, C. freundii, Stenotrophomonas maltophilia* and *E. cloacae* showed 100% resistance to all tested antibiotics (Table 4).

In general, there was high resistance to Penicillin 49 (96.1%), Ampicillin 46 (90.2%), Gentamicin 37 (72.4%), Ciprofloxacin 31 (60.8%) and Vancomycin 29 (56.9%) by Gram-positive aerobes. *Enterococcus* species showed absolute resistant to Penicillin and Ampicillin 2 (100%). There was also an increased rate of Methicillin resistance by *Staphylococus aureus* isolate (45%) (Table 5).

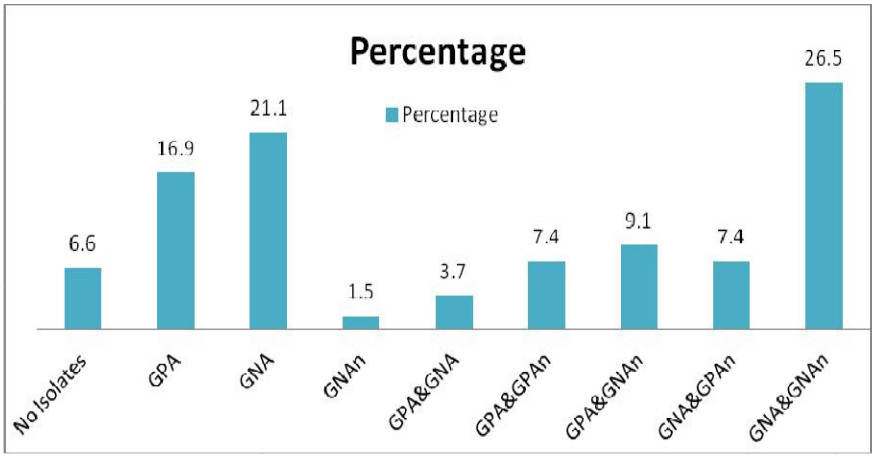

Fig. 1. Distribution of pyogenic bacteria according to class and occurrence

Keys: GPA- Gram Positive Aerobes, GNA- Gram Negative Aerobes, GPAn- Gram Positive Anaerobes, GNAn- Gram Negative Anaerobes

Table 2. Pyogenic isolates according to their species

Variables	Isolated pathogens	Frequency	Group percent (%)	Total percent
No growth	Nil	9	6.6	
Gram Positive	*Enterococci* spp.	2	3.9	-
Aerobes	*Staphylococcus aureus*	44	86.3	
	Streptococcus pyogenes	5	9.8	
	Total	**51**	**100**	**23.7**
Gram Negative Aerobes	*Acinetobacter baumannii*	7	8.6	
	Acinetobacter iwoffi	1	1.2	
	Citrobacter feudii	3	3.7	
	Cronobacter sakazakii	3	3.7	
	Enterobacter agglomerans	2	2.5	
	Escherichia coli	16	19.8	
	Escherichia fergusonii	2	2.5	
	Enterobacter cloacae	1	1.2	
	Klebsiella pneumoniae	9	11.1	
	Morganii morganii	3	3.7	
	Pseudomonas aeruginosa	24	29.6	
	Proteus mirabilis	9	11.1	
	Stenotrophomonas maltophilia	1	1.2	
	Total	**81**	100	**37.9**
Gram Positive	*Clostridium perfrigens*	5	25	
Anaerobes	*Peptococci* spp.	8	40	
	Peptostreptpcocci spp.	7	35	
	Total	**20**	100	**9.4**
Gram Negative	*Bacteroides fragilis*	28	54.9	
Anaerobes	*Fusobacterium* spp.	12	23.5	
	Prevotella melaninogenica	11	21.6	
	Total	**62**	**100**	**29.0**

4. DISCUSSION

Wound infections have become the most important cause for morbidity and mortality [14] According to studies, colonized wounds contain one-third of anaerobic bacteria while infected wounds contain 50% of anaerobic bacteria [21]. Generally this study revealed a total of 214 bacterial isolates, of which 132 (61.7%) were aerobes and 82 (38.3%) was anaerobes. This is similar to reports by some studies, [22] but differs from the work done by Brooks et al., which reported higher isolation of anaerobes over aerobes [23]. *Staphylococcus aureus,* 44 (20.6%), was the most prevalent aerobic bacteria isolated and this agrees with various other studies [24,25,26]. In contrast, *E. coli* and *Klebsiella* spp were reported by others as the most prevalent which was even a further contrasts to the *Pseudomonas aeruginosa* revealed by this study as the most prevalent Gram-negative bacteria causing wound infections [27,28]. The contrasts may have resulted from the differences in wound types and patients endogenous bacteria.

Of interest are the uncommonly reported organisms revealed by this study. These bacterial isolates were *Acinetobacter baumannii, Cronobacter sakazakii, Stenotrophomonas maltophilia, Morganii morganii, Enterobacter fergusonii, Acinetobacter iwoffii, Enterobacter agglomerans and Enterobacter cloacae*. They are known to cause opportunistic aerobic pyogenic wound infections in patients with suppressed immunity, prolonged hospitalization, frequent visits to the hospitals and prolonged antibiotic usage which may have been the conditions of some of the patients. However only few of the above pathogens have seemingly been reported in the past [25,29,30]. This is attributable to the expensive and complex techniques required for their isolation which in most cases are either unavailable or unaffordable.

Table 3. Distribution of Gram-positive and Gram-negative anaerobes by the presumptive antibiotic disc identification method

Class of bacteria	Kanamycin			Penicillin			Erythromycin			Vancomycin			Clindamycin			Colistin		
	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
C. perfringens																		
N=3			3	0		3	0		3			3		3			3	
% =			100	0		100	0		100			100		100			100	
Peptostrepcocci spp																		
n = 8			8			8		8				8					8	
% =			100		100	100		100	100			100		100			100	
Peptococci spp																		
n = 6					0	6		6	0			6					6	
% =						100		100	0			100					100	
Gram Negative Anaerobes																		
B. fragilis n = 26		26	0		26	0			26		26						26	
% =		100	0		100	0			100		100						100	
Fusobacterium spp. n = 23			23		0	23			23		23							
% =			100		0	100			100		100				100			
p. melaninogocus n=11		11				11			11		11				11			
% =		100				100			100		100				100			

Keys: I- Intermediate, R- Resistance, S- Sensitivity

Table 4. Antimicrobial susceptibility and resistance pattern of Gram-negative aerobe

	Ampicillin			Ciprofloxacin			Gentamicin			Ceftazidime			Imipenem			Amoxicillin-clavulanate		
	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
A.baumanii n=7	0	7	0	0	7	0	0	6	1	1	3	3	2	2	3	1	6	0
% = 8.6	0	100	0	0	100	0	0	85 .7	14.3	14.3	42.9	42.9	28.6	28.6	42.9	14.3	85.7	
A.iwoffi n = 1	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
% = 1.2	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0
C. freundii n = 3	1	2	0	0	3	0	0	3	0	0	3	0	0	0	3	0	3	0
% = 3.7	33.3	66.7	0	0	100	0	0	100	0	0	100	0	0	0	100	0	100	0
C.sakazakii n = 3	0	3	0	2	1	0	0	1	2	0	2	1	1	0	2	0	3	0
% = 3.7	0	100	0	66.7	33.3	0	0	33.3	66.7	0	66.7	33.3	33.3	0	66.7	0	100	0
E.agglomeran n = 2	0	1	1	0	0	2	0	1	1	0	0	2	0	0	2	0	0	2
% 2= 2.5	0	50	50	0	0	100	0	50	50	0	0	100	0	0	100	0	0	100
E. coli n = 16	2	14	0	0	8	8	1	8	7	3	4	9	1	0	15	5	9	2
% = 19.8	12.5	87.5	0	0	50	50	6.2	50.0	43.8	18.8	25	56.3	6.7	0	93.8	31.3	56.2	12.5
E. fergusonii n = 2	0	2	0	0	1	1	0	2	0	0	2	0	0	0	2	1	1	0
% 2.5	0	100	0	0	50	50	0	100	0	0	100	0	0	0	100	50	50	0
E. cloacae n= 1	0	1	0	0	1	0	0	1	0	0	0	1	0	0	1	0	1	0
% = 1.2	0	100	0	0	100	0	0	100	0	0	0	100	0	0	100	0	100	0
K.pneumoniae n = 9	0	9	0	2	4	3	1	6	2	2	3	4	1	1	7	0	7	2
% = 11.1	0	100	0	22.2	44.4	33.3	11.1	66.7	22.2	22.2	33.3	44.4	11.1	11.1	77.8	0.0	77.8	22.2
M. morganii n = 3	0	3	0	1	0	2	0	1	2	0	2	1	0	0	3	0	1	2

	Ampicillin			Ciprofloxacin			Gentamicin			Ceftazidime			Imipenem			Amoxicillin-clavulanate		
	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
% = 3.7	0	100	0	33.3	0	66.7	0	33.3	66.7	0	66.7	33.3	0	0	100	0	33.3	66.7
P. aeruginosa n = 24	2	22	0	2	15	7	1	14	8	2	8	14	0	4	20	7	15	2
% = 29.6	8.3	91.7	0	8.3	62.5	29.2	4.3	60.9	34.8	8.3	33.3	58.3	0	16.7	83.3	31.8	62.5	8 .3
*P. mirabilis*n = 9	0	9	0	1	7	1	0	6	3	2	3	4	0	0	9	2	6	1
% = 11.1	0	100	0	11.1	77.8	11.1	0	66.7	33.3	22.2	33.3	44.4	0	0	100	22.2	66.7	11.1
S. maltophilia n = 1	0	1	0	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0
% = 1.2	0	100	0	0	0	100	0	100	0	12.7	39.2	48.1	0	100	0	0	100	0
Total=81 (100%)	5	75	1	8	48	25	4	51	26	10	32	39	5	9	67	16	54	11
	6.2	92.6	1.2	9.9	59. 3	30.9	4.9	63	32.1	12.3	39.5	48.1	6.2	11.1	82.7	19.7	66.7	13.6

Keys: I- Intermediate, R- Resistances and S- Sensitivity

Table 5. Antimicrobial susceptibility and resistance pattern of Gram-positive aerobes

	Penicilin			Ampicillin			Vancomycin			Ciprofloxa			Gentamicin			Cefoxitin		
	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
Enterococci spp (n =2)	0	2	0	0	2	0	0	1	1	0	1	1	1	1	0	0	1	1
% = 3.9	0	100	0	0	100	0	0	50	50	0	50	50	50	50	0	0	50	50
s. aureus (n=44)	1	42	1	1	39	4	1	26	17	1	26	16	0	33	11	3	20	21
% = 86.3	2.3	95.5	2.3	2.3	88.6	9.1	2.3	59.1	38.6	2.3	59.1	38.6	0	75.0	25	6.8	45.5	47.7
S. pyogenes (n = 5)	0	5	0	0	5	0	0	2	3	1	4	1	0	3	2	0	1	4
% = 9.8	0	100	0	0	100	0	0	40.0	60.0	20	60	20	0	60.0	40.0	0	20.0	80.0
Total = 51	1	49	1	1	46	4	1	29	21	2	31	18	1	37	13	3	22	26
% value	2	96.1	2	2	90.2	7.8	2	56.9	41.2	4	60.8	35.2	2	72.5	25.5	5.9	43.1	51

Keys: I- Intermediate, R- Resistances and S- Sensitivity

The predominant anaerobic bacteria were *B. fragilis* 28 (54.9%). This was also the predominant isolate in studies reported by Yoonseon et al. and Shahanara et al. [31,32] However, studies by Eslami et al. and Ritu et al. [33,34] reported Peptostreptococcus as the most frequently isolated anaerobe. Still, Clostridium spp. have been reported as most common also [22].

Although *Peptococccci* and *Peptostreptococci* species were the predominant Gram-positive anaerobes from this study, few *Clostridia* spp. that causes gas gangrene not commonly reported in the environment of study was also isolated.

On antibiotic resistance, the Gram-positive aerobic bacteria generally resisted most of the commonly used antibiotics tested. Penicillin had the highest resistance 49 (96.1%) while cefoxitin had the least resistance 22 (43.1%). Some other related studies have also reported high resistance rates to the commonly used antibiotics especially penicillin [22,30,35,36]. The implication of this is that without sensitivity results most Gram-positive pyogenic organism will resist the commonly used antibiotics especially Penicillin if given empirically.

Also, the Gram-negative aerobic bacteria in this study revealed high resistance rates to commonly used antibiotics, especially Ampicillin. This is in agreement with other studies done in Nigeria and other countries, [25,37,38] which recorded also high resistances rates to commonly used antibiotics. This high resistance rates could be due to the indiscriminate use of these antibiotics by patients before reporting to hospital.

Imipenem usually a reserved drug with an expectant 100% sensitivity reported by some studies, showed lower susceptibility as revealed by this study [25,28]. Also, the observed absolute resistance by all isolates of *Enterobacter cloacae* and *Acinetobacter iwofii* to all tested antibiotics is an indication that using antibiotic empirically will lead to the treatment failures which may have been the case in this environment. *Acinetobacter baumanii* showed absolute resistance to ampicillin similar to what was revealed by other studies [30,39].

The increasing rate of resistance (45%) to Methicillin by *S. aureus* (MRSA) isolated in this study was worrisome especially as the test is not obtainable routinely thereby worsening the existing treatment failures noticed. This rate however was lower when compared with some related studies which had higher rates of up to 69.1% [40,41].

5. CONCLUSION

The bacterial agents causing pyogenic wound infection in Uyo comprised of 61.6% aerobes and 38.4% anaerobes. *Bacteriodes fragilis* was the prevalent anaerobic pathogen. However, while Gram-negative aerobes were more predominant, *Staphylococcus aureus*, a Gram-positve aerobe was the commonest cause of pyogenic wound infection. There were also the presence of rarely reported pathogens in the study area including *Acinetobacter iwoffi*, *Enterobacter cloacae* and *Stenotrophomonas maltophilia* and these showed 100% resistance to most tested antibiotics amidst the already existing high levels of antibiotic resistance and treatment failures.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Samples were collected from all consented adult patients with pyogenic wound infection that met the inclusion criteria. Informed consent was obtained from patients prior to inclusion in this study and all information was treated with utmost confidentiality. Only Wound samples from various body sites of adult patients were included in this study while paediatric patients and non-consented adults were excluded.

ETHICAL APPROVAL

Ethical clearance and approval (reference no.: UUTH/AD/3/96/VOL.XXI/J4, dated April 1, 2017) was gotten from the Ethical Review Board of the University of Uyo Teaching Hospital prior to commencement of this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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