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Research Article

Prevalence and Antibiogram of Bacterial Pathogens Associated with Wounds in Patients Attending University of Harcourt Teaching Hospital

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Abstract

The study investigated the antibiogram profile of bacteria that were isolated from wounds of patients attending university of Port Harcourt Teaching Hospital, Port Harcourt. A total of 236 wound swab samples were collected from road traffic accident (RTA) (56), diabetic foot ulcer (40), post-surgical wound (38), burns (20), chronic leg ulcer (CLU) (20) and soft tissue infections (62) both from the in-patient and out-patient departments. These samples were processed, cultured and microbial isolates were identified following standard operating protocols in a diagnostic microbiology laboratory. The samples with bacterial growth were 208 (88%) of which 28 (12%) was poly microbial growth. The most common pathogen isolated was *Staphylococcus aureus* 64 (27%) followed by *P. aeruginosa* 42 (18%), *Klebsiella pneumoniae* 36 (15%), *Proteus* sp., 24 (10%), *Escherichia coli* 20 (8%), *Streptococcus pyogenes* 6 (3%) while 16 (7%) had mixed growth and 28 (12%) had no bacterial growth. Overall, 132 (56%) female subjects and 104 (44%) male subjects had bacterial growth. Soft tissue wounds 68(28.81%) was the most infected wound followed by surgical wound infection 56 (24%), diabetic foot ulcer 46 (19%), burns 22 (9%), CLU 22 (9%) and RTA 22 (9%). Sensitivity of ofloxacin to *S. aureus, Pseudomonas aeruginosa, Klebsiella sp., Proteus sp., E. coli and S. pyogenes* was 60 (94%), 40 (95%), 30 (83%), 22 (92%), 20 (100%) and 5 (83%) while ciprofloxacin was 60 (94%), 40 (95%), 36 (100 %), 24 (100%), 20 (100%) and 5 (83%) respectively. Pefloxacin sensitivity was 62 (97%), 42 (100%), 36 (100%), 24 (100%), 20 (100%) and 5 (83%) to *S. aureus, P. aeruginosa, Klebsiella sp., Proteus sp., E. coli* and *S. pyogenes* respectively. This study showed *S. aureus* and *P. aeruginosa* are the top pathogen isolated from wound infections.

Keywords: Antimicrobial Resistance; Pathogens; Antibiotics; Epidemiology

Introduction

A wound occurs when the skin is damaged thereby exposing the under- lying subcutaneous tissue. This creates a moist, warm, and nutrient-rich environment that promotes the growth of opportunistic and harmful microorganisms. Wounds are generally categorized into two types: open wounds, such as incisions, lacerations, punctures, gunshot wounds, and abrasions, and closed wounds, including contusions (bruises), hematomas, and crush injuries [1]. While the body's immune system typically eliminates most contaminating microbes, some can multiply and become established, leading to wound colonization and infection [2].

WWhen bacteria invade a wound, they release toxic substances that are known as virulent factors that damage the host's tissues and help the bacteria to thrive. In response, the host's immune system sends inflammatory cells such as neutrophils, which release cytotoxic enzymes, oxygen radicals, and inflammatory mediators.

Unfortunately, these immune responses can damage the tissue and contribute to delayed healing in infected wounds [3]. Sterilizing infected tissue to prevent microbial growth promotes healing [3]. However, the prolonged use of antimicrobial agents has led to antibiotic resistance, driving the need for new treatment options. Also, the cost of discovering new drugs and the slow discovery rate have made this problem more concerning [4].

TThe most common organisms associated with wound infections include S. aureus, which accounts for 20-40% of cases, and P. aeruginosa which is responsible for 5-15% of nosocomial infections, particularly after surgeries and burns. Other pathogens such as Enterococci and members of the Enterobacteriaceae family, are often seen in immunocompromised patients and for those who have undergone abdominal surgery [3]. Although a few studies have found the absence of some of these pathogens in wounds [5]. Controlling wound infections has become increasingly difficult due to the rise of antibiotic-resistant bacteria, including methicillin-resistant S. aureus and polymicrobial infections. While antibiotics have been effective for both treatment and prevention, their success is heavily dependent on timely administration, the appropriate selection of antimicrobial agents, and the proper duration of use [3].

Despite the progress in infection control, the issue of wound infections persists due to the rise of drug-resistant strains. These infections can lead to severe complications such as sepsis, limb amputation, prolonged hospital stays, and increased costs, and contribute significantly to global mortality and morbidity. Wound infections are among the most common nosocomial infections [3]. While the problem cannot be completely eradicated, early intervention targeting the most common pathogens and proper wound care can significantly reduce the risk of infection [3].

Wound infections are considered the most common hospital-acquired infections, particularly among surgical patients [6]. These infections are a leading cause of postoperative complications, accounting for around a quarter of all nosocomial infections. Surgical wound infections represent 12% to 24% of hospital-acquired infections and rank among the top three most frequently reported. The likelihood of developing a surgical wound infection depends on the susceptibility of the wound for microbial contamination. Surgical site infection (SSIs) pose a serious risk with any surgery, significantly contributing to patient morbidity, mortality and increasing healthcare costs worldwide [7].

Postoperative infections are commonly caused by Gram-negative bacteria, with *E. coli*, *P. aeruginosa*, *S. aureus*, *K. pneumoniae*, *P. vulgaris*, and *S. epidermidis* being the predominant pathogens. All these isolates showed sensitivity to Imipenem and Chloramphenicol, although *P. aeruginosa* and *P. vulgaris* displayed high levels of multidrug resistance. The continuous use of systemic and topical antimicrobials use has led to the rise of antibiotic-resistant strains, driving the ongoing search for new treatment options. However, the increasing cost of developing effective antimicrobial agents, coupled with the slowing pace of discoveries, is making this issue more concerning. The control of wound infections has become increasingly difficult due to the widespread bacterial resistance and the rise in diseases caused by methicillin-resistant S. aureus and polymicrobial infections [3].

In developing nations such as Nigeria, wound infections are prevalent due to factors like poverty, illiteracy, poorly managed healthcare facilities, lack of adequate equipment, and limited awareness of hygiene and sanitation. Many individuals seek medical care only after wounds become chronic, leading to severe complications. Those most at risk include newborns, the elderly, obese individuals, malnourished people, diabetic patients, and burn victims [7]. Additionally, the use of non-sterile surgical instruments and unclean hands by medical personnel contribute to the high rate of wound infections. The significance of wound infection should not be underestimated, as improper initial wound care can result in numerous complications [3].

Wound colonization often involves a variety of microorganisms, many of which are potentially harmful, putting any wound at risk of infection [8]. Wound infections increase the burden of disease by prolonging hospital stays, raising treatment costs, and, in severe cases, leading to death, especially when complicated by sepsis or tetanus [9]. While many different organisms can cause wound infections [10], this study focuses on the most common causative agents, as infections can lead to delayed healing and complications if not properly managed [9]. The identification of the bacterial organisms and their antibiotic susceptibility patterns is crucial for the treatment of wound infections. The growing prevalence of multidrug-resistant bacteria highlights the need for regular bacteriological assessments to prevent the overuse of empirical treatments common in this region [11].

In this study, the antimicrobial susceptibility profiles of bacteria were evaluated, which were isolated from infected wounds in order to evaluate the effectiveness of conventional antibiotics in the treatment of these infections. A more rational approach to antibiotic use, based on microbial prevalence and antibiotic susceptibility, is necessary for managing infected wounds. Understanding the causative agents of wound infections is essential in selecting appropriate antimicrobial therapy and implementing infection control measures in Port Harcourt and the surrounding areas. The study aimed to identify the bacterial isolates from infected wounds and to evaluate their antimicrobial susceptibility patterns.

Material and Methods

Study area

This is a cross-sectional study that was carried out at the University of Port Harcourt Teaching Hospital (UPTH) Port Harcourt, Nigeria between May to November 2023 on subjects with various types of chronic ulcer or suspected wound infection of more than six weeks. University of Port Harcourt Teaching Hospital, Port Harcourt is a tertiary hospital situated in Choba, Port Harcourt with more than 1000 beds, and an annual average of 10,000 and 120,000 admissions and out-patients hospital visits respectively in the last five years.

Study participants

Two hundred and thirty-six (236) subjects with wound infection made up of 56 subjects with road traffic accident (RTA) injury, 40 subjects with diabetic foot ulcer, 38 subjects with post-surgical wounds, 20 subjects with burns, 20 subjects with chronic leg ulcer (CLU) and 62 subjects with soft tissue infections was used for this study. Any other patients who are on medications that will interfere with the study were excluded. The participants sampled consist of both males and female sexes.

Sample Size

Sample size was determined using the formula of Araoye [12]. The prevalence of wound infection in Port Harcourt is 81.20% [13] which gives 236 participants based on Cochrane formula calculation of sample size.

Sample collection

All collected wound samples showed signs of infection which were indicated by the presence of purulent material. Exudates were obtained from the wounds of patients prior to_dressing and cleansing using sterile cotton swabs sticks (Sterilin, UK). The samples were immediately transported in Stuart's transport medium to the Medical Microbiology laboratory in the Department of Medical Microbiology of Rivers State University.

Conventional identification of bacterial pathogens

The swabs were inoculated on blood and MacConkey agar and incubated aerobically and anaerobically in a candle extinction jar at 37^{o}C for 16 hours. Visible bacterial colonies were counted, and Gram stained as described by Amala., *et al*. [14].

Biochemical identification of bacterial pathogens

Bacterial pathogens were further characterized using biochemical tests. The tests were performed on these bacterial pathogens were methyl red, Voges-Proskauer, citrate utilisation, hanging drop, urease, carbohydrate fermentation, catalase, indole, oxidase tests. These methods were conducted according to the procedures described in Cheesbrough [15].

Antimicrobial susceptibility testing

Using the method adopted by Monsi., *et al*. [16], each bacterial colony were standardized using 0.5 McFarland standard and inoculated on Mueller Hinton agar plate. Oxoid antimicrobial susceptibility disks were placed on the agar and incubated at 37^{o}C for 16 hours. The zones of inhibitions were measured in millimetre and compared with standard breakpoint. The antibiotic disks used in this study included gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, cefuroxime, ampicillin, pefloxacin, erythromycin, streptomycin, septrin, nalidixic acid and ampiclox.

Data analyses

The results were presented in percentages.

Results

Prevalence of bacteria in wound infections

The prevalence of bacteria that were isolated from infected wounds in decreasing order were *S. aureus* 64 (27%), *P. aeruginosa* 42 (18%), *K. pneumoniae* 36 (15%), *Proteus* sp. 24 (10%), *E. coli* 20 (8%) and *S. pyogenes* 6 (3%). The prevalence of uncharacterized wounds with mixed growth was 16 (7%) while 28 (12%) had no bacterial growth. Overall, the prevalence of subjects with positive culture was 208 (88%) of which 28 (12%) showed a poly microbial growth as shown in Table 1.

Isolates	Prevalence (%)
S. aureus	64 (27)
P. aeruginosa	42 (18)
K. pneumoniae	36 (15)
Proteus spp.	24 (10)
E. coli	20 (8)
S. pyogenes	6 (3)
Mixed growth	16 (7)
No bacteria growth	28 (12)
Total	236 (100)

Table 1: Prevalence of Microorganisms in Wound Infection.

Bacteria prevalence based on the type of wound infection

The occurrence of *S. aureus* showed prevalence of 0 (0%), 0 (0%), 8 (36%), 8 (17%), 18 (32%) and 30 (44%) in burns, road ttraffic accidents, leg ulcers, diabetic foot ulcers, surgical wound and soft tissue wound infections respectively. P. aeruginosa were found in 6 (27%), 0 (0%), 6 (27%), 10 (22%), 12 (21%) and 8 (12%) in burns, road traffic accident, leg ulcer, diabetic foot ulcer, surgical wound and soft tissue wound infections respectively. K. *pneumoniae* reported incidence of 4 (18%), 10 (45%), 4 (18%), 0 (0%), 12 (21%) and 6 (9%) in burns, road traffic accident, leg ulcer, diabetic foot ulcer, surgical wound and soft tissue wound infections respectively. The occurrence of *Proteus* sp. occurrence was 8 (36%), 4 (18%), 0 (0%), 8 (17%), 4 (7%) and 0 (0%) in burns, road traffic accident, leg ulcer, diabetic foot ulcer, surgical wound and soft tissue wound infections respectively.

Escherichia coli had occurrence of 4 (18%), 4 (18%), 4 (18%), 0 (0%), 4 (7%) and 4 (6%) in burns, road traffic accident, leg ulcer, diabetic foot ulcer, surgical wound and soft tissue wound infections respectively. *Streptococcus pyogenes* had 0 (0%), 0 (0%), 0 (0%) and 0 (0%) in burns, road traffic accident, leg ulcer and diabetic foot ulcer, it was found in 2(4%) in surgical wound and 4 (6%) of soft tissue wound.

Diabetic foot ulcer had mixed bacteria growth rate of 12 (26%) while surgical wound had 4 (7%). There were no mixed bacteria growth in other types of wounds studied. No bacteria were isolated from wounds due to burns, leg ulcers and surgical wound 0 (0%) while road traffic accident had 4 (18%), diabetic foot ulcer 8 (17%) and 16 (24%) for soft tissue wound infections as shown in Table 2.

	Wound Source Prevalence (%)					
Isolate	Burns	Road Traffic Accident	Leg Ulcer	Diabetic Foot Ulcer	Surgical Wound	Soft Tissue Wound
S. aureus	0(0)	0(0)	8(36)	8(17)	18 (32)	30 (44)
P. aeruginosa	6(27)	0(0)	6(27)	10(22)	12(21)	8 (12)
K. pneumoniae	4(18)	10(45)	4(18)	0(0)	12 (21)	6 (9)
Proteus sp.	8(36)	4(18)	0(0)	8(17)	4(7)	0(0)
E. coli	4(18)	4(18)	4(18)	0(0)	4 (7)	4 (6)
S. pyogenes	0(0)	0(0)	0(0)	0(0)	2(4)	4 (6)
Mixed growth	0(0)	0(0)	0(0)	12 (26)	4 (7)	0(0)
No bacteria growth	0(0)	4(18)	0(0)	8(17)	0(0)	16 (24)
Total	22(100)	22(100)	22(100)	46(100)	56(100)	68(100)

Table 2: Prevalence of Bacteria in Different Wound Infection.

Prevalence of bacteria in wound infections based on sex

The prevalence of organism in female burns subjects showed the following prevalence: 0 (0.00%), 2 (20%), 4 (40%), 0 (0%), 4 (40%), 0 (0%), 0 (0%) and 0 (0%) for *S. aureus, P. aeruginosa, K. pneumoniae, Proteus* sp., *E. coli, S. pyogenes,* mixed growth and no bacteria growth respectively. In contrast, male burn subjects showed the following prevalence: 0 (0%), 4 (33%), 0 (0%), 8 (67%), 0 (0%), 0 (0%), 0 (0%) and 0 (0%) for *S. aureus, P. aeruginosa, K. pneumoniae, Proteus* sp., *E. coli, S. pyogenes,* mixed growth and no bacteria growth respectively.

Staphylococcus aureus, P. aeruginosa, K. pneumoniae, Proteus sp., *E. coli, S. pyogenes* and mixed growth had respective prevalence of 0 (0%), 0 (0%), 2 (14%), 4 (29%), 4 (29%), 0 (0%) and 0 (0%) in females involved in road traffic accident and 4 (29%) had no bacteria growth. In males involved in road traffic accident *S. aureus, P. aeruginosa, K. pneumoniae, Proteus* sp., *E. coli, S. pyogenes, and* mixed growth had respective prevalence of 0 (0%), 0 (0%), 8 (100%), 0 (0%), 0 (0%), 0 (0%) and 0 (0%) while 0 (0%) had no bacteria growth.

Female subjects with leg ulcer had occurrence of *S. aureus* in 2 (17%), *P. aeruginosa* 2 (17) and *Klebsiella* sp., 4 (33%) while *E. coli* had 4 (33%) while 0 (0%), 0 (0%), 0 (0%) and 0 (0%) of *Proteus* sp., *S. pyogenes,* mixed growth and no bacteria growth was recorded. Male subjects with leg ulcer had occurrence of *S. aureus* in 6 (60%), *P. aeruginosa* 4 (40%) while *Klebsiella* sp., *E. coli, Proteus* sp., *S. pyogenes,* mixed growth and no bacteria growth had 0 (0%), 0 (0%), 0 (0%), 0 (0%), 0 (0%) and 0 (0%) prevalence.

Female subjects with diabetic foot ulcer recorded 4 (14%), 4 (14%), 8 (29%) and 8 (29%) isolates of *S. aureus, P. aeruginosa, Proteus* sp., and mixed growth while 4 (14%) had no bacteria growth. *Klebsiella pneumoniae, S. pyogenes* and *E. coli* had 0 (0%) isolates each. Male subjects with diabetic foot ulcer recorded 4 (22%), 6 (33%) and 4 (22%) of *S. aureus, P. aeruginosa* and mixed growth while 4 (22%) had no isolate recorded. *K. pneumoniae, E. coli* and *S. pyogenes* had 0 (0%) isolates each.

Female subjects with surgical wound had occurrence of 8 (31%) in *S. aureus*, 4 (15%) *P. aeruginosa* and 8 (31%) *Klebsiella spp.*, isolated while *E. coli* had 4 (15%) and 2 (8%) *S. pyogenes*. In males, *S. aureus* had 10 (33%), *P. aeruginosa* had 8 (27%), *K. pneumoniae, Proteus* spp. and mixed growth each had incidence of 4 (13%).

In female subjects with soft tissue wounds, *S. aureus* had 16 (38%), *K. pneumoniae and E. coli* 4 (10%) each, *S. pyogenes* 2 (5%) but 16 (38%) had no bacterial growth while in males *S. aureus, P. aeruginosa, K. pneumoniae and S. pyogenes* had prevalence of 14 (54%), 8 (31%), 2 (8%) and 2 (8%) respectively.

Overall, in female subjects, 132 (56%) cultures had bacterial growth with 8 (6%) being polymicrobial growth while 24 (18%) had no isolate. In the male subjects, 104 (44%) culture had bacterial growth with 8 (8%) of the positive bacterial growth as polymicrobial growth while 4 (4%) had no isolate (Table 3).

Isolates	Burns		Road Traffic Accident		Leg Ulcer		Diabetic Foot Ulcer		Surgical Wound		Soft Tissue Wound	
	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)	F (%)	M (%)
S. aureus	0(0)	0(0)	0(0)	0(0)	2(17)	6(60)	4(14)	4(22)	8(31)	10(33)	16(38)	14(54)
P. aeruginosa	2(20)	4(33)	0(0)	0(0)	2(17)	4(40)	4(14)	6(33)	4(15)	8(27)	0(0)	8(31)
K. pneumoniae	4(40)	0(0)	2(14)	8(100)	4 (33)	0(0)	0(0)	0(0)	8(31)	4(13)	4(10)	2(8)
Proteus spp.	0(0)	8(67)	4(29)	0(0)	0(0)	0(0)	8(29)	0(0)	0(0)	4(13)	0(0)	0(0)
E. coli	4(40)	0(0	4(29)	0(0)	4 (33)	0(0)	0(0)	0(0)	4(15)	0(0)	4(10)	0(0)
S. pyogenes	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(8)	0(0)	2(5)	2(8)
Mixed growth	0(0)0(0)	0(0)	0(0)0(0)	0(0)	0(0)	0(0)	8(29)	4(22)	0(0)	4(13)	0(0)	0(0)
No bacteria growth	0(0)(0)	0(0)	4(29)	0(0)	0(0)	0(0)	4(14)	4(22)	0(0)	0(0)	16(38)	0(0)
Total	10(100)	12(100)	14(100)	8(100)	12(100)	10(100)	28(100)	18(100)	26(100)	30(100)	42(100)	26(100

Table 3: Prevalence of Microorganisms in Wound Infection of Different Gender. Key - F: Female, M: Male.

Antibiogram of wound isolates

Staphylococcus aureus was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, cefuroxime, ampicillin, pefloxacin, erythromycin, streptomycin, septrin, nalidixic acid and ampiclox in 45 (70%), 60 (94%), 60 (94%), 14 (22%), 38 (59%), 21 (33%), 14 (22%), 62 (97%), 14 (22%), 21 (33%), 14 (22%), 14 (22%) and 21 (33%) respectively. *Pseudomonas aeruginosa* was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, pefloxacin, erythromycin, streptomycin, septrin and ampiclox in 15 (36%), 40 (95%), 40 (95%), 26 (62%), 18 (43%), 42 (100%), 26 (64%), 7 (17%), 26 (62%) and 7 (17%) respectively. *Klebsiella sp.* was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, cefuroxime, ampicillin, pefloxacin, erythromycin, streptomycin, septrin, nalidixic acid and amplicon in 12 (33%), 30 (83%), 36 (100%), 16 (44%), 20 (56%), 8 (22%), 4 (11%), 36 (100%), 16 (44%), 16 (44%), 16 (44%), 8 (22%) and 16 (44%) respectively. *Proteus sp.* was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, erythromycin, streptomycin, septrin and ampiclox in 20 (83%), 22 (92%), 24 (100%), 14 (71%), 11 (57%), 24 (100%), 14 (71%),17 (86%), 11 (57%) and 11 (57%) respectively. *Escherichia coli.* was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, cefuroxime, ampicillin, pefloxacin, erythromycin, streptomycin, septrin, nalidixic acid and ampiclox with the following resistance antibiogram 8 (40%), 20 (100%), 20 (100%), 6 (30%), 6 (30%), 2 (10%), 10 (50%), 20 (100%), 6 (30%), 2 (10%), 8 (40%), 2 (10%) and 8 (40%) respectively. *Streptococcus pyogenes* was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, cefuroxime, ampicillin, pefloxacin, erythromycin, streptomycin, septrin, nalidixic acid and ampiclox in 2 (33%), 5 (83%), 5 (83%), 3 (50%), 4 (67%), 3 (50%), 1 (17%), 5 (83%), 4 (67%), 5 (83%), 2 (33%), 1 (17%) and 1 (17%) respectively. Mixed bacteria isolate was sensitive to gentamicin, ofloxacin, ciprofloxacin, ceftriaxone, ceftazidime, cefuroxime, ampicillin, pefloxacin, erythromycin, streptomycin, septrin, nalidixic acid and ampiclox in 10 (63%), 16 (100%), 16 (100%), 6 (38%), 8 (50%), 6 (38%), 12 (75%), 16 (100%), 6 (38%), 16 (100%), 8 (50%), 8 (50%) and 10 (63%) respectively (Table 4).

Antibiotic	***S. aureus*** **N = 64**	***P. aeruginosa*** **N = 42**	***Klebsiella sp.*** **N = 36**	***Proteus* sp. N = 24**	***E. coli*** **N = 20**	***S. pyogenes*** **N = 6**	**Mixed growth N = 16**
Gentamicin	45 (70%)	15 (36%)	12 (33%)	20 (83%)	8 (40%)	2 (33%)	10 (63%)
Ofloxacin	60 (94%)	40 (95%)	30 (83%)	22 92%)	20 (100%)	5 (83%)	16 (100%)
Ciprofloxacin	60 (94%)	40 (95%)	36 (100%)	24 (100%)	20 (100%)	5 (83%)	16 (100%)
Ceftriaxone	14 (22%)	26 (62%)	16 (44%)	14 (71%)	6 (30%)	3 (50%)	6 (38%)
Ceftazidime	38 (59%)	18 (43%)	20 (56%)	11 (57%)	6 (30%)	4 (67%)	8 (50%)
Cefuroxime	21 (33%)	-	8 (22%)	-	2 (10%)	3 (50%)	6 (38%)
Ampicillin	14 (22%)	-	4 (11%)	-	10 (50%)	1 (17%)	12 (75%)
Pefloxacin	62 (97%)	42 (100%)	36 (100%)	24 (100%)	20 (100%)	5 (83%)	16 (100%)
Erythromycin	14 (22%)	26 (64%)	16 (44%)	14 (71%)	6 (30%)	4 (67%)	6 (38%)
Streptomycin	21 (33%)	7 (17%))	16 (44%)	17 (86%)	2 (10%)	5 (83%)	16 (100%)
Septrin	14 (22%)	26 (62%)	16 (44%)	11 (57%)	8 (40%)	2 (33%)	8 (50%)
Nalidixic Acid	14 (22%)	-	8 (22%)	-	2 (10%)	1 (17%)	8 (50%)
Ampiclox	21 (33%)	7 (17%)	16 (44%)	11 (57%)	8 (40%)	1 (17%)	10 (63%)

Table 4: Resistance Profile of Antibiotics on Isolates from Wound Infection.

Discussion

Wound infection has been a major concern among health care practitioners not only due to increased trauma to the patient but also given its burden on financial resources and the increasing requirement for cost-effective management within the health care system. This study showed the prevalence of subjects with a positive bacterial culture was 208 (88%) of which 28 (12%) was polymicrobial growth. This is similar to positive bacteria culture of 86% in Yenagoa [17], greater than 81% obtained by Ayodele., et al. [13] but lower than 96% obtained by Agnihotri., et al. [18]. Ayodele et al. [13] reported that 164 (81%) wound swab samples had microbial isolates while 38 (19%) yielded no growth. Ayodele., *et al*. [13]

also reported that Gram-negative bacterial organisms accounted for 124 (60%) as against 82 (40%) from the Gram-positive organisms. The infecting microorganism may belong to aerobic as well as anaerobic groups [1].

The prevalence of bacterial pathogens that were isolated from the wound infections analysed here are *S. aureus, P. aeruginosa*, *Klebsiella* spp., *Proteus* species, *E. coli* and *Streptococcus* species in that order. Previous studies have identified the pathogens as common in wound infection in Umuahia [19] and Uyo [20]. The microbiological analysis reveals that *S. aureus* is the leading etiologic agent of wound infection in this study. This is similar to other reports in Nigeria [21,22], India [23], Thailand [24] and Japan [25]. This was however in contrast to the findings of Stainer., *et al*. [26] which showed that *P. aeruginosa* was the most common pathogen isolated. *S. aureus* was the most frequently isolated microorganism from wounds caused by incision to reach pus or fluid collection under the skin surface and from wound types observed in the study by Shittu., *et al*. [22] at Ile Ife. Mumtaz., *et al*. [27] and Mahmood [28] have also found *S. aureus* as the most common pathogen in their studies on wound infections. *S. aureus* has been identified as an important risk factor for the acquisition of *S. aureus* infection, although this may depend on an array of factors that may either be environmental or patient-related [29]. The postulated sequence of events which leads to infection is initiated with *S. aureus* nasal carriage which is then disseminated via hand carriage to other body sites where infection can occur with breaks in the dermal surfaces. The emergence of methicillin-resistant *S. aureus* in wound infections has led to higher treatment costs and prolongation of hospital stays with serious consequences in infection control especially in developing countries.

Staphylococcus aureus is both a human skin commensal and a frequent cause of clinically important infections including boils, styes, pustules, impetigo, infections of wounds (cross infections) and osteomyelitis [30]. This would explain its widest spread presence more than all the isolates in all the wound specimens collected. The second position is occupied by *P. aeruginosa* in the occurrence can be explained on the ground that it is a free-living bacterium and can be found in the bowels of 5% healthy persons [31], water, soil and sewage and is frequently found in moist environments in hospitals (sinks, cleaning buckets, drains, humidifiers etc). Because of this, many infections with *P. aeruginosa* are opportunistic hospital-acquired, affecting those already in poor health and immunosuppressed [32].

P. aeruginosa was the highest pathogen isolated from burns infection. The highest prevalence of *P. aeruginosa* in this study may be related to the greater risk of soil-borne *P. aeruginosa* contamination of distal leg ulcers which constituted the majority of ulcers seen in this study compared with proximal ulcers. *Pseudomonas aeruginosa* causing wound infection has been proven to be acquired from poor environmental sources [9,33]. This is contrary to a study on urinary tract infections that showed *E. coli* and *Klebsiella* spp. are the most prevalent pathogens [34]. This current study further showed that the nature of the sample, in this case, wound determines the types of pathogens that are present. It has been estimated that 75% of all deaths following thermal injuries are related to infections [35]. Nowadays, *P. aeruginosa* and other gram-negative bacteria (*Enterobacter*, *Klebsiella*) are responsible for nosocomial infections in wounds [36]. Colonized patients and staff are a major source of cross-contamination of other patients.

Staphylococcus aureus was also the prevalent etiologic agent in soft tissue infection, surgical wounds, diabetic and leg ulcer infections. *P. aeruginosa* was also high in these wound conditions. Shriyan., *et al*. [37] reported *S. aureus* as the prevalent etiologic agent in surgical wound. Post-operative wound infections have been found to pose a major problem in the field of surgery for a long time. The surveillance of nosocomial infections with an emphasis on antimicrobial audits will reduce the risk of post-operative wound infections [38].

Kehinde., *et al*. [39] reported that *Klebsiella* species were most predominant in burn wounds at 34% followed by *P. aeruginosa* (29%) and *Proteus* species the least prevalent (7%). Again Ihanni., *et al*. [40] and Oni., *et al*. [41] working in a tertiary hospital in Ibadan observed different prevalence rates of the Gram-negative organisms in their studies in which *Proteus* species were the least prevalent. The difference in the *Proteus* spp. prevalence rates may be related to their distribution in the various environments. Mumtaz., *et al*. [27] also isolated *E. coli* (26%) *Klebsiella* spp. (10%), *P. aeruginosa* (9%) and *Proteus* spp. (4%) in their study while Mahmood [28] also isolated *P. aeruginosa* (16%), *E. coli* (14%), *K. pneumoniae* (12%), miscellaneous Gram-negative rods (6%) and *S. pyogenes* (1%). While *Klebsiella* spp. were isolated in this study, another study found that this organism was absent in wound samples [5].

Overall, female subjects' cultures had 132 (56%) positive bacterial growth with 8 (6%) being polymicrobial growth while 24 (18%) had no isolate. In the male subjects, 104 (44%) cultures had positive bacterial growth with 8 (8%) of the positive as polymicrobial growth while 4(4%) had no isolate. This contrasts with previous studies by Obi [19], Kaabachi., *et al*. [42] and Jamali., *et al*. [43]. Kaabachi., *et al*. [42], in a study at Tunis, reported a sex ratio of 1.6 boys/girl while Jamali., *et al*. [43] reported 1.7 boys/female in Pakistan. It suggests that contracting wound infection has no relation to sex. The slight difference that has been noted is just due to our social behaviour where males were given superiority to the females and if get diseased are brought immediately to hospitals in comparison to females for treatment.

The incidence of different types of wound infections was found to be the highest of soft tissue 68 (29%), surgical wound infection 56 (24%), diabetic foot ulcer 46 (19%) followed by burns 22 (9%), leg ulcer 22 (9%) and road traffic accident 22 (9%). This is contrary to study by Aizza., *et al*. (2007) who reported that the incidence of different types of wound infections was found to be the highest in surgical wound infection (57%) followed by acute soft tissue infection (43%). Obi [19] reported that wounds from burns gave the highest number of isolates (21) in the Federal Medical Centre, Umuahia, Nigeria contrary to result of this study.

Antibiotics are chemical substances produced by a microorganism that have the capacity, in dilute solutions, to selectively inhibit the growth of or to kill other micro-organisms [45]. Optimal antimicrobial prophylaxis in the appropriate dose, time and duration, which has been selected on the basis of the antimicrobial susceptibility pattern of the most common isolates in the hospital, would ensure a decreased rate of post-operative wound infections [46-48]. Whereas it is now generally accepted that systemic antibiotics are essential for the management of clinically infected wounds, the choice of antibiotic to be used is not always apparent. Only after a comprehensive assessment process including consideration of patient characteristics, the results of microbiological investigations and the identification of both the nature and location of the wound, can the most appropriate antibiotic be identified.

The routine use of topical antibiotics is not justified for colonised or infected wounds [49]. In addition, a recent systematic review of antimicrobial agents has concluded that systemic or topical antimicrobials are generally not indicated for the management of chronic wound infections [50]. However, there may be some value in the prophylactic use of topical antimicrobials for the initial management of acute cellulitis, whilst awaiting clarification of antibiotic sensitivity and the establishment of a therapeutic regimen. It is noteworthy that the majority of isolates were resistant to ampicillin except *E. coli*. The resistance to ampicillin may be related to the pressure of prolonged usage and regular abuse in our society. This may also be related to the pressure of prolonged usage and regular abuse of these antibiotics. High antimicrobial resistance is likely promoted due to selective pressure exerted on bacteria for numerous reasons such as non-adherence to hospital antibiotic policy and excessive and indiscriminate use of broad-spectrum antibiotics. These multi-drug-resistant strains establish themselves in the hospital environment in areas like sinks, taps, railings, mattresses, toilets, and thereby spread from one patient to another. In addition to the misuse of classical antibiotics, some recent investigations noted that developing countries resort to the use of herbal antibiotics in the treatment of wounds and other kinds of infections [51,52]. This practice has led to an increased rate of antibiotic resistance in addition to enhancing the pathogenicity of even opportunistic pathogens through the development of biofilm, growth and serum resistance [16,52].

The result of this study showed that the organisms isolated had high sensitivity to fluoroquinolones such as pefloxacin, ofloxacin, and ciprofloxacin. This is similar to the report of Akinjogunla., *et al*. [20]. The sensitivity of all the isolates to the fluoroquinolones (pefloxacin, ofloxacin, and ciprofloxacin) tested, however, makes them the drug of choice in the empiric management of infected wounds except when contraindicated. The variety of organisms observed in this study supports the need to obtain culture specimens from infected wounds for microbiological evaluation and antibiotic susceptibility determination so that adapted chemotherapy can be prescribed. This will help to facilitate successful wound management and also assist in the control of antibiotic usage, hence stemming the spread of antibiotic-resistant bacteria.

Conclusion

The study showed high prevalence of *S. aureus* and *P. aeruginosa* as the top pathogen in wound infection while the female subjects had higher prevalence of wound pathogen than male subjects.

The highest prevalence of different types of wound infections was found to be soft tissue infection then surgical wound infection while burns and leg ulcer was the least. Sensitivity of most of the isolates to fluroquinolones such as pefloxacin, ofloxacin and ciprofloxacin however makes them the drug of choice in the empiric management of infected wounds to facilitate successful wound management and also assist in the control of antibiotic usage hence stem the spread of antibiotic-resistant bacteria. The study showed that other antibiotics tested showed a low sensitivity rate compared to the fluoroquinolones.

Authors' Contributions

VOE and TPM designed the study. VOE and CMM performed the statistical analysis, wrote the protocol, and drafted the first version of the manuscript. TPM, CMM, and RUC managed the study's analyses. VOE conducted the literature searches. All authors read and approved of the final manuscript.

Consent

All authors declare that 'written informed consent was obtained from the patient.

Ethical Approval

All authors hereby declare that all experiments were examined and approved by the Health Research Ethics committee of the Rivers State Hospital Management Board (RSHMB/RSHREC/2024/075), Rivers State, Nigeria and were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Disclaimer (Artificial Intelligence)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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APPENDIX

QUESTIONNAIRE

Instruction: Please study carefully and fill in appropriately

PERSONAL DATA

Name---

Age---------------- Sex-------------

State of Origin_______________ Tribe_____________________

Hospital ward____

Type of Wound____

Site of wound____________________

Duration of Hospital admission____________: (None) (0-6 Months), (7-12 Months), (13-18 Months)

Nature of wound

1. Purulent? YES ◻ NO ◻

2. Drugs? YES ◻ NO ◻

3. Type of Drugs: Antibiotics? YES◻ NO ◻ Placebo? YES◻ NO◻

4. Do you have any history of family illness? Yes◻ No◻