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# Antibacterial Activities of Herbal Extracts and Conventional Antibiotics on Methicillin Resistant *Staphylococcus aureus* Isolated from Wound

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## ABSTRACT

***Background*:** Methicillin-resistant *Staphylococcus aureus* (MRSA) strains continue to be a leading cause of infections with high morbidity and mortality in wound patients, but little is known about the prevalence, characterization, and evaluation of the antibacterial activity of methanol leaf and stem bark extracts of *Newbouldia laevis*, *Parkia biglobosa* and conventional available antibiotics on MRSA from various wound sources in Abakaliki. This study aimed to investigate the prevalence of MRSA and its associated risk factors among wound patients in a Tertiary Hospital. ***Methods***: A total of 200 samples from post-surgical wounds, burn wounds, decubitus ulcer, and diabetic foot ulcer patients were collected from March 2021 to February 2022 using a sterile swab stick on the affected site. The collected specimens were immediately subjected to bacteriological analysis. MRSA was screened for Antibiotic Susceptibility Testing (AST) and results were analyzed using the Clinical Laboratory Standard Institute (CLSI) zone diameter breakpoints. The antibacterial activity of methanol leaf and stem-bark extract of *Newbouldia laevis* and *Parkia biglobosa* against the MRSA isolates was determined using the agar well diffusion method. ***Results*:** The prevalence of MRSA accounted for 55.5 %. Antibiogram result shows that the MRSA isolates were 87.8% and 100% susceptible to imipenem and amikacin but 78.9% and 100% resistant to erythromycin, penicillin, lincomycin, vancomycin, trimethoprim-sulfamethoxazole, tetracycline respectively. At 25mg/ml, 12.5mg/ml, and 6.25mg/ml, *Parkia biglobosa* showed high inhibitory activity against MRSA at the range of 9mm – 19mm compared to *Newbouldia laevis* having inhibitory activity against MRSA at the range of 0 – 15mm at the same concentrations. ***Conclusion*:** Our study reports the prevalence of MRSA with multi-resistant phenotype in wound samples and also advocates for the judicious use of imipenem and amikacin as drugs of choice against the test isolate. These findings validate the use of methanol leaves and stem-bark extract of *P. biglobosa* as an alternative medicine for treating MRSA-associated wound infection and recommend further complementary studies in ethno-pharmacological use.

**Keywords:** methicillin-resistant *Staphylococcus aureus*, *Parkia biglobosa*, *Newbouldia laevis*, wound

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## INTRODUCTION

Methicillin-resistant *Staphylococcus aureus* (MRSA) encodes the *mec*A gene that mediates resistance to penicillin-derived methicillin and another beta-lactam antibiotic (Peter *et al.,* 2022a). The presence of an altered penicillin-binding protein (PBP2a) encoded by the *Mec*A strain has been recognized as a factor essential for methicillin resistance (Peter *et al.,* 2022a). This housekeeper gene is found as an integral portion of the *Staphylococcal* cassette chromosome *mec* (SCC mec) (Peter *et al.,* 2022b). Methicillin-resistant *Staphylococcus aureus* is considered a priority pathogen in the community and hospital-acquired infection of which their potential risk is also a matter of concern (Peter *et al.,* 2022a; Peter *et al.,* 2022b).

MRSA has a high global burden in immunocompromised patients particularly wound patients causing significant morbidity and mortality (Ghaznavi-Rad & Ekrami, 2018; Garoy *et al.,* 2018). In humans, MRSA remains a medically important bacteria that colonizes bone and wound infections (Peter *et al.,* 2022c). The expression of virulence by MRSA in osteomyelitis and postoperative wound infections in orthopedic medicine are the leading cause of delayed bone/wound healing and non-union which may necessitate the amputation of such bones (Peter *et al.,* 2022a; Peter *et al.,* 2022c). Prior studies have reported a high risk of MRSA infection in fracture and post-surgical wound patients (Peter *et al.,* 2022a; Peter *et al.,* 2022c). MRSA is often multi-resistant eroding the effectiveness of most conventional antibiotics with limited treatment options. Another key element that contributes to treatment failure in wound patients is the creation of various virulence factors. For example, MRSA strains that produce Panton-Valentine Leukocidin (PVL) have higher lethality than PVL-negative bacteria (Holmes *et al.,* 2005) as observed in soft tissue infection, surgical site infection (SSI) and burn wounds (Chen *et al.,* 2018). Although MRSA is a substantial health issue, there is a lack of research on the frequency of MRSA in wounds in Nigeria. In most hospital departments/wards with wound patients, ampicillin, ampicillin, gentamicin, and ciprofloxacin are the most widely prescribed antibiotics. The majority of recently utilized medications in most hospitals are not novel in therapeutic use, but rather refinements of existing classes of antibacterial treatments that can only provide temporary relief to wound patients. It is, nonetheless, difficult to imagine a world without antibiotics. However, this is rapidly approaching because diseases and disease-causing agents that were formerly thought to have been conquered and beaten by antibacterial medicines are emerging in a new pattern of resistance to therapeutic drugs.

Researchers are currently looking for compounds from plants that can operate as cutting-edge antimicrobials, with a broader spectrum of activity against bacteria of both Gram-positive and Gram-negative origin and no major side effects (Ude *et al.,* 2021; Peter *et al.,* 2022d; Agbo *et al.,* 2024). The ability of plants to produce an endless number of secondary metabolites that serve as the foundation for plant-derived antibacterial agents.

Smooth *Newbouldia* or boundary tree is the popular name for *Newbouldia laevis* (Bignoniaceae) (Akerele *et al.,* 2011). It can reach a height of 7 – 15 meters, but it is more commonly a shrub of 2-3 meters with multiple stems producing clumps of gnarled branches (Akerele *et al.,* 2011). Most tribes in Nigeria refer to it as Eto Adanha in Ibibio-Efik, Akoko in Yoruba "Ogirisi" in Igbo, "Ikhimi" in Edo, and "Aduruku" in Hausa (Akerele *et al.,* 2011). *Newbouldia laevis* is commonly used in folk medicine in South Eastern and Midwestern Nigeria for the treatment of infected wounds and eye issues (Akerele *et al.,* 2011). Scientific studies on the plant's phytochemical contents indicated the presence of phenylpropanoids and alkaloids in the root (Germann *et al.,* 2006) tannins, and flavonoids in the leaves (Usman & Osuji, 2007). Also, *Parkia biglobosa* (African locust bean tree) is native to Africa (Jauro *et al.,* 2018) and is commonly referred to as Orgili in the Igbo tribe of Nigeria. *Parkia biglobosa* is a plant that has demonstrated a promising source of phytomedicinal compounds (Millogo-Kone *et al.,* 2007), as well as other ethnobotanical and folkloric applications. The World Health Organization (WHO) has stated that medicinal plants may be the finest source of a wide range

of medications (Agbo *et al.*, 2024). As a result, there has been a global renaissance in the use of herbal remedies in illness management across all continents, with most developing countries now incorporating phytomedicine into their healthcare systems. Diseases are treated in Nigeria's healthcare system utilizing medicinal plants alongside with contemporary medicine. As the looming threat of clinical antibacterial tolerance or resistance persists, susceptibility tests remain essential for the screening and selection of medicinal and conventional antibacterial agents. As a result, this study looks into the screening of available antibiotics and the antibacterial ability of *Parkia biglobosa* and *Newbouldia laevis* leaf and stem bark as a panacea for the treatment of MRSA wound infection.

## METHODS

### Inclusion and Exclusion Criteria

The wound samples were collected from patients at Alex Ekwueme Federal Teaching Hospital Abakaliki, Ebonyi State Abakaliki, located at latitude 6.3231$^{o}$ N and longitude 8.1121$^{o}$ E (Ilang *et al.*, 2023). Ebonyi State is located 64 kilometers southeast of Enugu in southeastern Nigeria. The study comprised consenting patients with current post-surgical wounds, burn wounds, decubitus ulcer, and diabetic foot ulcers occurring within 30 days or one year if an orthopedic implant is in place. Patients with community-acquired pyogenic infections such as furuncle, abscess, and carbuncle; patients with episiotomy infection; and patients with open fractures were excluded from the study.

### Demographic Data and Sample Collection

Demographic and clinical data were acquired from consenting patients utilizing a standardized validated questionnaire and patient files. These included age, gender, previous antibiotic intake, beginning of the lesion/length of hospital stay, type, and associated medical condition. A total of 200 samples (Fifty [50] each) were collected within the period of 12 months from post-surgical wounds, burn wounds, decubitus ulcers and diabetic foot ulcers patients were collected by rotating a sterile swab on the affected site. The collected specimens were taken within one hour of collection via moist Amie's transport medium to the microbiology research unit of the Ebonyi State University Abakaliki, Nigeria for bacteriological investigation.

### Isolation and Identification of Test Organisms

The wound swab specimens were suspended in a sterilized nutrition broth (Oxoid, UK) and incubated for 24 hrs at 37$^{o}$C. The turbid bacterial growth was plated onto MP1571 Denim Blue Chromogenic MRSA Screening Agar (Oxoid, UK), and incubated for 24 hrs at 37$^{o}$C. Bacterial colonies on MP1571 Denim Blue Chromogenic MRSA Screening Agar (Oxoid, UK) with atypical MRSA features of denim blue colonies were aseptically purified by subculturing onto nutrient agar (Oxoid, UK) and incubated at 24 hrs at 37$^{o}$C. The pure culture strains were subsequently identified via and PBP2 latex agglutination tests (DR0900A) and Vitex 2 compact 60 next-generation automated system (BIOMERIEUX, U.S.A).

### Antibiotic Susceptibility Testing

According to the Clinical and Laboratory Standards Institute (CLSI) criteria (CLSI, 2019), a standardized Kirby-Bauer disk diffusion method with the Mueller-Hinton agar (MHA) (Oxoid, Basingstoke, Hampshire, UK) plate technique was performed. A suspension of bacterial cells (i.e., the equivalent of $1x10^{6}$ colony forming unit per milliliter (CFU/ml) was swabbed onto each Petri dish containing solidified Mueller-Hinton agar and adjusted to 0.5 MacFarland turbidity standard. The inoculated organisms were allowed for 15 minutes for pre-

diffuse of bacteria suspension. Commercially available antibiotic discs comprising the following antibiotics: Vancomycin (30 µg), Amikacin (10µg), Ceftazidime (30 µg), Cefotaxime (30 µg), Erythromycin (5µg), lincomycin (15µg), Imipenem (30 µg), Trimethoprim-Sulfamethoxazole (30 µg), Penicillin (10 µg), Tetracycline (15µg) (Oxoid) were was aseptically applied with sterile forceps onto the surfaces of the solidified Mueller-Hinton agar (Oxoid, Basingstoke, Hampshire, UK) plates and gently pressed to achieve uniform contact. The plates were incubated for 24 hrs at 37° C. The inhibition zones were interpreted in millimeters (mm) according to CLSI guidelines for antibiotics sensitivity (CLSI, 2019; Oke *et al.*, 2024).

***Collection and Authentication of Parkia biglobosa and Newbouldia laevis***

*Parkia biglobosa* and *Newbouldia laevis* leaf and stem bark were collected at Ndufe-Alike community (located at latitude 6º 7' 54''N and longitude 8º 8' 29''E) in Ikwo L. G. A in Ebonyi State. The plant materials were examined and validated with voucher no: HP/344/67R by Dr. C. D Udechukwu, a taxonomist in the Department of Biology at Alex Ekwueme Federal University Ndufe-Alike in Ikwo L. G. A in Ebonyi State, Nigeria.

***Extraction of Stem-bark and Leaf of Parkia biglobosa and Newbouldia laevis***

This was performed following a modification in the methods of Osuntokun *et al.* (2018) as stated below.

*Modification:* The work of Osuntokun *et al.* (2018) air-dried the plant material for 10 days and the plant materials were not cut into pieces before maceration. The filtrate was dried using a rotary evaporator. *Parkia biglobosa* and *Newbouldia laevis* leaf and stem bark were sun-dried for 5 days after being washed with sterile water. The plant material was cut into pieces and then pulverized with a sterile mortar and pestle to reduce into powdered particles (Jauro *et al.*, 2018; Osuntokun *et al.*, 2018). Before extraction, exactly 200 grams of *Parkia biglobosa* and *Newbouldia laevis* in each leaf and stem bark were soaked in 400 ml volume of methanol (Labpak Chemicals Ltd Conventry, England) and allowed to stand overnight at room temperature. It was then filtered with a muslin cloth (Peter *et al.*, 2022d). The filtrate was evaporated to dryness at <40ºC using a rotary evaporator and stored in the desiccator until needed.

***Preparation of Different Concentration of the Extracts***

Exactly, one gram (1g) of each plant part was reconstituted separately in 10 ml of 70% Dimethylsulphoxide (Tianjin kermel Chemical Reagent Co., Ltd, China) as diluent to obtain a concentration of 100 mg/ml. Exactly, $10^{-5}$ serial dilution was carried out from the stock solution to obtain extract concentrations of 50 mg/ml, 25 mg/ml, 12.5 mg/ml and, 6.25 mg/ml.

***Antibacterial Activity of Methanol stem-bark and leaf extract of Parkia biglobosa and Newbouldia laevis***

The antibacterial activity of plant extracts was determined using the agar well diffusion method as described by earlier researchers (Nwankwo *et al.*, 2023). A suspension of bacterial cells (i.e., the equivalent of $1x10^6$ colony forming unit per milliliter (CFU/ml) was seeded onto each petri dish containing solidified Mueller-Hinton agar (Oxoid, Basingstoke, Hampshire, UK) and adjusted to 0.5 MacFarland turbidity standard. This was allowed to stand for 15 minutes to enable the inoculated organisms to pre-diffuse. The wells were then aseptically bored on seeded agar plates with an 11 mm sterile Cork borer (supertek®, U. S. A). The wells were filled with 1 ml of each extract concentration. The inoculated agar plates were incubated for 24 hours at $37^OC$. After incubation, clear inhibition zones were measured using a metric rule and interpreted in millimeters (mm).

## RESULTS

### Prevalence of MRSA from Wound Samples

MRSA from isolated *Staphylococcus aureus* recovered from post-surgical wound, burn wounds, diabetic foot ulcers, and decubitus ulcer samples showed prevalence rates of 87.2, 78.5, 51.7, and 62.9 respectively. The total prevalence rate was 55.5 % as shown in Table 1.

### Demographic and Relevant Clinical Information of Wound Patients with MRSA

MRSA among wound patients was predominant amongst 35-49 years recording 21.5%, followed by 50 – 69 years recording 18.5%, and 20 – 34 years having 15.5%. Gender distribution of MRSA was observed in females than males with MRSA occurrence rates of 33.5% and 22.0% respectively. Duration of hospitalization within 2 months displayed a high prevalence of MRSA 18.5%. Duration of 4 months and above showed 10.5%, greater than 1 week 10.0%, 7 days showed 7.5%, duration of 3 months showed 5.0% and the least prevalence of MRSA was found within 1 month duration as shown in Table 2.

### Antibiotic Susceptibility Profile of MRSA

The results of the antibiotic susceptibility profile of MRSA from post-surgical wound swabs in Table 2 showed 100%, 87.8%, and 51.2% susceptibility to imipenem, amikacin, and cefotaxime respectively. The isolates also showed the highest (100%) resistance to penicillin and tetracycline, followed by 97.5%, 951% and 87.8% resistance to lincomycin, trimethoprim-sulfamethoxazole, and vancomycin.

MRSA isolated from burn wound patients were 100% resistant to penicillin, tetracycline, trimethoprim-sulfamethoxazole, and vancomycin while 78.9%, 69.7%, and 57.6% resistant was observed against erythromycin, lincomycin and ceftazidime respectively. The MRSA isolated was 100% susceptible to amikacin, imipenem, and cefotaxime followed by 42.2%, 30.3% and 21.2% recorded against ceftazidime, lincomycin, and erythromycin respectively. While MRSA isolates from burn wound patients were 100 % susceptible to amikacin, cefotaxime and imipenem while ceftazidime, erythromycin, and lincomycin recorded 42.4 %, 21.2 % and 30.3 % respectively as shown the Table 2.

MRSA isolated from decubitus ulcer patients were susceptible to aminoglycoside (amikacin 90.9 %), cephalosporin (cefotaxime 100 %) and carbapenem (imipenem 100%) but less susceptible against erythromycin and ceftazidime recording 13.6 %, and 27.3 % respectively. MRSA isolated from decubitus ulcer patients exhibits a high level of resistance recording 100 % to trimethoprim-sulfamethoxazole, vancomycin, tetracycline, penicillin, and lincomycin while 86.4 %, 72.7 %, and 9.1% resistance rates was recorded against erythromycin, ceftazidime and amikacin respectively as presented in Table 3. Also, MRSA recovered from diabetic foot ulcer patients were 100 % resistant to lincomycin, penicillin, tetracycline, trimethoprim-sulfamethoxazole, and vancomycin. Amikacin showed resistance of 9.1 % against 90.9 % susceptible. Then, ceftazidime and erythromycin recorded 72.7 % and 86.4 % resistance as presented in Table 3.

***Antibacterial activity of methanol crude extract of Parkia biglobosa against MRSA isolates from post-surgical wound***

Methanol leaf extract of *Parkia biglobosa* had an inhibition zone diameter within the range of 11-15 mm at 100 mg/ml concentration while stem-bark extract had inhibition zone diameters within the range of 19-26 mm at 100 mg/ml concentration against MRSA isolates from a post-surgical wound in Table 4.

***Antibacterial activity of methanol crude extract of Parkia biglobosa against MRSA isolates from Burn wound***

Methanol leaf extract of *Parkia biglobosa* showed no inhibitory effect against MRSA isolates from burn wounds while stem-bark extract showed antibacterial activity at 100mg/ml concentration within the range of 15-25mm against the test isolates (Table 5). Stem-bark extract demonstrated antibacterial activity within the range of 13-21mm and 9-17mm at 50mg/ml and 25mg/ml concentration against MRSA isolates from burn wounds.

***Antibacterial activity of methanol crude extract of Parkia biglobosa against MRSA isolates from Burn wound***

MRSA isolates from Diabetic foot ulcers were less sensitive to methanol leaf extract of *Parkia biglobosa* at 12.5 mg/ml and 6.25 mg/ml concentration with no inhibitory effect while high inhibitory zone diameter of 24mm and 21mm was observed at 100mg/ml and 50 mg/ml concentration of stem-bark extract as presented in Table 6.

***Antibacterial activity of methanol crude extract of Parkia biglobosa against MRSA isolates from Decubitus ulcer***

Stem-bark extract of *Parkia biglobosa* was active at 6.25 mg/ml concentration recording 9-11mm against MRSA isolates from Decubitus ulcer. The stem bark showed active resistance at a concentration of 100 mg/ml recording 14-25mm and 9-21mm at the concentration of 50mg/ml as shown in Table 7.

***Antibacterial activity of methanol crude extract of Newbouldia laevis against MRSA isolates from Post-surgical wound***

Methanol crude extract of *Newbouldia laevis* showed no inhibitory activity at 12.5 mg/ml and 6.25 mg/ml concentration against MRSA isolates from post-surgical wounds. The leaf extract at 100mg/ml showed the highest activity measuring18mm but the stem bark recorded high activity measuring 20mm as shown in Table 8.

***Antibacterial activity of methanol crude extract of Newbouldia laevis against MRSA isolates from Burn wound***

Leaf extract of *Newbouldia laevis* demonstrated high antibacterial activity with inhibitory zone diameter of 15mm and 12mm at 100mg/ml and 50 mg/ml concentration respectively while *Newbouldia laevis* stem-bark extract showed no inhibitory activity at 12.5 mg/ml and 6.25 mg/ml concentration against MRSA isolates from burn wounds shown in Table 9.

***Antibacterial activity of methanol crude extract of Newbouldia laevis against MRSA isolates from Diabetic foot ulcers***

*Newbouldia laevis* leaf and stem bark extract against MRSA isolates from diabetic foot ulcers revealed inhibitory zone diameters (20mm, 17mm), and (15mm, 15mm) at 100mg/ml and 50 mg/ml concentrations respectively as shown in Table 10.

***Antibacterial activity of methanol crude extract of Newbouldia laevis against MRSA isolates from Decubitus ulcer***

Methanol leaf extract of *Newbouldia laevis* demonstrated an inhibitory effect against MRSA isolates from decubitus ulcer while Stem-bark extract revealed high inhibitory zone diameter of 21mm and 17mm at 100mg/ml and 50mg/ml concentrations respectively (Table 11).

**Table 1: Prevalence of MRSA from wound samples.**

| Clinical Sample | No. of sample | MRSA positive (%) |
|---|---|---|
| Post-surgical wound | 67 | 41(20.5) |
| Burn wound | 51 | 33(16.5) |
| Diabetic foot ulcers | 35 | 15(17.5) |
| Decubitus ulcer | 47 | 22(11.0) |
| **Total** | **200** | **111(55.5)** |

**Table 2: Demographic and Relevant Clinical information of wound patients with MRSA**

| Characteristic | | No. sampled | MRSA (%) |
|---|---|---|---|
| **Age group** | 20-34 years | 68 | 31(15.5) |
| | 35-49 years | 84 | 43(21.5) |
| | 50-69 years | 48 | 37(18.5) |
| **Gender** | Male | 96 | 67(33.5) |
| | Female | 104 | 44(22.0) |
| **Duration of hospitalization** | 7 days | 26 | 15(7.5) |
| | > 1 week | 39 | 20(10.0) |
| | 1 month | 27 | 8(4.0) |
| | 2 months | 53 | 37(18.5) |
| | 3 months | 24 | 10(5.0) |
| | 4 months & above | 31 | 21(10.5) |
| **Medical Condition** | Post-surgical wound | 67 | 41(87.2) |
| | Burn wound | 51 | 33(78.5) |
| | Decubitus ulcer | 47 | 22(62.9) |
| | Diabetic foot ulcers | 35 | 15(51.7) |
| **Previous Antibiotic intake** | Ampicillin | 56 | 29(14.5) |
| | Ampiclox | 67 | 47(23.5) |
| | Ciprofloxacin | 43 | 15(7.5) |
| | Gentamicin | 34 | 20(10.0) |

**Table 3: Antibiotic susceptibility profile of MRSA**

| | | Post-surgical wound | | Burn wound | | Decubitus ulcer | | Diabetic foot ulcers | |
|---|---|---|---|---|---|---|---|---|---|
| | | ***n*=41** | | ***n*=33** | | ***n*=22** | | ***n*=15** | |
| **Antibiotic** | **Disc potency (µg)** | **R (%)** | **S (%)** | **R (%)** | **S (%)** | **R (%)** | **S (%)** | **R (%)** | **S (%)** |
| Amikacin | 20 | 5(12.2) | 36(87.8) | 0(0.0) | 33(100) | 2(9.1) | 20(90.9) | 0(0.0) | 15(100) |
| Cefotaxime | 30 | 20(48.9) | 21(51.2) | 0(0.0) | 33(100) | 0(0.0) | 22(100) | 7(46.7) | 8(53.3) |
| Ceftazidime | 30 | 24(58.5) | 17(41.5) | 19(57.6) | 14(42.4) | 16(72.7) | 6(27.3) | 12(80) | 3(20) |
| Erythromycin | 15 | 21(51.2) | 20(48.9) | 26(78.9) | 7(21.2) | 19(86.4) | 3(13.6) | 15(100) | 0(0.0) |
| Imipenem | 30 | 0(0.0) | 41(100) | 0(0.0) | 33(100) | 0(0.0) | 22(100) | 0(0.0) | 15(100) |
| Lincomycin | 15 | 40(97.5) | 1(2.4) | 23(69.7) | 10(30.3) | 22(100) | 0(0.0) | 15(100) | 0(0.0) |
| Penicillin | 10 | 41(100) | 0(0.0) | 33(100) | 0(0.0) | 22(100) | 0(0.0) | 15(100) | 0(0.0) |
| Tetracycline | 30 | 41(100) | 0(0.0) | 33(100) | 0(0.0) | 22(100) | 0(0.0) | 10(66.7) | 5(33.3) |
| Trimethoprim-Sulfamethoxazole | 30 | 39(95.1) | 2(4.9) | 33(100) | 0(0.0) | 22(100) | 0(0.0) | 15(100) | 0(0.0) |
| Vancomycin | 30 | 36(87.8) | 5(12.2) | 33(100) | 0(0.0) | 22(100) | 0(0.0) | 15(100) | 0(0.0) |

Key: R-Resistance, S- Susceptible, *n-n*umber of MRSA

**Table 4: Antibacterial activity of methanol crude extract of *Parkia biglobosa* against MRSA isolates from post-surgical wound**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 2 | Leaf | 11 | 10 | NI | 8 | 7 |
| MRSA 5 | | NI | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 9 | | 15 | 12 | 10 | 7 | 8 |
| MRSA10 | | 14 | 9 | 9 | 8 | NI |
| MRSA 11 | | 14 | 12 | 10 | 9 | 9 |
| MRSA 12 | | 13 | 12 | 8 | NI | NI |
| MRSA 14 | | NI | NI | NI | NI | NI |
| MRSA 15 | | NI | NI | NI | NI | NI |
| MRSA 2 | Stem-bark | 21 | 20 | 19 | NI | NI |
| MRSA 5 | | 20 | 15 | NI | NI | NI |
| MRSA 7 | | 21 | 17 | 12 | NI | NI |
| MRSA 9 | | 19 | 15 | 11 | NI | NI |
| MRSA 10 | | 24 | 16 | 16 | 15 | NI |
| MRSA 11 | | 26 | 19 | 15 | 12 | 17 |
| MRSA 12 | | 18 | 12 | 10 | NI | NI |
| MRSA 14 | | 19 | 14 | 11 | 10 | NI |
| MRSA 15 | | 20 | 17 | 15 | 12 | 10 |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 5: Antibacterial activity of methanol crude extract of *Parkia biglobosa* against MRSA isolates from Burn wound**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 20 | Leaf | 14 | 9 | 10 | NI | NI |
| MRSA 22 | | 15 | 12 | 10 | 8 | 7 |
| MRSA 10 | | 12 | 9 | NI | NI | NI |
| MRSA 2 | | NI | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 8 | | NI | NI | NI | NI | NI |
| MRSA 5 | | NI | NI | NI | NI | NI |
| MRSA 6 | | NI | NI | NI | NI | NI |
| MRSA 1 | | NI | NI | NI | NI | NI |
| MRSA 20 | Stem-bark | 21 | 18 | 15 | 14 | NI |
| MRSA 22 | | 23 | 21 | 16 | 10 | NI |
| MRSA 10 | | 18 | 15 | 13 | 9 | 9 |
| MRSA 2 | | 16 | 11 | 9 | NI | NI |
| MRSA 7 | | 22 | 20 | 17 | 11 | NI |
| MRSA 8 | | 25 | 19 | 15 | 12 | 9 |
| MRSA 5 | | 15 | 13 | 10 | NI | NI |
| MRSA 6 | | 19 | 18 | 11 | 11 | NI |
| MRSA 1 | | 20 | 14 | 9 | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 6: Antibacterial activity of methanol crude extract of *Parkia biglobosa* against MRSA isolates from Burn wound**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 1 | Leaf | 14 | 12 | NI | NI | NI |
| MRSA 3 | | 11 | NI | NI | NI | NI |
| MRSA 15 | | NI | NI | NI | NI | NI |
| MRSA 4 | | 17 | 15 | 11 | NI | NI |
| MRSA 7 | | 19 | 16 | 13 | NI | NI |
| MRSA 10 | | NI | NI | NI | NI | NI |
| MRSA 12 | | NI | NI | NI | NI | NI |
| MRSA 2 | | NI | NI | NI | NI | NI |
| MRSA 5 | | NI | NI | NI | NI | NI |
| MRSA 1 | Stem-bark | 23 | 21 | 17 | 15 | 11 |
| MRSA 3 | | 18 | 15 | 13 | 13 | NI |
| MRSA 15 | | 18 | 14 | NI | NI | NI |
| MRSA 4 | | 22 | 17 | 15 | NI | NI |
| MRSA 7 | | 16 | 13 | 10 | NI | NI |
| MRSA10 | | 16 | 11 | 9 | NI | NI |
| MRSA 12 | | 24 | 19 | 17 | 16 | 11 |
| MRSA 2 | | 21 | 15 | 13 | 12 | 9 |
| MRSA 5 | | 19 | 15 | 12 | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 7: Antibacterial activity of methanol crude extract of *Parkia biglobosa* against MRSA isolates from Decubitus ulcer**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 15 | Leaf | 14 | 11 | NI | NI | NI |
| MRSA 16 | | NI | NI | NI | NI | NI |
| MRSA 18 | | NI | NI | NI | NI | NI |
| MRSA 3 | | NI | NI | NI | NI | NI |
| MRSA 5 | | 17 | 15 | 14 | 11 | NI |
| MRSA 8 | | 19 | 17 | 11 | 10 | 10 |
| MRSA 9 | | NI | NI | NI | NI | NI |
| MRSA 7 | | 15 | 12 | NI | NI | NI |
| MRSA 22 | | 18 | 13 | NI | NI | NI |
| MRSA 15 | Stem-bark | 22 | 19 | 17 | 14 | 11 |
| MRSA 16 | | 24 | 16 | 12 | 10 | NI |
| MRSA 18 | | 18 | 18 | 14 | 11 | 9 |
| MRSA 3 | | 16 | 11 | NI | NI | NI |
| MRSA 5 | | 14 | 9 | NI | NI | NI |
| MRSA 8 | | 23 | 17 | 15 | 14 | 10 |
| MRSA 9 | | 25 | 21 | 19 | 17 | 11 |
| MRSA 7 | | 19 | 17 | 13 | **9** | NI |
| MRSA 22 | | 15 | 11 | NI | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 8: Antibacterial activity of methanol crude extract of *Newbouldia laevis* against MRSA isolates from Post-surgical wound**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 40 | Leaf | 17 | 16 | 15 | NI | NI |
| MRSA 41 | | 12 | 8 | 9 | NI | NI |
| MRSA 30 | | 15 | 8 | NI | NI | NI |
| MRSA 35 | | NI | NI | NI | NI | NI |
| MRSA 1 | | 18 | 11 | NI | NI | NI |
| MRSA 3 | | NI | NI | NI | NI | NI |
| MRSA7 | | NI | NI | NI | NI | NI |
| MRSA 8 | | NI | NI | NI | NI | NI |
| MRSA 10 | | NI | NI | NI | NI | NI |
| MRSA40 | Stem-bark | 20 | 15 | NI | NI | NI |
| MRSA 41 | | 19 | 15 | 13 | NI | NI |
| MRSA 30 | | NI | NI | NI | NI | NI |
| MRSA 35 | | 18 | 11 | NI | NI | NI |
| MRSA 1 | | 15 | 13 | NI | NI | NI |
| MRSA 3 | | NI | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 8 | | 20 | 12 | NI | NI | NI |
| MRSA 10 | | NI | NI | NI | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 9: Antibacterial activity of methanol crude extract of *Newbouldia laevis* against MRSA isolates from Burn wound**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 23 | Leaf | 14 | 12 | NI | NI | NI |
| MRSA 25 | | 12 | 9 | NI | NI | NI |
| MRSA 2 | | 15 | 12 | 8 | NI | NI |
| MRSA 5 | | 9 | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 10 | | NI | NI | NI | NI | NI |
| MRSA 6 | | NI | NI | NI | NI | NI |
| MRSA 3 | | 14 | NI | NI | NI | NI |
| MRSA 16 | | 11 | NI | NI | NI | NI |
| MRSA 23 | Stem-bark | 18 | 15 | NI | NI | NI |
| MRSA 25 | | 20 | 19 | 15 | NI | NI |
| MRSA 2 | | 15 | 9 | NI | NI | NI |
| MRSA 5 | | NI | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 10 | | NI | NI | NI | NI | NI |
| MRSA 6 | | NI | NI | NI | NI | NI |
| MRSA 3 | | NI | NI | NI | NI | NI |
| MRSA 16 | | NI | NI | NI | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 10: Antibacterial activity of methanol crude extract of *Newbouldia laevis* against MRSA isolates from Diabetic foot ulcers**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 2 | Leaf | NI | NI | NI | NI | NI |
| MRSA 4 | | NI | NI | NI | NI | NI |
| MRSA 8 | | 17 | 14 | 12 | NI | NI |
| MRSA 10 | | 12 | NI | NI | NI | NI |
| MRSA 6 | | NI | NI | NI | NI | NI |
| MRSA 1 | | NI | NI | NI | NI | NI |
| MRSA 14 | | NI | NI | NI | NI | NI |
| MRSA 15 | | 15 | NI | NI | NI | NI |
| MRSA 12 | | 20 | 15 | NI | NI | NI |
| MRSA 2 | Stem-bark | NI | NI | NI | NI | NI |
| MRSA 4 | | NI | NI | NI | NI | NI |
| MRSA 8 | | 12 | 9 | NI | NI | NI |
| MRSA 10 | | NI | NI | NI | NI | NI |
| MRSA 6 | | NI | NI | NI | NI | NI |
| MRSA 1 | | 17 | 15 | 15 | 8 | NI |
| MRSA 14 | | NI | NI | NI | NI | NI |
| MRSA 15 | | NI | NI | NI | NI | NI |
| MRSA 12 | | NI | NI | NI | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

**Table 11: Antibacterial activity of methanol crude extract of *Newouldia laevis* against MRSA isolates from Decubitus ulcer**

| | | Extract Concentration | | | | |
|---|---|---|---|---|---|---|
| **Strain** | **Plant part** | **100mg/ml** | **50 mg/ml** | **25 mg/ml** | **12.5 mg/ml** | **6.25 mg/ml** |
| MRSA 13 | Leaf | NI | NI | NI | NI | NI |
| MRSA 16 | | NI | NI | NI | NI | NI |
| MRSA 2 | | NI | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 17 | | NI | NI | NI | NI | NI |
| MRSA 21 | | NI | NI | NI | NI | NI |
| MRSA 18 | | NI | NI | NI | NI | NI |
| MRSA 11 | | NI | NI | NI | NI | NI |
| MRSA 13 | Stem-bark | 18 | 13 | NI | NI | NI |
| MRSA 16 | | 21 | 17 | 14 | 11 | 9 |
| MRSA 2 | | NI | NI | NI | NI | NI |
| MRSA 7 | | NI | NI | NI | NI | NI |
| MRSA 17 | | NI | NI | NI | NI | NI |
| MRSA 21 | | NI | NI | NI | NI | NI |
| MRSA 18 | | 17 | 15 | 11 | 9 | NI |
| MRSA 11 | | 20 | NI | NI | NI | NI |

Key: NI-No inhibition, MRSA-Methicillin Resistant *Staphylococcus aureus*

## DISCUSSION

MRSA is assessed by a series of resistant determinants according to different strains. As a result, the chromogenic agar was used to identify MRSA strain in wounds with an occurrence rate of 55.5%**.** In concordance with this result, high incidence of MRSA has been found in wound infection in Nigeria; Olowe *et al.* (2007) reported 47.7 % in Osogbo, south-western Nigeria, two studies reported 75% in Zaria (Obajuluwa *et al.*, 2013; Udobi *et al.*, 2013), Ikeh (2003) reported an MRSA prevalence of 81% from in-patients in Jos, Nigeria. Nwankwo & Nasiru (2011) reported a prevalence rate of 62% from in-patients in Kano Nigeria. In Enugu, Nigeria, MRSA strain accounted for 86(28.4 %) and 78(25.7 %) of post-surgical wounds and

fracture wounds respectively (Peter *et al.,* 2022a). Taiwo *et al*. (2004) earlier reported a prevalence of 70.6% in the city of Ilorin from in-patients.

However, low and higher values have been reported in wound samples from inter-country studies: 18.8% in Mwanza-Tanzania *et al.* (2011), 25% in Jinja-Uganda (Anguzu & Olila, 2007), 37.4% in Madinah kingdom of Saudi Arabia (Ghanem *et al.,* 2018), 25 (61%) in Iran (Ghaznavi-Rad & Ekrami, 2018), 75% from surgical wounds in Algeria (Rebiahi *et al.,* 2011), 72.0% in Eritrea (Garoy *et al.,* 2018), 80% in Peru (Guzman-Blanco *et al.,* 2009) and in a setting in Colombia 90% (Jimenez *et al.,* 2012). Many published researches have also documented a rise in the prevalence of MRSA, the majority of which was caused by wounds (Ariom *et al.,* 2019; Peter *et al.,* 2022c). Several reasons can explain the intra- and inter-country heterogeneity in MRSA prevalence. These include variances in study design, specimen type, laboratory techniques, and study duration, among other things (Deyno *et al.,* 2017). Some studies, for example, depend completely on phenotypic processes to detect MRSA, while others rely on a DNA-based approach (Multilocus Sequence Typing [MLST]), microarrays, whole genome sequencing, spa-typing, conventional PCR, and among others) to identify *mec*A. Investigations relying on DNA-based technique by PCR tend to reveal a lower incidence of MRSA (Nwankwo & Nasiru, 2011; Peter *et al.,* 2022c).

MRSA was more predominant in post-surgical wounds 20.5% than in another wound sample in the study. This reiterates the prevalence of MRSA 3.9%-35.6% in post-surgical wounds, as documented by other researchers (Kolawole *et al.,* 2013; Garoy *et al.,* 2018). Our findings suggest that post-surgical patients may be prone to toxigenic equipment carriage and antibiotic-resistance clonal strains of *S. aureus.* More research into the pathogenicity potential and characteristics of MRSA populations from post-surgical wound patients could be beneficial. Given the discovery of numerous toxin genes, including the *tst* gene, in hospitalized post-operative patients (Kolawole *et al.,* 2013). Post-surgical wound patients in this study may likely be at risk of postsurgical toxic shock syndrome which results in delayed wound healing and prolonged hospitalization.

In this study, male patients harbor MRSA than females with MRSA occurrence rates of 33.5% and 22.0% respectively, and is consistent with earlier research: males 55.9% vs females 44.1% (Garoy *et al.,* 2018), males 71% vs female 25% (Ghanem *et al.,* 2018). This is also consistent with previous studies from other parts of the world. In one such study from Madinah, it was reported that MRSA strains were three times more prevalent in male patients in all studied cases (Ali *et al.,* 2013; Shirah *et al.,* 2017). A study from Makkah found a similar pattern of males having higher MRSA isolation rates (Haseeb *et al.,* 2016). This trend could be linked to various factors, including males being more susceptible to bacterial sepsis; being less compliant and so inclined to greater infection rates (Magliano *et al.,* 2012). According to research, the female hormone (estrogen) has a negative effect on the development of virulence factors in pathogens (Neuman *et al.,* 2015; Ekuma *et al.,* 2023). Furthermore, the patient's hygiene habits, socioeconomic status, occupation, and lifestyle all play essential roles in determining gender-infection correlations, which must be investigated further. It is generally known that women make up a larger proportion of the workforce in Abakaliki, so it is not surprising that samples taken from female patients were more numerous, resulting in a low MRSA isolation rate.

Age group assessment of MRSA among wound patients was more predominant amongst 35-49 years recording 21.5%. Another study has reported a high rate of MRSA with 22(37.3%) in the 19–40 year-old age group (Garoy *et al.,* 2018). Low prevalence in this study was observed amongst those aged 50-69 years and has been found elsewhere (Seni *et al.,* 2013; Garoy *et al.,* 2018). This low isolation rate amongst ages 50-69 years may be linked to the sample size recruited in the study.

Previous antibiotic intake assessment among wound patients showed 23.5% occurrence rate of MRSA amongst ampiclox users followed by ampicillin users 14.5%, while least occurrence rate 7.5% was recorded against ciprofloxacin users. Ampiclox and ampicillin is the most commonly prescribed antibiotics medications to wound patients in Nigeria. MRSA strain is known to possess low affinity to β-lactam antibiotics. Therefore, exposure to sublethal dose of this β-lactam antibiotics may result in observed increase of MRSA colonization in those users. The finding in this study that MRSA is connected with key risk variables such as age, gender, antibiotic overuse, and prolonged stay in ICU has also been documented in other studies (Garoy *et al.,* 2018; Peter *et al.,* 2022a; Orji *et al.,* 2024). Despite considerable efforts to manage antibiotic resistance bacteria through rigorous infection control strategies, antibiotic-resistant *Staphylococci*, particularly MRSA, have become the most common bacteria encountered in bone and wound infections in orthopedic treatment (Peter *et al.,* 2022a; Peter *et al.,* 2022c).

MRSA is a big concern worldwide (Peter *et al.,* 2022a), with a high significant morbidity and mortality rate in immunocompromised patients, particularly burn wound patients (Ghaznavi-Rad *et al.,* 2015; Peter *et al.,* 2022a).

This study shows that MRSA exhibits resistance to macrolides (that induce *erm* expression) and lincosamide. These isolates demonstrate 51%-100% resistance to lincomycin and erythromycin and it's similar to another study (Seni *et al.,* 2013; Ghaznavi-Rad & Ekrami, 2018; Garoy *et al.,* 2018; Peter *et al.,* 2022a). This means that both lincomycin and erythromycin are ineffective in these patients.

The majority of our MRSA showed 100% resistance to penicillin and tetracycline as per the pattern reported in Abakaliki and Jiangxi province (Chen *et al.,* 2018 Ariom *et al.,* 2019). This could be due to early exposure of these isolates to this antibiotic, which may have accelerated resistance development. In our country, there is a significant degree of antibiotic abuse due to self-medication, which is frequently connected with inappropriate dosage and failure to comply with treatment, as well as the accessibility of antimicrobial agents for patients over the counter without or with a prescription.

Like other studies conducted in Nigeria (Taiwo *et al.,* 2004; Onolitola *et al.,* 2007; Obajuluwa *et al.,* 2013; Peter *et al.,* 2022a). This study confirms the presence of vancomycin-resistant MRSA among wound patients in Abakaliki. Low vancomycin-resistant MRSA from wounds 11.0% in Asmara, Eritrea (Garoy *et al.,* 2018) have been published. In contrast, several studies found that MRSA is 50-100% susceptible to vancomycin (Omuse *et al.,* 2012; Seni *et al.,* 2013; Ghanem *et al.,* 2018; Abdullahi & Iregbu, 2019). According to Falagas *et al.* (2013), the sensitivity of MRSA identified in Africa to VRSA ranges between 82-100%. These estimates and findings contradict an earlier report that VRSA strains are rare, and there is a limited indication of rising prevalence (Kong *et al.,* 2016).

The observed heterogeneity could be explained by changes in antibiotic prescription patterns between countries. Additionally, the *vanA* gene complex, which encodes a high degree of glycopeptide resistance in enterococci, was detected in the vancomycin-resistant *Staphylococcus. aureus* (VRSA) isolates (Peter *et al.,* 2022a). To date, all VRSA isolates found in the United States are methicillin-resistant and carry the *mec*A gene. The *van*A gene complex appears to confer alterations in the cell wall comparable to those seen in vancomycin-resistant *enterococci* in *S. aureus*, and *mec*A and *van*A appear to function independently (Peter *et al.,* 2022a).

MRSA from wounds in this study develops resistance to oxacillin, cephalosporins, macrolides, lincosamides, glycopeptide, and trimethoprim-Sulfamethoxazole. MRSA evolution has been linked to the acquisition of the exogenous gene (*mec*A), which is part of the staphylococcal cassette chromosome mec (SCCmec) (types I-VII) and is controlled by MecI (a repressor) and MecR1 (a transducer) and represents the regulatory/signaling proteins of the

blaZ system (Peter *et al.,* 2022a; Peter *et al.,* 2022d) The *mec*A gene encodes an extra penicillin-binding protein (PBP2a), a peptidoglycan transpeptidase that can give resistance to all -lactam antibiotics and others antibiotic category (Peter *et al.,* 2022a; Orji *et al.,* 2024) as evidence in this study.

Interestingly, all MRSA isolates showed high susceptibility to imipenem 100% while the isolates were 87.8-100% susceptible to Amikacin. In corroboration with earlier literature, MRSA 73.2% and 92.6% susceptibility to imipenem and Amikacin has been reported (Abdullahi & Iregbu, 2019; Rajaduraipandi *et al.,* 2006). The susceptibility of this aminoglycoside and Carbapenem (regarded as last-resort antibiotics for Gram-positive and negative bacterial infections) may result from their relative expensive and unavailability of these drugs for abuse. As such, imipenem and Amikacin could be considered for the treatment of wound infections harboring MRSA.

Considerably, a substantial quantity of the toxin tst gene that mediates toxic shock syndrome in wound patients and PVL operon (*lukS-PV and lukF-PV* genes) has been reported from wound infection (Shittu *et al.,* 2011; Kolawole *et al.,* 2013). Expression of these virulent genes may delay wound healing which leads to prolonged hospitalization and increased duration of antibiotic administration in wound patients. The profile of multidrug antibiotic resistance reported in wound samples in this study is in line with reports in the same setting (Garoy *et al.,* 2018; Peter *et al.,* 2022a). This implies that the isolates emerged from a high-risk source of contamination, where antibiotics are frequently administered and probably abused as a result of poor infection control and prevention policies. As such, the high multidrug-resistant value demonstrated among MRSA isolates may also be linked to external sources of contamination besides the hospital setting in the studied patients.

Plant-derived antimicrobial compounds are effectively utilized in disease management globally. Keeping the above fact in view, the antibacterial activity of *P. biglobosa* leaf and stem-bark methanol extracts shows concentration dependent pattern on the MRSA isolates. *P. biglobosa* stem-bark produces an inhibition zone diameter of 14mm at 25mg/ml concentration against MRSA isolates from Decubitus ulcer patients which is corroborated with the work of Obajuluwa *et al*. (2013) who reported that twenty-eight (28) MRSA isolates from bedsore had inhibitory zone of 11-14mm at25mg/ml concentration. Stem-bark and leaf extract exhibit high inhibitory effects of 25mm and 19mm respectively at 100mg/ml against MRSA isolates. This finding revealed that stem-bark extract had higher antibacterial activity than leaf extract. However, variability in the zone of inhibition diameter was observed at different concentrations. The variations were comparable to prior research on *P. biglobosa* methanol leaf extract (Ajaiyeoba, 2002; Udobi *et al.,* 2010; Obajuluwa *et al*., 2013). By the observed inhibitory activity, *Parkia biglobosa* contains secondary metabolites e.g., tannins, flavonoids, and saponins (Ajaiyeoba, 2002), which possess high antibacterial properties. According to Millogo-Kone *et al.* (2007), the stem bark contains triterpenes, sterols, tannins, anthocyanins, saponosides, coumarins, reducing compounds, and flavonoids, while the leaf contains flavonoids, coumarins, tannins, coumarins, reducing compounds, and anthocyanins (Millogo-Kone *et al.,* 2007). The higher antibacterial activity of *Parkia biglobosa* stem-bark extract found in the present research was attributed to the presence of many constituent groups that may be functioning synergistically against MRSA isolates.

From the results, most MRSA isolates were not susceptible to methanol leaf and stem bark *Newbouldia laevis* extract. It was noted that, for fewer MRSA isolates, the inhibitory effects became more pronounced at 100mg/ml and 50mg/ml as presented in the result. In contrast with these findings, previous literature has reported the antibacterial activity of stem bark *Newbouldia* against *Staphylococcus aureus* from infected wounds and eyes. Our result, although inconsistent with reports from earlier findings (Akerele *et al.,* 2011), the composition of phytochemicals in the extracts may have been changed directly by changes in the extraction

process, nature, and selection of solvents utilized across investigations. This could explain the observed discrepancy. Comparatively, the general variability observations amongst *P. biglobosa* and *Newbouldia laevis* against MRSA in this study can be attributed to phytomolecules' affinity for solvents. The bioactive compounds found in *P. biglobosa* plant extract are thus more soluble in methanol than those found in *Newbouldia laevis*. The methanol extracts of the stems and barks were more active than the extracts of the leaves. This gap can be explained by differences in a plant's physiological features depending on its environmental microclimate, maturity, and soil type. These variables are critical in the production of chemical principles and thereby influence plant pharmacological action.

## CONCLUSION

The present study reports that MRSA isolates constituted a percentage frequency of 55.5% recovered from various wound samples. *In vitro*, failure of most antibiotics (erythromycin, lincomycin, tetracycline, Trimethoprim-Sulfamethoxazole, Vancomycin, penicillin, ceftazidime) with resistant trend of 50-100% against MRSA in this study justifies the need for more effective antibiotic therapy for wound infections with MRSA. Amikacin and imipenem were the only antimicrobial drugs that demonstrated 87.8-100% sensitivity to the test isolate, making them a better therapeutic option in single or combination regimen treatment. In comparison to *P. biglobosa* leaf and stem extract, *Newbouldia laevis* leaf and stem bark methanol extract had no good inhibitory effect at 25mg/ml, 12.5mg/ml, and 6.25 mg/ml concentrations against MRSA isolate. As a result, the findings of this study have verified folklore medicine's assertions about the use of *P. biglobosa* for the treatment of wound infections. The ample presence of phytochemicals substance in the methanol extracts *P. biglobosa* underscores their antibacterial activity against MRSA isolates in this study. The *Newbouldia laevis* plant's limited or low antibacterial activity *in vitro* needs further testing with different solvents. More research with a wide range of target strains is required to determine the abundant pharmacological value of the *Newbouldia laevis* and *P. biglobosa* plants on a large scale.

## ABBREVIATIONS

| | |
|---|---|
| MRSA | Methicillin Resistant *Staphylococcus aureus* |
| NI | No Inhibition |
| AST | Antibiotic Susceptibility Testing |
| CFU | Colony Forming Unit |

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## AUTHOR'S CONTRIBUTION

This work was carried out in collaboration among all authors. Authors VFN and KA wrote the protocol. Authors IUP and IRI wrote the first draft of the manuscript. Authors CIE, UNU, FCA, IMO, ANN, and HO managed the characterization and analyses of the study. Author IRI did the supervision. All authors read and approved the final manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## DATA AVAILABILITY STATEMENT

Data supporting these findings are available within the article or upon request.

## INSTITUTIONAL REVIEW BOARD STATEMENT

The ethical committee of Alex Ekwueme Federal University Teaching Hospital in Abakaliki, Ebonyi State, authorized this study conveyed with approval number: AEFUTHA26/11/2020. This was based on a thorough knowledge of the scientific literatures, satisfactory laboratory protocols, and other relevant sources of information guiding this area of research. Every fundamental study was done in line with the World Medical Association (WMA) declaration of Helsinki on the principles for medical research involving human subjects, and identifiable human material or data.

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