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Original Article

Bacteriology and Antibiotic Sensitivity Patterns of Suppurative Hand Infections in a Tertiary Hospital in the Niger Delta, Nigeria: A 4-Year Prospective Study

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Abstract

Background: Hand infections are a significant cause of morbidity and emergency surgical presentations. The anatomical complexity of the hand predisposes patients to rapid spread of infection, with severe functional consequences if management is delayed. The global emergence of Methicillin-Resistant Staphylococcus aureus (MRSA) and evolving antibiotic resistance patterns make local bacteriological data essential for guiding empirical therapy. This study evaluated the bacteriology and antibiotic sensitivity patterns of suppurative hand infections in Bayelsa State, Nigeria.

Methods: This prospective observational study was conducted from December 2020 to January 2024 at a tertiary medical facility in the Niger Delta. A total of 161 patients presenting with suppurative hand infections were enrolled. Microbiological culture and antibiotic susceptibility testing were performed on 126 patients (78.3%); the remaining 35 patients (21.7%) were not cultured due to inadequate sample volume, initiation of direct empirical treatment for clinically mild infections, or operational constraints at the time of presentation. Pus swabs or tissue aspirates were analyzed by microscopy, culture, and sensitivity (MCS). Data were analyzed using SPSS version 27.

Results: The study included 90 males and 71 females (M:F ratio 1.3:1) with a mean age of 27 ± 10 years. The most common infection types were paronychia (34.2%) and subcutaneous abscesses (21.1%). Of 126 cultured samples, *Staphylococcus aureus* was the predominant isolate (52.4%), followed by *Streptococcus* species (9.5%) and *Escherichia coli* (7.9%). Susceptibility testing revealed high resistance to Penicillin, Ampicillin, and Tetracycline while Ceftriaxone, Ciprofloxacin and Gentamicin demonstrated high efficacy across Gram-positive and Gram-negative isolates.

Conclusion: *Staphylococcus aureus* remains the primary pathogen in suppurative hand infections in this

region and demonstrates significant resistance to first-line penicillins. Empirical treatment with Cephalosporins or Fluoroquinolones, combined with appropriate surgical intervention, is recommended to reduce morbidity and improve outcomes.

Key words: Hand infection; Bacteriology; Staphylococcus aureus; Antibiotic Resistance; Niger Delta; Paronychia

Introduction

Hand infections are a frequent and potentially debilitating presentation in surgical emergency units globally. The intricate anatomy of the hand, comprising distinct facial spaces, tendon sheaths, and a limited soft tissue envelope, facilitates the rapid spread of infection and development of serious complications. Infections that begin as minor trauma can escalate into compartment syndrome, osteomyelitis, permanent stiffness, or amputation if not managed aggressively (12).

Historically, *Staphylococcus aureus* and *Streptococcus* species have been the predominant pathogens identified in acute hand infections (3) The microbiological profile of hand infections continues to evolve and the global emergence of Community-Acquired Methicillin-Resistant *Staphylococcus aureus* (CA-MRSA) has significantly complicated empirical antibiotic selection.[7] Additionally, polymicrobial infections involving Gram-negative organisms such as *Escherichia coli* and *Klebsiella* species have become increasingly common, especially among patients with underlying conditions such as diabetes mellitus, immunosuppression, or specific trauma mechanisms such as crush injuries or animal bites (45).

In low- and middle-income countries (LMICs) such as Nigeria, the problem is compounded by delayed presentation, unsupervised antibiotic use, and reliance on traditional medicine (6). Antibiotic misuse drives selection pressure and resistance, rendering commonly available older antibiotics (penicillins, tetracyclines) increasingly ineffective (7). Local data on microbiological flora and antibiograms for hand infections in the Niger Delta region remain scarce. In addition, global guidelines may not reflect local resistance patterns, necessitating region-specific surveillance.

This prospective study aims to bridge the gap by defining the bacterial aetiology and antibiotic sensitivity profiles of suppurative hand infections at a tertiary hospital in Bayelsa state, Nigeria and support the development of evidence-based empirical treatment protocols.

Methods and materials

Study setting

The study was conducted at the Niger Delta University Teaching Hospital (NDUTH), a 200-bed tertiary referral hospital located in Bayelsa State, in the Niger Delta region of Nigeria.

Study Design and Period

This was a prospective observational study involving all patients presenting with suppurative hand infections from December 2020 to January 2024.

Population

All patients, regardless of age or gender, presenting to the emergency room or outpatient clinic with clinical signs of suppurative hand infection such as pain, swelling, erythema, warmth, loss of function, or purulent discharge were included. Written informed consent was

obtained from all participating patients or from their parents/guardians prior to enrolment to this study. Patients with non-infectious inflammatory conditions (e.g., gout, rheumatoid arthritis), those with superficial skin infections not requiring surgical drainage (such as minor folliculitis), and patients who declined consent were excluded. 32 patients fell into this category.

Data collection

Demographic data (age, sex, occupation) and clinical history (duration of symptoms, predisposing factors, type of infection) were recorded using a structured questionnaire and exported to an Excel spreadsheet for further analysis.

Microbiological analysis

Samples were obtained using sterile applicator swabs or aspiration of pus during incision and drainage. Microbiological culture was requested for 126 of the 161 enrolled patients (78.3%). Culture was not performed in the remaining 35 patients (21.7%), comprising cases in which inadequate sample volume was collected to permit standard processing, cases managed conservatively with empirical antibiotics where clinical severity did not mandate operative intervention, and cases in which laboratory requisition forms were not completed due to operational constraints at the time of presentation.

Specimens were transported to the laboratory immediately and inoculated onto blood agar, chocolate agar, and MacConkey agar plates, then incubated aerobically at 37°C for 24–48 hours. Bacterial isolates were identified using standard biochemical tests (catalase, coagulase, oxidase) and Gram staining. Fungal elements (Candida albicans) were identified based on colonial morphology (cream-colored, convex, moist colonies on blood and chocolate agar) and confirmed by Gram stain demonstrating Gram-positive budding yeast cells and pseudohyphae. Facilities for anaerobic culture were not available at the study institution during the study period. Formal identification was performed by a qualified microbiologist.

Antibiotic susceptibility was determined using the Kirby-Bauer disc diffusion method, in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines (16). The antibiotics tested were selected based on local prescribing patterns, coverage of expected pathogens, and availability on the Nigerian National Essential Medicines List. These included Penicillin, Ampicillin, Cloxacillin, Tetracycline, Chloramphenicol, Gentamicin, Streptomycin, Erythromycin, Co-trimoxazole, Cefuroxime, Ciprofloxacin, Ofloxacin, and Ceftriaxone.

Statistical analysis

Data were de-identified, and all variables were exported to an Excel spreadsheet and analysed using IBM Statistical Package for Social Sciences (SPSS) version 27 (IBM Corporation, Armonk, New York, USA). Descriptive statistics were employed; categorical variables (sex, type of infection, bacterial isolates) were expressed as frequencies and percentages, while continuous variables (age) were summarised using means and standard deviations. The chi-square (χ^2) test was used to examine associations between categorical variables (e.g., infection type and organism isolated) where appropriate, with statistical significance set at $p < 0.05$.

Results

A total of 161 patients were enrolled, ranging in age from 5 weeks to 76 years, with a mean age of 27 ± 10 years. The peak incidence occurred in the 21–30-year age group (30.4%). Males (n = 90, 55.9%) were more frequently affected than females (n = 71, 44.1%), (Table 1).

Table 1: Age and Sex Distribution of Patients

Age Group (Years)	Male (n)	Female (n)	Total (n)	Percentage (%)
0–10	12	12	24	14.9
11–20	18	12	30	18.6
21–30	26	23	49	30.4
31–40	13	10	23	14.3
41–50	13	8	21	13.0
51–60	6	3	9	5.6
>60	2	3	5	3.1
Total	90	71	161	100.0

Simple paronychia was the most common presentation (34.2%), followed by subcutaneous abscesses (21.1%) and cellulitis (10.6%). Deep space infections, including mid-palmar space infections (2.5%) and thenar space infections (1.2%), were less frequent but clinically severe. Osteomyelitis complicated 2.5% of cases. Complex paronychia, also termed run-around paronychia, describing infection that tracks around the nail fold to involve both lateral nail folds simultaneously accounted for 7.5% of cases (Table 2).

Table 2: Spectrum of Suppurative Hand Infections (n = 161)

Type of Infection	Frequency (n)	Percentage (%)
Simple paronychia	55	34.2
Subcutaneous abscess	34	21.1
Cellulitis	17	10.6
Felon	15	9.3
Complex paronychia (run-around)	12	7.5
Web space infection	7	4.3
Osteomyelitis	4	2.5
Gangrene	4	2.5
Mid-palmar space infection	4	2.5
Others (Crush injuries / Burns)	4	2.5
Chronic paronychia	3	1.9
Thenar space infection	2	1.2
Total	161	100.0

Microbiological culture was performed in 126 cases (78.3%), yielding 126 bacterial isolates in total, with mixed infections accounting for 8.7% of culture-positive cases. Gram-positive cocci constituted 54.8% of isolates and Gram-negative bacilli 11.9%. Staphylococcus aureus was the single most frequently isolated pathogen (52.4%), followed by Streptococcus species (9.5%) and E. coli (7.9%). Fungal elements (Candida albicans, 5.6%) were identified predominantly in association with chronic paronychia and immunocompromised states, based on colonial morphology and confirmatory Gram stain (Table 3).

Table 3: Distribution of Isolates (n = 126)

Bacterial Isolate	Frequency (n)	Percentage (%)
Staphylococcus aureus (Gram-positive)	66	52.4
Streptococcus species (Gram-positive)	12	9.5
Escherichia coli (Gram-negative)	10	7.9
Coliforms, other (Gram-negative)	10	7.9
Staphylococcus epidermidis (Gram-positive)	8	6.3
Candida albicans	7	5.6
Pseudomonas species (Gram-negative)	5	4.0
Proteus species (Gram-negative)	5	4.0
Klebsiella species (Gram-negative)	3	2.4
Total	126	100.0

Susceptibility testing revealed marked resistance to older, affordable antibiotics. *Staphylococcus. aureus* showed 0% sensitivity to Penicillin and Ampicillin, and only 30% sensitivity to Tetracy-

cline. However, it retained high sensitivity to Ceftriaxone (100%), Ciprofloxacin (90%), and Cefuroxime (90%). Gram-negative isolates (*Escherichia coli*, *Proteus*, *Klebsiella*) demonstrated excellent sensitivity to Ceftriaxone (100%) and Ofloxacin (up to 100%), but poor sensitivity to Ampicillin and Tetracycline. Full antibiotic sensitivity data are presented in Table 4, organized by Gram-positive and Gram-negative organism groupings. It should be noted that susceptibility data for Klebsiella spp. (n = 3), Pseudomonas spp. (n = 5), and Proteus spp. (n = 5) are based on small isolate numbers and must be interpreted with caution; the percentages reported for these organisms are indicative only. Robust antibiogram conclusions are therefore restricted to Staphylococcus aureus (n = 66). Furthermore, the 100% Ceftriaxone susceptibility recorded for Pseudomonas spp. is anomalous relative to the well-established intrinsic resistance of Pseudomonas aeruginosa to third-generation cephalosporins and may reflect species-level heterogeneity within this isolate group or a limitation of phenotypic identification; this finding is discussed further in the Limitations section and should not be used to guide empirical anti-pseudomonal prescribing.

Table 4: Antibiotic Sensitivity by Organism (% Sensitive). GP = Gram-positive; GN = Gram Negative; NT= Not Tested; † See footnote below

Antibiotic	GP				GN		
	S. aureus	Strep. spp.	S. epid.	E. coli	Klebsiella	Pseudomonas	Proteus
Penicillin	0	80	0	0	0	0	0
Ampicillin	0	70	0	0	0	0	0
Cloxacillin	76	80	0	20	0	0	0
Tetracycline	30	10	0	20	0	0	0
Chloramphenicol	60	50	100	40	66	33	40
Gentamicin	90	60	86	70	100	100	60
Streptomycin	40	0	0	40	33	0	0
Erythromycin	86	—	70	0	33	60	40
Co-trimoxazole	30	NT	20	NT	NT	NT	30
Cefuroxime	90	95	90	90	90	90	90
Ciprofloxacin	90	100	NT	66	90	100	90
Ofloxacin	90	90	NT	NT	100	NT	NT
Colistin	NT	NT	NT	NT	66	100	NT
Ceftriaxone	100	100	100	100	100	100	100

GP = Gram-positive; GN = Gram Negative; NT= Not Tested.

† The 100% Ceftriaxone susceptibility reported for Pseudomonas spp. (n = 5) is anomalous relative to the well-documented intrinsic resistance of Pseudomonas aeruginosa to third-generation cephalosporins. This finding may reflect species-level heterogeneity within the Pseudomonas isolates (i.e., non-aeruginosa species with variable susceptibility) or a limitation of phenotypic disc-diffusion identification in the absence of automated speciation. All susceptibility testing was performed using the Kirby-Bauer disc diffusion method in accordance with CLSI M100 (32nd edition, 2022), with standard reference strains (Escherichia coli ATCC 25922; Staphylococcus aureus ATCC 25923) used for quality control on Mueller-Hinton agar. This result should not be taken as evidence of reliable Ceftriaxone activity against Pseudomonas spp. in clinical practice, and anti-pseudomonal agents should be chosen on the basis of local susceptibility data.

Discussion

Hand infections in the Niger Delta are predominantly caused by Gram-positive organisms, especially *Staphylococcus aureus*, which accounted for more than half of all isolates. This finding is consistent with recent global literature identifying *Staphylococcus aureus* as the primary pathogen in 40–60% of acute hand infections (8) A recent systematic review and meta-analysis of wound, skin, and soft tissue infections across sub-Saharan Africa identified it as the most commonly isolated pathogen, with MRSA rates exceeding 40% of isolates across the region (17) The preponderance of young adults (21–30 years) with a male predominance reflects the working-age population most exposed to occupational trauma, a risk factor well documented in comparable populations in similar developing regions (9).

While Gram-positive cocci dominated, Gram-negative organisms (*E. coli*, *Pseudomonas*, *Klebsiella*) constituted nearly 12% of isolates. This is noteworthy and consistent with contemporary reports documenting an increase in Gram-negative hand infections, particularly in patients with crush injuries or agricultural exposures (10). The presence of mixed flora in 8.7% of cases shows the complexity of these infections and the potential need for broad-spectrum empirical coverage in selected patients. *Candida albicans* (5.6%) was isolated mostly in association with chronic paronychia and immunocompromised states, as reported in published literature (10).

One of the most clinically significant findings is the profound resistance of *Staphylococcus aureus* to Penicillin (0%) and Ampicillin (0%), and the limited sensitivity to Tetracycline (30%). These agents are now obsolete for empirical therapy in this environment, despite their continued availability and relative affordability (11). This pattern most likely reflects widespread community use of non-prescription antibiotics (12).

A systematic review of MRSA trends in Nigeria documented a rising prevalence of methicillin resistance, with non-susceptibility to commonly prescribed and affordable antibiotics being particularly high across Nigerian tertiary facilities.[18] Skin and soft tissue infections represent the predominant infection type associated with *Staphylococcus aureus* in Nigerian teaching hospitals.[19] The high efficacy of Ceftriaxone (100%) and the Fluoroquinolones (Ciprofloxacin/Ofloxacin >90%) in our study suggests that these should be the preferred agents for empirical management of moderate-to-severe hand infections. Ceftriaxone demonstrated 100% susceptibility across Gram-negative Enterobacteriaceae with adequate isolate numbers (Escherichia coli, n = 10; other Coliforms, n = 10), supporting its role as an empirical agent where Gram-negative involvement is suspected. The reported 100% Ceftriaxone susceptibility among Pseudomonas spp. (n = 5) is, however, inconsistent with the established intrinsic resistance of Pseudomonas aeruginosa to third-generation cephalosporins and should not inform empirical prescribing. Anti-pseudomonal agents should be selected on the basis of local susceptibility data and clinical context.

The sensitivity of *Staphylococcus aureus* to Cloxacillin (76%) suggests that methicillin-sensitive strains remain prevalent; however, 24% of isolates demonstrated phenotypic non-susceptibility to Cloxacillin. While this is clinically noteworthy and may signal the presence of methicillin-resistant strains, formal confirmation of MRSA status was not performed in this study. No cefoxitin disc diffusion testing, oxacillin susceptibility testing, or mecA gene detection was carried out. Accordingly, MRSA prevalence cannot be established from the present data, and this finding should be

interpreted as an indicator requiring confirmatory investigation rather than as evidence of a defined MRSA burden. Definitive confirmation of MRSA status using the cefoxitin disc diffusion test or molecular detection of the mecA gene was not performed in this study and should be incorporated into future protocols (14).

The findings of this study carry significant implications for antibiotic stewardship programmes (ASPs) in resource-limited settings. The demonstrated inefficacy of penicillins and tetracyclines underlines the need to remove these agents from empirical protocols for hand infections in this environment. While Ceftriaxone and Fluoroquinolones showed excellent activity, their unrestricted prescription risks accelerating resistance to these agents. Institutional ASPs should promote culture-directed therapy, with empirical prescribing limited in duration and subject to review once susceptibility results are available. This approach aligns with published recommendations for the management of skin and soft tissue infections in sub-Saharan African settings, which emphasis the critical role of antibiotic stewardship in containing emerging resistance (20). Healthcare workers and patients should be educated on the importance of completing treatment courses and avoiding non-prescribed antibiotic use, which remains a major driver of community resistance in Nigeria (13).

The cost and availability of recommended antibiotics represent important barriers in this low-resource context. Ceftriaxone and fluoroquinolones, while demonstrating excellent activity, are substantially more expensive than older first-line agents such as penicillin and ampicillin. In settings where patients bear direct healthcare costs, adherence to these more expensive regimens may be compromised, potentially contributing to treatment failure and further resistance selection. Healthcare policy interventions to improve the affordability and supply chain reliability of effective antibiotics are an integral component of any sustainable response to antibiotic resistance in this region.

Limitations

This study has a few limitations that should be considered when interpreting the findings. First, the absence of anaerobic culture facilities at the study institution may have led to underestimation of the prevalence of anaerobic organisms, which are particularly relevant in bite injuries and deep closed-space abscesses (100. Second, no confirmatory testing for methicillin resistance was performed in this study. MRSA status was not assessed using cefoxitin disc diffusion (the CLSI-recommended surrogate marker for mecA-mediated resistance), oxacillin susceptibility testing, or molecular detection of the mecA gene. Consequently, MRSA prevalence cannot be established from the present data. Future prospective studies in this environment should incorporate standardised MRSA confirmation protocols to permit accurate local epidemiological surveillance.

Third, microbiological culture was not performed in 35 of 161 enrolled patients (21.7%), which limits the generalizability of the bacteriological findings to the full cohort. In addition, this is a single-center study at a tertiary hospital and the findings may not fully represent the epidemiology of hand infections in primary and secondary healthcare settings or in more rural communities in the Niger Delta.

Fourth, the small number of isolates for several Gram-negative species like Klebsiella spp. (n = 3), Pseudomonas spp. (n = 5), and Proteus spp. (n = 5) limits the reliability of organism-specific sensitivity patterns for these pathogens; susceptibility percentages for these groups should be regarded as indicative only, and robust conclusions are restricted to S. aureus (n = 66). Fifth, isolate identification relied on standard biochemical methods without automated identification platforms, which may have introduced species-level misclassification,

particularly within Gram-negative rod isolates. The anomalous 100% Ceftriaxone susceptibility recorded for Pseudomonas spp. most probably reflects this constraint. If the small isolate number is also taken into consideration, this result should not be extrapolated to clinical practice. All susceptibility testing was performed using the Kirby-Bauer disc diffusion method in accordance with CLSI M100 (32nd edition, 2022), with reference strains (Escherichia coli ATCC 25922; Staphylococcus aureus ATCC 25923) used for quality control on Mueller-Hinton agar. Future multi-centre studies should aim to accumulate adequate isolate numbers for less common pathogens and incorporate automated susceptibility systems for improved accuracy.

Finally, the absence of follow-up functional outcome data on hand infection sequelae such as restricted range of motion, loss of grip strength, tendon adhesion, and occupational incapacity are a significant omission (15). Future prospective studies should incorporate validate functional outcome tools such as the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score, alongside range of motion assessments at defined follow-up intervals, to more fully quantify the long-term burden of hand infections in this population and guide comprehensive rehabilitation protocols.

Conclusion

Initial empirical treatment for moderate-to-severe hand infections should include a third-generation cephalosporin (e.g., Ceftriaxone) or a fluoroquinolone (e.g., Ciprofloxacin), reflecting the high susceptibility rates demonstrated in this study.Penicillin and Ampicillin should be avoided as empirical agents for hand infections in this region unless specific culture-proven sensitivity is demonstrated. In addition, timely incision and drainage remain the cornerstone of treatment for purulent hand infections (15). Antibiotic therapy serves an adjunctive role and is not a substitute for prompt and adequate surgical drainage.

Microbiological culture and sensitivity testing should be routinely performed in all cases requiring operative intervention, to enable culture-directed therapy and support local antibiotic stewardship initiatives. In addition, healthcare institutions in this region should invest in anaerobic culture capabilities and MRSA-specific confirmatory testing (cefoxitin disc or mecA PCR) to improve diagnostic accuracy. Finally, continuous surveillance of antibiotic resistance and sensitivity patterns is essential, as resistance profiles evolve rapidly (7).

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Ethical considerations

Ethical approval for this prospective observational study was obtained from the Medical and Research Ethics Committee of the Niger Delta University Teaching Hospital (Approval Number: NDUTH/MREC/122/20). The study was conducted in full accordance with the ethical principles outlined in the Declaration of Helsinki (2013 Revision). Written informed consent was obtained from all participants prior to enrolment. Confidentiality was maintained by anonymising all patient data during analysis and reporting.

Data availability statement

The data that support this study are available from the corresponding author upon reasonable request.

Conflicts of interest

The authors declared no conflicts of interest exist.

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