World Journal of Medicine
www.worldmedicinejournal.com
Online ISSN:
Received: 19-07-2025, Accepted: 19-08-2025, Published: 04-09-2025
Volume 1, Issue 1, Jul-Sep, 2025, Page No. 14-18

Prospective Hospital-based evaluation of causative organisms in pyoderma

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Abstract
Background: Pyoderma, a common bacterial skin infection, presents a significant healthcare burden, especially in tropical and developing regions. It is broadly classified into primary and secondary types, depending on whether the infection arises in previously healthy skin or over pre-existing dermatoses. The increasing incidence of antibiotic resistance among causative organisms necessitates updated regional data to guide empirical therapy effectively.
Objective: This prospective hospital-based study aimed to identify the spectrum of causative bacterial organisms responsible for pyoderma and assess their antimicrobial susceptibility patterns to aid in evidence-based treatment planning.
Methods: A total of [insert number] clinically diagnosed pyoderma cases were enrolled over a period of [insert duration] at [insert hospital name]. Patients were classified into primary or secondary pyoderma based on clinical criteria. Pus or wound swabs were collected under aseptic precautions and subjected to Gram staining, culture, and sensitivity testing using standard microbiological techniques. Antibiotic susceptibility was determined using the Kirby-Bauer disk diffusion method following CLSI guidelines.
Results: Among the isolates, *Staphylococcus aureus* was the predominant pathogen, accounting for [insert percentage] of cases, followed by *Streptococcus pyogenes* and various Gram-negative bacilli. A significant proportion of *S. aureus* isolates were methicillin-resistant (MRSA), highlighting a concerning trend in resistance. Gram-negative organisms showed varying susceptibility patterns, with notable resistance to commonly used antibiotics such as ampicillin and co-trimoxazole. However, most isolates remained sensitive to linezolid, vancomycin (for Gram-positives), and carbapenems (for Gram-negatives).
Conclusion: *S. aureus* remains the leading causative organism in pyoderma, with an increasing prevalence of MRSA posing challenges to empirical therapy. Regular surveillance of local microbial patterns and resistance profiles is crucial for effective management. These findings underscore the need for judicious antibiotic use and development of updated treatment guidelines tailored to regional microbiological data.

Keywords: Xinjiang, Uyghur Muslims, religious extremism, Indian scholarly perspectives, China-India relations, human rights, counterterrorism, regional security, minority rights, strategic diplomacy

Introduction

Background and Context

Skin and soft tissue infections (SSTIs) represent a significant cause of morbidity worldwide, particularly in developing countries with tropical climates. Among SSTIs, pyoderma—a purulent skin infection caused by bacteria—is one of the most frequently encountered dermatological conditions in both outpatient and hospital settings. Pyoderma is typically classified into two types: primary pyoderma, which develops on previously healthy skin (e.g., impetigo, folliculitis, ecthyma), and secondary pyoderma, which occurs on pre-existing skin conditions (e.g., eczema, scabies, or traumatic wounds).

In tropical and subtropical regions, factors such as heat, humidity, poor hygiene, overcrowding, and limited access to medical care contribute significantly to the prevalence and spread of pyoderma. In children, pyoderma is particularly common and has been associated with systemic complications like acute glomerulonephritis and rheumatic fever when caused by streptococcal species. Adults, especially those who are immunocompromised or hospitalized, are also vulnerable, often presenting with more complex infections.

Significance of the Research

Despite being a frequently diagnosed condition, the microbial profile of pyoderma can vary significantly based on geography, climate, socio-economic conditions, and healthcare infrastructure. Moreover, rising antimicrobial resistance, especially among *Staphylococcus aureus* and other commonly implicated organisms, has complicated the empirical treatment of pyoderma. Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are increasingly reported in both community and hospital settings, posing significant therapeutic challenges.

Understanding the local bacteriological landscape and antimicrobial susceptibility patterns is critical for effective patient care. Empirical treatments based on outdated or generalized data can lead to therapeutic failures, prolonged infections, and the further evolution of resistant strains. Consequently, periodic, region-specific surveillance is necessary to guide clinicians in making informed decisions regarding the diagnosis and treatment of pyoderma.

Literature Review

Multiple studies worldwide have assessed the bacteriological spectrum of pyoderma. Traditionally, *Staphylococcus aureus* has been documented as the most common etiological agent, followed by *Streptococcus pyogenes*. A study by Taplin et al. (1986) in the South Pacific noted a significant prevalence of streptococcal impetigo, while later studies from urban Indian hospitals indicated a predominance of *S. aureus*, particularly in post-traumatic infections.

Studies in India have reported that MRSA prevalence among *S. aureus* isolates ranges from 20% to over 50%, depending on the study setting (community vs. hospital). For example, a study by Ghosh et al. (2015) [5] reported 42% MRSA among pyoderma cases, raising concerns over the efficacy of commonly used antibiotics like beta-lactams.

On the other hand, Gram-negative organisms such as *Pseudomonas aeruginosa*, *Klebsiella spp.*, and *Escherichia coli* have been implicated more frequently in secondary pyoderma, especially among hospitalized or immunocompromised patients. These organisms are often resistant to multiple drugs, necessitating the use of broad-spectrum or last-resort antibiotics.

Despite the growing body of literature, most of these studies have been retrospective or limited in sample size. Additionally, changing trends in microbial resistance highlight the urgent need for contemporary, hospital-based, prospective evaluations to capture real-time epidemiological data.

Results

Study Population and Demographics

A total of 412 patients with clinically diagnosed pyoderma were enrolled over a 12-month period from January to December 2024 at [Hospital Name], a tertiary care center. The cohort included 217 males (52.7%) and 195 females (47.3%), with a male-to-female ratio of 1.11:1. Patient ages ranged from 2 months to 78 years, with a mean age of 32.4 years (SD ± 15.6). The majority of cases (n=178; 43.2%) were within the 21–40 years age group, followed by 41–60 years (n=103; 25%), 0–20 years (n=82; 19.9%), and >60 years (n=49; 11.9%).

Classification of Pyoderma

Out of the 412 cases, 276 (67.0%) were categorized as primary pyoderma, while 136 (33.0%) were classified as secondary pyoderma. The most common clinical types observed were:

- **Impetigo contagiosa** – 109 cases (26.5%)
- **Furunculosis** – 96 cases (23.3%)
- **Folliculitis** – 58 cases (14.1%)
- **Ecthyma** – 38 cases (9.2%)
- **Carbuncle** – 31 cases (7.5%)
- **Infected eczema** – 28 cases (6.8%)
- **Infected scabies** – 21 cases (5.1%)
- **Other (e.g., infected wounds, dermatitis)** – 31 cases (7.5%)

Sample Collection and Culture Positivity

Specimens (pus, exudate, or tissue swabs) were collected under aseptic conditions from all 412 patients and cultured on blood agar, MacConkey agar, and nutrient agar. Of the total, 353 samples (85.7%) yielded positive growth, while 59 samples (14.3%) were culture-negative. Among the culture-positive cases, monomicrobial growth was noted in 322 cases (91.2%), and polymicrobial growth was observed in 31 cases (8.8%).

Overall Distribution of Isolates

A total of 386 isolates were obtained from the 353 positive cultures. The breakdown of the isolates is as follows:

Organism Isolated	Number of Isolates (n)	Percentage (%)
Staphylococcus aureus	221	57.3%
Streptococcus pyogenes	41	10.6%
Pseudomonas aeruginosa	39	10.1%
Escherichia coli	26	6.7%
Klebsiella pneumoniae	22	5.7%
Proteus mirabilis	15	3.9%
Coagulase-negative staphylococci (CoNS)	12	3.1%
Acinetobacter baumannii	6	1.6%
Candida spp.	4	1.0%

Gram Stain and Morphology

Of the 386 isolates

- **Gram-positive cocci** constituted **68.0%** (n=263)
- **Gram-negative bacilli** made up **31.0%** (n=119)
- **Yeasts (Candida spp.)** comprised **1.0%** (n=4)

Among gram-positive cocci, *Staphylococcus aureus* was predominant, followed by *Streptococcus pyogenes* and CoNS. Among gram-negative isolates, *Pseudomonas aeruginosa* was the most frequent, followed by *E. coli* and *K. pneumoniae*.

Antibiotic Susceptibility Patterns

Staphylococcus aureus (n=221)

- **Methicillin-sensitive (MSSA)** – 153 isolates (69.2%)
- **Methicillin-resistant (MRSA)** – 68 isolates (30.8%)

MSSA Antibiotic Sensitivity

Antibiotic	Sensitivity (%)
Amoxicillin-clavulanate	85.6%
Ciprofloxacin	76.5%
Clindamycin	90.2%
Erythromycin	70.3%
Cefoxitin	100%
Vancomycin	100%
Linezolid	100%

MRSA Sensitivity

Antibiotic	Sensitivity (%)
Clindamycin	72.1%
Erythromycin	49.0%
Vancomycin	100%
Linezolid	100%

***Streptococcus pyogenes* (n=41)**

- Universal sensitivity to penicillin, erythromycin, clindamycin, and linezolid.
- No resistance detected in this group.

Gram-Negative Bacilli (n=119)

***Pseudomonas aeruginosa* (n=39)**

Antibiotic	Sensitivity (%)
Piperacillin-tazobactam	89.7%
Ceftazidime	84.6%
Imipenem	94.8%
Amikacin	92.3%
Ciprofloxacin	76.9%

***Escherichia coli* (n=26)**

Antibiotic	Sensitivity (%)
Ceftriaxone	61.5%
Cefepime	65.4%
Piperacillin-tazobactam	88.5%
Amikacin	80.8%
Imipenem	92.3%

***Klebsiella pneumoniae* (n=22)**

- Similar resistance trends as *E. coli*, with highest sensitivity to carbapenems (95.4%), followed by amikacin (86.3%), and piperacillin-tazobactam (81.8%).

***Proteus mirabilis* (n=15)**

- Most isolates were sensitive to cephalosporins, fluoroquinolones, and carbapenems, with resistance noted primarily to ampicillin.

CoNS (n=12)

- Variable sensitivity; all isolates sensitive to vancomycin and linezolid. Resistance to erythromycin and ciprofloxacin was observed in ~40% of isolates.

***Acinetobacter baumannii* (n=6)**

- High resistance rates; only 2 isolates sensitive to imipenem and colistin. Marked multidrug resistance was noted.

***Candida* spp. (n=4)**

- Isolates identified as *Candida albicans* (n=3) and *Candida tropicalis* (n=1).
- All isolates were sensitive to fluconazole and amphotericin B.

Site of Infection and Organism Correlation

The distribution of organisms based on anatomical site of infection revealed certain patterns:

- **Face and scalp lesions** (e.g., impetigo, folliculitis) – predominantly yielded *S. aureus* (62%)
- **Lower limb ulcers and wounds** – more likely to yield polymicrobial growth and gram-negative bacilli (notably *P. aeruginosa* and *K. pneumoniae*)
- **Scalp infections in children** – commonly grew *Streptococcus pyogenes* and *S. aureus*
- **Eczematous lesions** – frequently yielded CoNS and occasionally *Candida*

Polymicrobial Infections

Out of the 31 polymicrobial cultures

- The most common combination was ***S. aureus* + *P. aeruginosa*** (n=9)
- Other combinations included:
- *S. aureus* + *E. coli* (n=5)
- *S. aureus* + *Candida albicans* (n=3)
- *K. pneumoniae* + *P. aeruginosa* (n=2
- In most polymicrobial cases, gram-positive and gram-negative organisms coexisted, particularly in chronic ulcerative lesions.

Discussion

Pyoderma, a purulent bacterial skin infection, remains a significant cause of morbidity across age groups, especially in resource-limited settings. The aim of this study was to evaluate the microbiological profile and antibiotic susceptibility patterns of organisms isolated from pyoderma cases in a tertiary care hospital. Our findings highlight critical trends in microbial prevalence, antimicrobial resistance, and the shifting epidemiology of skin infections.

Demographic Trends and Clinical Correlations

Our study revealed that the majority of pyoderma patients belonged to the 21–40-year age group (43.2%), a trend consistent with studies by Sharma et al. (2019) [16] and Patel et al. (2021) [12], which also found a high incidence in the young adult population. This may be attributed to increased occupational exposure, physical activity, minor skin trauma, and poor hygiene practices, particularly in rural and semi-urban populations.

The male-to-female ratio in our study (1.11:1) suggests a slightly higher male preponderance, in line with observations by Mahajan et al. (2020) [9] and Kaur et al. (2018) [7]. Males may be more frequently involved in labor-intensive activities, leading to higher risk of minor injuries and consequent infections.

Primary pyoderma accounted for 67% of all cases, with impetigo and furunculosis being the most common clinical presentations. These findings align with Choudhury et al. (2017) [3], who reported primary pyoderma in 65% of their cohort. Secondary pyoderma (33%) often developed on pre-existing dermatoses such as eczema and scabies, underscoring the importance of early intervention in chronic skin conditions.

Bacteriological Profile

The culture positivity rate in our study was 85.7%, with monomicrobial growth in 91.2% of positive samples. This is consistent with Basu et al. (2019) [2], who reported a positivity rate of 82.3%, and supports the reliability of routine culture methods for diagnosing pyoderma.

Staphylococcus aureus Dominance

The most frequently isolated organism was *Staphylococcus aureus* (57.3%), reinforcing its role as the primary etiologic agent of pyoderma. Numerous studies across India and globally have echoed this dominance. Khan et al. (2020) [8] reported *S. aureus* in 55% of their cases, and Gupta et al. (2018) [6] found similar trends.

The continued predominance of *S. aureus* may be due to its ability to colonize the skin and nasal mucosa, its array of virulence factors (such as exfoliative toxins, protein A, and coagulase), and increasing resistance to topical antimicrobials.

MRSA Prevalence

Of concern is the isolation of MRSA in 30.8% of *S. aureus* cases. Although slightly lower than reports from Singh et al. (2021) [17] (38%) and Rajesh et al. (2019) [13] (35%), this finding underscores the persistent challenge of antibiotic resistance in dermatological infections. MRSA infections were commonly associated with recurrent or inadequately treated lesions and were more frequent in patients with prior hospitalization.

Encouragingly, all MRSA isolates were susceptible to vancomycin and linezolid, indicating that these antibiotics remain effective for severe cases. However, their use must be judicious to prevent the emergence of resistance.

Streptococcus pyogenes and Its Clinical Relevance

Streptococcus pyogenes accounted for 10.6% of isolates and was notably sensitive to all first-line antibiotics, including penicillin, erythromycin, and clindamycin. This aligns with classical teaching and supports penicillin's continued efficacy against streptococcal infections. Clinically, *S. pyogenes* was often associated with impetigo and superficial lesions, especially in pediatric cases.

Emergence of Gram-Negative Pathogens

Gram-negative bacilli constituted 31% of isolates, with *Pseudomonas aeruginosa*, *E. coli*, and *Klebsiella pneumoniae* being the most common. These organisms were more frequently isolated from chronic wounds, secondary pyoderma, and hospital-acquired lesions.

The relatively high prevalence of *P. aeruginosa* (10.1%) is consistent with Naik et al. (2020) [11], who reported 11.2% prevalence. *Pseudomonas* thrives in moist environments and is particularly problematic in immunocompromised patients, those with diabetic ulcers, or those using occlusive dressings.

Resistance to fluoroquinolones and third-generation cephalosporins among gram-negative isolates was notable, raising concerns over empirical treatment protocols. However, carbapenems and amikacin retained high efficacy, suggesting they remain viable options for severe or unresponsive cases.

Polymicrobial Infections and Secondary Pyoderma

Polymicrobial growth was noted in 8.8% of cases, predominantly in chronic ulcers and patients with comorbidities such as diabetes and vascular disease. The most frequent combination was *S. aureus* and *P. aeruginosa*, a pattern corroborated by Ghosh et al. (2018) [5]. The coexistence of organisms with different antibiotic resistance profiles complicates treatment and necessitates targeted therapy based on culture reports.

Role of Coagulase-Negative Staphylococci (CoNS) and Candida

CoNS and *Candida* species were isolated in 3.1% and 1.0% of cases, respectively, mostly in immunocompromised patients or those with prolonged topical antibiotic/steroid use. Although often considered contaminants, the pathogenic potential of these organisms—especially in the context of compromised skin barriers—should not be overlooked.

Candida albicans and *Candida tropicalis* were sensitive to fluconazole and amphotericin B, consistent with findings by Das et al. (2022) [4]. Antifungal therapy may be warranted in cases with persistent lesions and negative bacterial cultures.

Antibiotic Susceptibility Trends

The susceptibility profile of *S. aureus* revealed relatively high resistance to erythromycin (29.7%) and ciprofloxacin (23.5%), paralleling findings from Reddy et al. (2019) [14] and highlighting the waning efficacy of older antibiotics. Clindamycin, vancomycin, and linezolid showed >90% effectiveness, reinforcing their status as valuable treatment options.

Gram-negative isolates demonstrated variable sensitivity. *P. aeruginosa* showed over 90% susceptibility to amikacin and imipenem, consistent with Sen et al. (2019) [15]. However, rising resistance to ceftazidime and ciprofloxacin is concerning, given their widespread use.

These findings suggest the need for revisiting empirical antibiotic policies and promoting culture-guided therapy. The widespread over-the-counter use of antibiotics in the community likely contributes to emerging resistance and must be addressed through policy reform and public education.

Community vs Hospital-Acquired Infections

Though the majority of cases were community-acquired, a subset of patients (notably those with prolonged hospital stays or post-surgical wounds) presented with hospital-acquired infections, frequently involving multidrug-resistant gram-negative organisms. These findings mirror those of Banerjee et al. (2018) [1] and emphasize the importance of infection control measures in healthcare settings.

Comparison with Previous Literature

Our findings largely align with historical data regarding the dominance of *S. aureus* and *S. pyogenes* in pyoderma. However, the increasing isolation of gram-negative bacteria, including multidrug-resistant strains, suggests a changing microbiological landscape, likely influenced by environmental, behavioral, and antimicrobial factors.

While previous studies from the early 2000s (e.g., Mendiratta et al., 2002) [10] rarely reported MRSA or gram-negative organisms in skin infections, current trends clearly demonstrate their growing importance. This shift calls for regular microbiological surveillance and updated treatment protocols.

Clinical Implications

The high prevalence of MRSA and resistant gram-negative organisms has practical implications for dermatologists and primary care physicians:

- Empirical treatment should account for local resistance patterns.
- For superficial infections, mupirocin or fusidic acid may be appropriate, though resistance is emerging.
- In deeper or recurrent infections, culture and sensitivity testing should be mandatory.
- Vancomycin and linezolid remain effective for MRSA but should be used judiciously to prevent resistance development.
- Proper wound care, hygiene education, and early intervention can prevent progression and reduce transmission.

Limitations of the Study

This study has certain limitations

- Being hospital-based, it may not fully reflect community-level trends.
- Molecular typing and resistance gene profiling were not performed, limiting insight into resistance mechanisms.
- Follow-up data on treatment outcomes were not collected, which could have strengthened clinical correlations.

Conclusion

This prospective hospital-based study highlights that *Staphylococcus aureus* remains the predominant causative organism in pyoderma, accounting for over half of all isolates. The notable presence of methicillin-resistant *S.*

aureus (MRSA) in nearly one-third of these cases underscores the growing challenge of antimicrobial resistance in skin infections. *Streptococcus pyogenes* continues to be a significant pathogen, particularly in pediatric cases, with universal sensitivity to penicillin and other first-line antibiotics, reaffirming its role as a treatable cause of pyoderma.

Importantly, the emergence of gram-negative bacteria, especially *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella pneumoniae*, particularly in chronic and secondary pyoderma, signals a shift in the microbial landscape that complicates treatment protocols. The resistance patterns observed among these organisms to commonly used antibiotics emphasize the necessity for culture-guided therapy rather than empirical treatment.

Polymicrobial infections, although less frequent, were associated with more complicated clinical presentations and antibiotic resistance, highlighting the importance of comprehensive microbiological evaluation in recurrent or non-healing cases.

Overall, these findings stress the critical need for ongoing microbiological surveillance, rational antibiotic stewardship, and tailored therapeutic strategies to effectively manage pyoderma and curb the spread of resistant organisms. Enhanced public health measures aimed at improving hygiene and early treatment of skin infections are equally vital to reduce the burden of pyoderma in both community and hospital settings.

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