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Original Research Article

Prevalence and Antibiotic Sensitivity Patterns of Bacterial Skin Infections: A Cross-Sectional Study

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Abstract:

Background: Bacterial skin and soft tissue infections are common clinical conditions associated with significant morbidity and increasing antimicrobial resistance, particularly in developing countries. Continuous surveillance of causative organisms and their resistance patterns is essential for effective management.

Aim: To determine the prevalence of bacterial pathogens causing skin infections and to assess their antibiotic sensitivity patterns.

Methodology: This single-centre cross-sectional study included 130 clinically diagnosed cases of bacterial skin infections. Samples were subjected to Gram staining, culture, and identification, followed by antibiotic susceptibility testing using the Kirby–Bauer disc diffusion method as per CLSI guidelines.

Results: Males (64.6%) and adults aged 21–50 years were predominantly affected. Staphylococcus aureus was the most common isolate (32.3%), with a high proportion of MRSA (40.5%). All S. aureus isolates were 100% sensitive to vancomycin and linezolid. Among Gram-negative isolates, Escherichia coli was most frequent, and carbapenems showed the highest sensitivity. ESBL production was detected in 37.1% of Gram-negative isolates.

Conclusion: The study highlights a high burden of antimicrobial resistance, including MRSA and ESBL-producing organisms, emphasizing the need for routine culture-based therapy and strengthened antimicrobial stewardship.

Keywords: Bacterial skin infections, Staphylococcus aureus, MRSA, ESBL, Antibiotic susceptibility, Cross-sectional study.

Introduction

Skin is the largest organ of the human body; it covers about 1.5-2.0 square meters in an average adult. It is a highly specialized and versatile organ essential for maintaining homeostasis and protecting the body against external insults. Anatomically, the skin consists of a stratified cellular epidermis and an underlying dermis composed of connective tissue, blood vessels, nerves, and immune cells [1,2], while functionally, it plays a very important role in maintaining electrolyte balance, regulating water loss, and aiding in thermoregulation. It is a primary physical and immunological barrier against invading microorganisms and other noxious environmental agents [3].

Despite these protective mechanisms, the skin is still regularly subjected to a wide range of physical, chemical, and biological factors that may compromise its integrity. Any breach in either the normal structural or functional integrity of the skin will render it susceptible to microbial invasion, which subsequently results in infection. The pathogenesis of bacterial skin infection usually is devised in a step-by-step manner that includes bacterial adherence to host tissues, evasion of host defense mechanisms, and production of toxins and virulence factors facilitating tissue invasion and damage [4]. After being breached, the underlying subcutaneous tissues become exposed to a moist, warm, nutrient-rich environment, making conditions highly conducive for microbial colonization and proliferation.

These bacteria can be derived from any of the following sources: the surrounding environment, from normal flora of adjacent skin, and as endogenous organisms from the gastrointestinal tract, genitourinary tract, and oropharyngeal mucosa [5,6]. In favorable conditions, these organisms may invade the compromised skin and give rise to localized or systemic infections. By virtue of their high incidence, varied clinical presentations, and potential for severe complications, bacterial skin infections pose an important clinical and public health problem worldwide.

Epidemiological data reveals the significant burden of skin bacterial infections on healthcare systems. In the United States, in 2005, it was estimated that skin diseases due to bacterial agents ranked among the most frequent conditions seen in clinical practice, accounting for approximately 14.2 million ambulatory care visits [7]. These infections range from superficial conditions such as impetigo and folliculitis to deeper cellulitis, abscesses, and necrotizing soft tissue infections-all with significant morbidity if not diagnosed and appropriately anti-microbially managed in a timely manner.

The burden of skin infections becomes all the more daunting in developing countries like India, where most skin diseases are of infectious origin and, to a great extent, preventable and controllable [8,9]. Overcrowding, poor hygiene, insufficient health care, malnutrition, and lack of proper sanitation all contribute to a high prevalence of skin infections. Skin infections not only cause discomfort and disability but also increase hospital stay, cost of healthcare, morbidity, and mortality. Prolonged hospitalization due to infected wounds is not only economically burdensome to the patient and healthcare systems; it also enhances the risks of nosocomial infection and emergence of antimicrobial resistance [10].

Several studies have shown that the patients being admitted with skin infections tend to have a hospital stay that is approximately 6–10 days longer in comparison to patients whose wounds heal without infection. This seems to almost double the overall treatment costs, showcasing the economic impact of bacterial skin infections [11,12]. Moreover, certain patient populations are more susceptible to developing severe and rapidly progressive skin infections. For instance, individuals who have a compromised immune status, such as those suffering from AIDS, or chronic conditions like diabetes mellitus, are highly susceptible. In such a patient, a mild skin infection can rapidly advance into a life-threatening disease condition if not promptly and adequately treated [13].

Proper management of the disease usually depends on the rational selection of an antimicrobial agent. Ideally, antimicrobial therapy should be guided based on culture and antibiotic sensitivity testing to provide appropriate targeted therapy. However, in routine clinical practice and especially in acute settings, initial therapy is often empirical because therapy cannot wait until after microbiological confirmation [11]. This dependence on empirical therapy, while necessary, contributes to the growing problem of antimicrobial resistance.

Resistance strategies developed by bacteria against antimicrobial pressure include enzymatic degradation of drugs, alteration of drug targets, and reduced drug permeability [14]. In the past twenty years, infections due to organisms resistant to commonly used antimicrobial agents have substantially increased. Specifically, dramatic increases in the prevalence of methicillin-resistant Staphylococcus species and ESBL producing gram-negative bacilli, both in hospitals and within the community [15,16] raise serious concerns. These resistant pathogens significantly narrow the therapeutic arsenal and present a formidable challenge to clinicians when empirical therapy needs to be initiated.

In view of the increasing burden of bacterial skin infections and the alarming rise in antimicrobial resistance, regular surveillance of the prevalence of bacterial pathogens and their sensitivity patterns to antibiotics is urgently called for. Knowledge of local epidemiological trends and resistance profiles will inform empirical therapy in a most appropriate manner to ensure better treatment outcomes, minimize hospital stay, and spread of resistant organisms. This cross-sectional study is thus designed to evaluate the prevalence and antibiotic sensitivity patterns of bacterial pathogens causing skin infections, adding to essential data that support evidence-based clinical decision-making and efforts for better antimicrobial stewardship.

Methodology

Study Design: This study was designed as a single-centre, cross-sectional, and analytical study conducted to determine the prevalence of bacterial skin infections and to assess the antibiotic sensitivity patterns of isolated organisms.

Study Area: The study was carried out in the Department of Skin, Venereal Diseases (VD), and Leprosy, Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India.

Study Duration: The study was conducted over a period of 11 months.

Sample Size: A total of 130 patients clinically diagnosed with bacterial skin and soft tissue infections were included in the study.

Study Population: The study population comprised patients of both sexes and all age groups attending the outpatient and inpatient services of the Department of Skin VD and Leprosy at Sheikh Bhikhari Medical College and Hospital, Hazaribagh, during the study period.

Data Collection: After obtaining informed consent, relevant demographic details, clinical history, and examination findings were recorded in a pre-designed proforma. Samples such as pus, wound swabs, or exudates were collected aseptically from skin lesions and sent to the microbiology laboratory for processing.

The specimens were subjected to:

- Gram staining
- Culture and identification of bacterial isolates using standard microbiological techniques
- Antibiotic susceptibility testing using the Kirby–Bauer disc diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines

Inclusion Criteria

- Patients of all age groups and both sexes
- Clinically suspected cases of bacterial skin and soft tissue infections
- Patients attending outpatient or admitted to the Department of Skin VD and Leprosy
- Patients who provided informed consent to participate in the study

Exclusion Criteria

Patients with one or more of the following conditions were excluded:

- Neonates
- History of antimicrobial use within the previous one week
- Pregnant women
- Patients with known Human Immunodeficiency Virus (HIV) infection, malignancy, or other immuno-compromised states
- Patients unwilling to give consent for participation

Study Procedure: Eligible patients were clinically evaluated, and appropriate samples were collected under aseptic precautions. The samples were transported promptly to the microbiology laboratory for analysis. Identified bacterial isolates were tested for antibiotic susceptibility, and results were documented systematically.

Statistical Analysis: Data collected were entered into Microsoft Office Excel and analyzed using Statistical Package for Social Sciences (SPSS) and EPI software. Descriptive statistics were used to calculate frequencies and percentages. Proportional data were analyzed using Pearson's Chi-square test and Binomial proportion test where applicable. A p-value of <0.05 was considered statistically significant."

Result

Table 1 summarizes the demographic characteristics of the study population (n = 130) by age group and sex. The majority of participants were males (84; 64.6%) compared with females (46; 35.4%). The largest proportion of participants belonged to the 31–40-year age group, accounting for 38 individuals (29.2%), followed by those aged 21–30 years with 24 participants (18.5%) and 41–50 years with 21 participants (16.2%). Participants aged 51–60 years comprised 17 (13.1%), while smaller proportions were observed in the 11–20-year group (14; 10.8%) and 61–70-year group (9; 6.9%). Very few participants were in the extreme age groups of 1–10 years (5; 3.8%) and 71–80 years (2; 1.5%). Overall, the study population was predominantly male and concentrated in the 21–50-year age range.

Table 1: Demographic characteristics of the study population

Age group (years)	Male	Female	Number n = 130 (%)
1–10	3	2	5 (3.8)
11–20	8	6	14 (10.8)
21–30	15	9	24 (18.5)
31–40	26	12	38 (29.2)
41–50	14	7	21 (16.2)
51–60	11	6	17 (13.1)
61–70	6	3	9 (6.9)
71–80	1	1	2 (1.5)
Total	**84 (64.6%)**	**46 (35.4%)**	**130 (100)**

Table 2 shows the distribution of bacterial isolates obtained from skin infection samples (N = 130). Staphylococcus aureus was the most frequently isolated organism, accounting for 42 isolates (32.3%). This was followed by Escherichia coli with 18 isolates (13.8%). Mixed bacterial growth was observed in 20 samples (15.4%), while no bacterial growth was detected in 18 cases (13.9%). Among other organisms, Klebsiella species constituted 10 isolates (7.7%), Pseudomonas aeruginosa 9 isolates (6.9%), Proteus species 7 isolates (5.4%), and Streptococcus pyogenes was the least common isolate with 6 cases (4.6%). Overall, gram-positive bacteria, particularly Staphylococcus aureus, were the predominant pathogens in skin infections in this study.

Table 2: Distribution of bacterial isolates from skin infections (N = 130)		
Organism isolated	**Number of isolates**	**Percentage (%)**
Staphylococcus aureus	42	32.3
Escherichia coli	18	13.8
Klebsiella species	10	7.7
Proteus species	7	5.4
Pseudomonas aeruginosa	9	6.9
Streptococcus pyogenes	6	4.6
Mixed bacterial growth	20	15.4
No growth	18	13.9
Total	**130**	**100**

Table 3 depicts the prevalence of methicillin-sensitive Staphylococcus aureus (MSSA) and methicillin-resistant Staphylococcus aureus (MRSA) among the S. aureus isolates (N = 42). MSSA constituted the majority, with 25 isolates accounting for 59.5% of cases, while MRSA was identified in 17 isolates, representing a substantial proportion of 40.5%. These findings indicate a relatively high prevalence of MRSA among S. aureus isolates, highlighting its clinical significance in skin infections.

Table 3: Prevalence of MRSA and MSSA among Staphylococcus aureus isolates		
Staphylococcus aureus (N = 42)	**Number of isolates**	**Percentage (%)**
MSSA	25	59.5
MRSA	17	40.5
Total	**42**	**100**

Table 4 presents the antibiotic susceptibility pattern of Staphylococcus aureus isolates (N = 42). A high level of resistance was observed to penicillin, with 32 isolates (76.2%) being resistant and only 10 (23.8%) sensitive. Resistance to cefoxitin was seen in 17 isolates (40.5%), corresponding to the MRSA proportion. Moderate resistance was noted for erythromycin (20; 47.6%) and ciprofloxacin (16; 38.1%), while lower resistance rates were observed for clindamycin (14; 33.3%) and gentamicin (12; 28.6%). Notably, all isolates showed complete susceptibility to vancomycin and linezolid, with 100% sensitivity (42; 100%) and no detected resistance. Overall, these findings indicate significant resistance to commonly used antibiotics, while vancomycin and linezolid remain highly effective against S. aureus isolates in this study.

Table 4: Antibiotic susceptibility pattern of Staphylococcus aureus isolates (N = 42)		
Antibiotic	**Sensitive n (%)**	**Resistant n (%)**
Penicillin	10 (23.8)	32 (76.2)
Cefoxitin	25 (59.5)	17 (40.5)
Clindamycin	28 (66.7)	14 (33.3)
Erythromycin	22 (52.4)	20 (47.6)
Gentamicin	30 (71.4)	12 (28.6)
Ciprofloxacin	26 (61.9)	16 (38.1)
Vancomycin	42 (100)	0 (0)
Linezolid	42 (100)	0 (0)

Table 5 illustrates the antibiotic susceptibility pattern of Gram-negative bacterial isolates (N = 44). The highest sensitivity was observed with meropenem, to which 38 isolates (86.4%) were sensitive, followed by imipenem with 36 isolates (81.8%) and piperacillin–tazobactam with 34 isolates (77.3%). Amikacin also showed good activity, with 32 isolates (72.7%) being sensitive. Moderate sensitivity was noted for gentamicin (28; 63.6%) and ciprofloxacin (25; 56.8%). In contrast, ceftriaxone showed the highest resistance, with 23 isolates (52.3%) resistant compared to 21 (47.7%) sensitive. Overall, carbapenems and piperacillin–tazobactam were the most effective agents against Gram-negative isolates, while higher resistance to third-generation cephalosporins was evident.

Table 5: Antibiotic susceptibility pattern of Gram-negative bacterial isolates (N = 44)		
Antibiotic	**Sensitive n (%)**	**Resistant n (%)**
Amikacin	32 (72.7)	12 (27.3)
Gentamicin	28 (63.6)	16 (36.4)
Ciprofloxacin	25 (56.8)	19 (43.2)
Ceftriaxone	21 (47.7)	23 (52.3)
Piperacillin–Tazobactam	34 (77.3)	10 (22.7)
Imipenem	36 (81.8)	8 (18.2)
Meropenem	38 (86.4)	6 (13.6)

Table 6 shows the prevalence of extended-spectrum beta-lactamase (ESBL)–producing Gram-negative isolates. Among Escherichia coli isolates (n = 18), 7 were ESBL producers, giving a prevalence of 38.9%. Similarly, Klebsiella species demonstrated a comparable ESBL positivity rate, with 4 out of 10 isolates (40.0%) producing ESBL. Proteus species showed a slightly lower prevalence, with 2 of 7 isolates (28.6%) being ESBL positive. Overall, out of 35 Gram-negative isolates tested, 13 (37.1%) were ESBL producers, indicating a substantial burden of ESBL-mediated resistance among Gram-negative pathogens in this study.

Table 6: Prevalence of ESBL-producing Gram-negative isolates		
Organism	**Total isolates**	**ESBL positive n (%)**
Escherichia coli	18	7 (38.9)
Klebsiella species	10	4 (40.0)
Proteus species	7	2 (28.6)
Total	**35**	**13 (107.5)**

Discussion

In the present study, 130 patients with bacterial skin infections were analyzed, out of which male patients accounted for 64.6%, while females accounted for 35.4%. This male preponderance is in agreement with works by Farhan et al. (2015) [17] and Malhotra et al. (2012) [18], who reported that males are more involved in skin infections due to increasing environmental exposure and occupational hazards in addition to sociocultural factors that precipitate males to medical attention before females. Our age distribution showed the age group of 31–40 years as the highest (29.2%), closely followed by the 21–30-year group (18.5%), which was in concordance with several studies that have stated that young adults and middle-aged individuals are most commonly infected with bacterial skin infections due to increased activity, occupational exposures, and minor traumas that provide easy access to infection (Marwa et al., 2007) [19]. However, our study showed low infection rates in children and geriatric groups, 3.8% and 8.4%, respectively (1–10 years and >60 years), a trend which, though globally accepted, contrasted with several works that reported high susceptibility among the pediatric populations due to their immature immune defense mechanisms (Prabhu et al., 2011) [20]."

In our study, Staphylococcus aureus emerged as the predominant pathogen with a prevalence rate of 32.3%. The same pathogen was noted to be the leading cause of both primary and secondary skin infections in several other studies (Gupta et al., 2008; Van der Heijden et al., 2001) [21,22]. Methicillin-sensitive strains formed 59.5%, while MRSA isolates were 40.5%, showing a moderately high percentage of MRSA. The reported rates of MRSA in several similar studies ranged from 40.8%, which is related to our findings, and those in tertiary care hospitals in other regions (Mama et al., 2014) [23]. However, reports from community-based studies revealed relatively lower rates, approximately 25–30%, suggesting that hospital-acquired strains may play an important role in higher resistance patterns (Marwa et al., 2007) [19].

Accordingly, S. aureus susceptibility testing showed a high prevalence of resistance to penicillin at 76.2%, while all isolates were susceptible to vancomycin and linezolid at 100%. This agrees with the global trend where S. aureus isolates have shown widespread resistance to penicillin but preserved susceptibility to glycopeptides and oxazolidinones (Prabhu et al., 2011) [20]. In contrast, sensitivities recorded in our study to clindamycin at 66.7%, to gentamicin at 71.4%, and to ciprofloxacin at 61.9% are relatively higher than those from some regional reports, which had lower sensitivities of 11% to gentamicin and 21% to ciprofloxacin (Mama et al., 2014) [23]. The sensitivity to erythromycin was 52.4%, which agrees with other literature that suggested its use moderately. Inducible resistance, however, does remain a challenge to be considered (Prabhu et al., 2011) [20]. The findings, therefore, emphasize the need for a continued update on resistance patterns of S. aureus in order to inform empirical treatment properly.

Of the Gram-negative isolates, the most common organism was Escherichia coli (13.8%), followed by Klebsiella species, 7.7%, Pseudomonas aeruginosa, 6.9%, and Proteus species, 5.4%. This trend is in agreement with previous literature reports in which Enterobacteriaceae were the second most common pathogens, following S. aureus, in secondary skin infections (Marwa et al., 2007) [19]. Gram-negative bacteria exhibited the highest sensitivity rates to meropenem (86.4%), imipenem (81.8%), followed by a moderately good sensitivity rate to piperacillin–tazobactam, 77.3%, and aminoglycosides, like amikacin, 72.7%, and gentamicin, 63.6%. Similar findings have been reported by Mama et al. (2014) [23], though some studies reported slightly lower sensitivity rates for carbapenems, indicating variable antimicrobial resistance pressure in different settings. On the other hand, the sensitivity of ciprofloxacin, which was 56.8%, and the resistance to ceftriaxone, 52.3%, as seen in this study, are relatively high compared to other similar studies reporting the rates of ciprofloxacin resistance to be as high as 75% among Gram-negative isolates (Prabhu et al., 2011) [20].

Among the Gram negatives, 37.1% isolates were found to be ESBL producers, of which E. coli represented 38.9% and Klebsiella species 40%. These findings compare with other studies that report the rate of ESBLs among Enterobacteriaceae to be in the range of 40–50% from skin infections (Gupta et al., 2008; Mama et al., 2014) [21,23]. Thus, high rates of both MRSA and ESBL producing organisms in our study point out the daunting task ahead for management of bacterial skin infections in tertiary care. Such strains compromise the efficiency of commonly used antibiotics and demand a prudent selection of empirical therapy based on local antibiograms. Wounds and defects in skin integrity are established risk factors for colonization by resistant flora, emphasizing the importance of regular microbiologic surveillance and susceptibility testing of these populations (Van der Heijden et al., 2001; Gupta et al., 2008) [22,21].

Overall, our findings support the global trend of an increasing resistance profile among pathogens causing bacterial skin infections. The predominance of S. aureus and the increasing prevalence of MRSA, along with the high proportion of ESBL-producing Gram-negative bacteria, highlight the need for continued monitoring, timely detection, and proper antimicrobial stewardship to guide empirical treatment and prevent further dissemination of resistant strains in both hospital and community settings.

Conclusion

This cross-sectional study highlights bacterial skin infections in adults and males, where Staphylococcus aureus was the main agent responsible for infections, followed by Gram-negative bacteria of variable types and a significant rate of mixed infections. Methicillin-resistant S. aureus was significantly present. In view of rising antimicrobial resistance, a large increase in skin infection rates is being reported. S. aureus demonstrated a high rate of resistance against commonly used antibiotics but remained uniformly susceptible to last-line agents and thus continues to appear clinically reliable. Gram-negative isolates demonstrated variable susceptibility with better responses to higher-end antibiotics. A considerable occurrence of ESBL-producing strains, particularly among E. coli and Klebsiella spp., was observed. The study emphasizes that routine culture and sensitivity testing is necessary in order to guide appropriate therapy, limit inappropriate antibiotic use, and reduce the development of resistant pathogens in skin and soft tissue infections.

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