

## ORIGINAL ARTICLE

## Bacteriology of Burn Wound Infections and their Antibioqram

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## ABSTRACT

**Introduction:** Burn wound infections are among the most serious complications following thermal injuries and contribute significantly to morbidity and mortality. Approximately 75% of deaths following burns are attributed to infection. The increasing prevalence of multidrug-resistant (MDR) organisms, such as Extended-Spectrum Beta-Lactamase (ESBL)-producing Gram-negative bacilli and Methicillin-Resistant *Staphylococcus aureus* (MRSA) poses a major therapeutic challenge. This highlights the need for periodic surveillance of microbial profiles and antibiotic susceptibility patterns in burn units.

**Aim:** To determine the bacteriological profile and antimicrobial resistance patterns of bacterial isolates from burn wound patients admitted to the burns ward over one year (September 2018 – October 2019), and to compare the findings with data from a similar study conducted 18 years ago in the same institution.

**Methods:** Wound swabs were collected aseptically from burn patients admitted to the burns ward of King George Hospital, Visakhapatnam, and processed at the Department of Microbiology, Andhra Medical College. Bacterial identification was done using standard microbiological techniques. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method and interpreted as per CLSI guidelines. ESBL, MBL, and MRSA were identified using standard phenotypic tests.

**Results:** Of the 264 samples processed, 238 bacterial isolates were obtained. *Pseudomonas aeruginosa* (4.6%) and *Enterococcus faecalis* (1.6%) were among the isolated organisms. Among the 238 isolates, 163 (68%) were identified as multidrug-resistant. Notably, 31 isolates (13%) were Methicillin-Resistant *Staphylococci*, 81 (34%) were ESBL producers, and 51 (21%) were MBL producers.

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**Conclusion:** The study reveals a high prevalence of multidrug-resistant organisms in burn wounds, underscoring the urgent need for regular microbiological surveillance and rational antibiotic use. The evolving resistance trends over 18 years necessitate updated antibiotic stewardship protocols to optimize treatment outcomes and reduce burn-related morbidity and mortality.

## KEYWORDS

• Burns • Wound Infection • Anti-Bacterial Agents • Drug Resistance • Bacterial  
• Pseudomonas Aeruginosa • Staphylococcus Aureus

## INTRODUCTION

Burns are one of the most common and devastating forms of trauma.<sup>1</sup> There were over 33.5 million thermal burn injuries in 2016 globally, resulting in over 100,000 years lost to disability, and 237,500 deaths.<sup>2</sup>

Bacteria rapidly colonize the open skin wounds after burn injury. Thermal destruction of the skin barrier and concomitant depression of local and systemic host cellular and humoral immune responses are pivotal factors contributing to infectious complications in patients with severe burns.<sup>1</sup> The organisms responsible for infections in patients who suffer from burn injuries may be endogenous or exogenous, which can change over time in the individual patient.<sup>3</sup>

Typically, the burn surface is sterile immediately following thermal injury, but after 48 hours, the wound is colonized with skin commensals. After one week, the wounds become colonized with organisms from the host's gastrointestinal or respiratory tracts or the hospital environment.<sup>4</sup> This colonization, if uncontrolled, may progress to invasion with systemic complications and death.

The pathogens that cause infections burn patients vary from place to place, time to time, based on the duration of hospital stay. Studies have mentioned that Gram-positive organisms predominate during 1st week, with replacement by Gram-negative bacteria in the course of hospital stay.<sup>5</sup>

Additionally, the problem of multidrug resistance in Gram-negative bacilli, due to Extended-spectrum beta-lactamases (ESBL) production, and among Gram-positive organisms, such as Methicillin-resistant Staphylococcus aureus (MRSA), is becoming a serious threat, as the therapeutic options for these organisms are limited. This necessitates

a periodic review of the isolation pattern and antibiogram of the burns ward, which forms the basis for the modification of the drug regimen strategy.<sup>6</sup>

The present study was conducted to determine bacteriological profile and the resistance pattern of bacterial isolates from the patients who were admitted in burn ward over one year (September 2018 – October 2019) and comparison of this data with the results of a study conducted in this institution 18 years ago on Bacteriology of Burns to ascertain any change in the bacteriological profile and microbiological resistance pattern.

## AIMS AND OBJECTIVES

1. To identify the aerobic bacterial agents responsible for burn wound infection.
2. To study the antibiogram of bacterial isolates.
3. To detect the various antibiotic resistance patterns in the isolates.

## METHODOLOGY

This prospective study was conducted in the burns ward of King George Hospital, Visakhapatnam, over one year from September 2018 to October 2019. Wound swabs were aseptically collected from burn wounds of admitted patients and immediately transported to the Department of Microbiology, Andhra Medical College, for processing.

### Inclusion criteria:

1. All age groups and both genders were included.
2. Subjects who were admitted to the burns ward during the study period and gave their written consent to participate in the study.

3. Patients with burn wounds ranging from 10% to 90% total body surface area burns.

#### Exclusion criteria:

1. Subjects with burn injuries who were not treated in the burns ward
2. Subjects who did not give their consent for the study
3. Patients with burn wounds less than 10% and more than 90%
4. Patients with electrical burns

#### Sample collection:

- Pre-sterilized swab in a sterile, sealed plastic container was used for the collection of samples. Gloves and a mask were worn throughout the procedure.
- The area around the burn wound was cleaned with normal saline, and the sample was collected from the depth of the wound using two sterile cotton swabs. Samples were collected immediately after the patients were admitted to the burns unit, at 72 hours, and after 1 week of admission.
- The samples were immediately transported to the microbiology laboratory for bacterial culture and antibiotic sensitivity

#### Processing of Samples:

- Processing of samples was carried out in the Department of Microbiology, Andhra Medical College, Visakhapatnam.
- 1<sup>st</sup> swab was used for direct Gram staining to see the presence of pus cells presence of microorganisms.
- 2<sup>nd</sup> swab was inoculated on Nutrient agar, Blood agar, MacConkey's agar, and incubated at 37°C for 24 hours and observed for growth.
- After incubation, the colonial and cultural characteristics of isolates were observed, biochemical tests were done for identification, and documented as per National CLSI (Clinical and Laboratory Standards Institute) guidelines.<sup>27</sup>
- The antimicrobial susceptibility testing was done by the modified Kirby-Bauer disc diffusion method.<sup>12</sup>

#### Detection of Drug-Resistant Strains:

- Methicillin-Resistant *Staphylococcus aureus* (MRSA)

The phenotypic test for the detection of Methicillin-Resistant *Staphylococcus aureus* (MRSA) was done by using a Cefoxitin disk (30mg). A zone of inhibition equal to or more than 22mm was considered susceptible and reported as Methicillin Sensitive *Staphylococcus aureus* (MSSA). Those isolates that produced a zone of inhibition less than or equal to 21 mm were considered as Methicillin-resistant *Staphylococcus aureus* (MRSA).

- **Detection of Extended-Spectrum Beta-Lactamases (ESBL)**

This was performed by phenotypic confirmatory test as per the recommendations of CLSI by using discs of Ceftazidime (30mg) and Ceftazidime + Clavulanic acid (30/10mg), respectively. An increase in the zone diameter, which was equal to or more than 5mm for the antimicrobial agent that was tested in combination with Clavulanic acid, in comparison to the antimicrobial that was tested alone, indicated that the strain was an ESBL producer

- **Detection of Metallo Beta Lactamases (MBL)**

This was performed by the Imipenem EDTA combined disc test. Two (10g) Imipenem discs were placed on a plate inoculated with the test organism, and 10 µl of 0.5 M EDTA solution was added to one disc. A zone diameter difference between the Imipenem and Imipenem + EDTA of 7 mm was interpreted as a positive result for MBL production.

All data were analysed to determine the prevalence of various bacterial species, their antimicrobial resistance patterns, and the proportion of multidrug-resistant organisms. These findings were then compared with historical data from a similar study conducted 18 years earlier at the same institution.

## STATISTICAL ANALYSIS

Data obtained from the study were compiled and analysed using Microsoft Excel and IBM SPSS Statistics software version 26. The analysis was primarily descriptive. Frequencies and percentages were used to summarize categorical variables such as age, sex, ethnicity, extent, and degree of burns, culture positivity, bacterial isolates, and antibiotic resistance patterns. The distribution of multidrug-resistant organisms, including Methicillin-Resistant *Staphylococcus aureus*

(MRSA), Extended-Spectrum Beta-Lactamase (ESBL) producers, and Metallo Beta-Lactamase (MBL) producers, was also calculated in terms of absolute numbers and percentages.

As the study was observational and exploratory, no inferential statistical tests (e.g., Chi-square or p-values) were applied. The results are presented in tabular form to illustrate trends and distributions in the microbial profile and resistance patterns among burn wound infections.

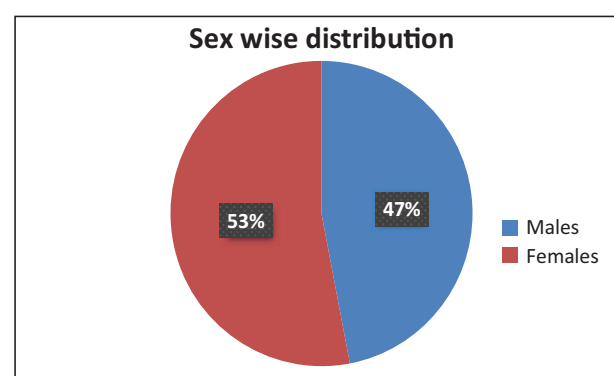
## RESULTS

The demographic analysis revealed that females (53%) slightly outnumbered males (47%) among the burn patients (Table 1). Age-wise, the majority of cases were concentrated in the younger age groups, with 46% of patients falling between 11 to 30 years of age, suggesting that young adults are the most commonly affected demographic (Table 2). Flame burns emerged as the predominant aetiology, accounting for 84% of cases, whereas scald injuries comprised the remaining 16% (Table 3). In terms of burn severity, the highest proportion of patients had 41–60% Total Body Surface Area (TBSA) involvement (38%), followed by 21–40% TBSA (28%) (Table 4). Most burns were of third-degree depth (41%), followed by second-degree (36%) and first-degree burns (21%) (Table 5). Microbiological assessment showed that 68% of the total 264 wound swab samples were culture-positive. The culture positivity increased with duration of hospital stay, rising from 6% at admission to 34% at 72 hours, and 27% at one week (Table 6). Among the culture-positive samples, monomicrobial and polymicrobial infections were almost equally distributed at 49% and 51%, respectively (Table 7). A total of 238 bacterial isolates were recovered, of which *Pseudomonas aeruginosa* was the most frequently isolated organism (34.1%), followed by *Staphylococcus aureus* (20.2%), *Klebsiella pneumoniae* (11.7%), *Acinetobacter baumannii* (11.3%), and *Proteus* species (9.3%). Less frequent isolates included *Escherichia coli* (7.2%), coagulase-negative *Staphylococci* (4.6%), and *Enterococcus faecalis* (1.6%) (Table 8). Antibiotic susceptibility testing revealed that Gram-negative isolates showed the highest sensitivity to colistin (up to 93%), piperacillin-tazobactam, imipenem, and cefoperazone-

sulbactam. *P. aeruginosa* demonstrated 93% sensitivity to colistin and 80% to cefoperazone-sulbactam (Table 9). Gram-positive organisms such as *S. aureus* and coagulase-negative *Staphylococci* exhibited 100% sensitivity to linezolid and vancomycin, with high sensitivity also noted for teicoplanin and azithromycin (Table 10). Of the 238 isolates, 163 (68%) were multidrug-resistant (MDR). Among these, 31 isolates (13%) were Methicillin-Resistant *Staphylococcus aureus* (MRSA), 81 (34%) were Extended-Spectrum Beta-Lactamase (ESBL) producers, and 51 (21%) were Metallo Beta-Lactamase (MBL) producers (Table 11). These findings underscore the high burden of antimicrobial resistance in burn wound infections and highlight the need for vigilant microbiological monitoring and antibiotic stewardship.

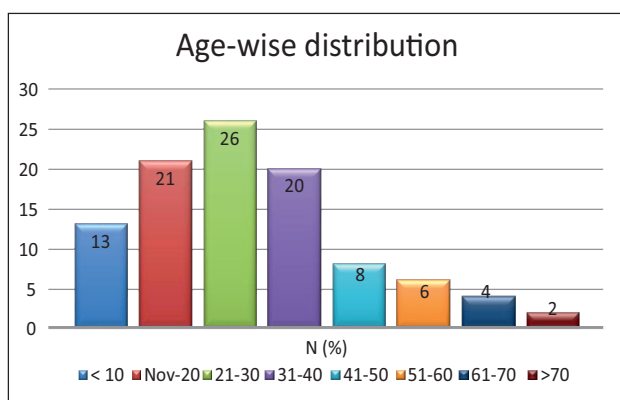
**Table 1:** Sex wise distribution

| Sex     | N (%)    |
|---------|----------|
| Males   | 47 (47%) |
| Females | 53 (53%) |



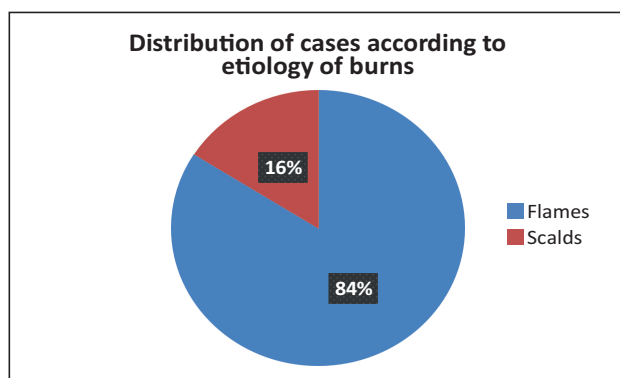
**Table 2:** Age-wise distribution

| Range of age | N (%)    |
|--------------|----------|
| < 10         | 13 (13%) |
| 11-20        | 21 (21%) |
| 21-30        | 26 (26%) |
| 31-40        | 20 (20%) |
| 41-50        | 8 (8%)   |
| 51-60        | 6 (6%)   |
| 61-70        | 4 (4%)   |
| >70          | 2 (2%)   |



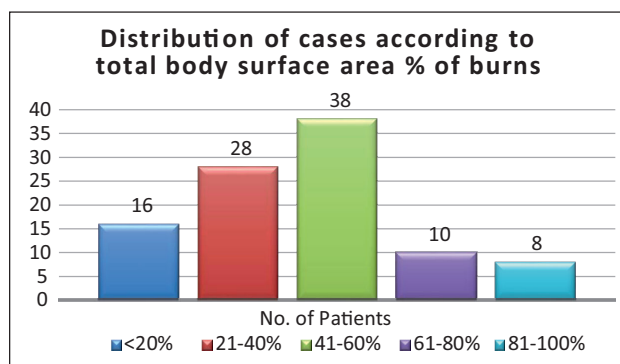
**Table 3:** Distribution of cases according to etiology of burns

| Causes of Burns | N (%)    |
|-----------------|----------|
| Flames          | 84 (84%) |
| Scalds          | 16 (16%) |



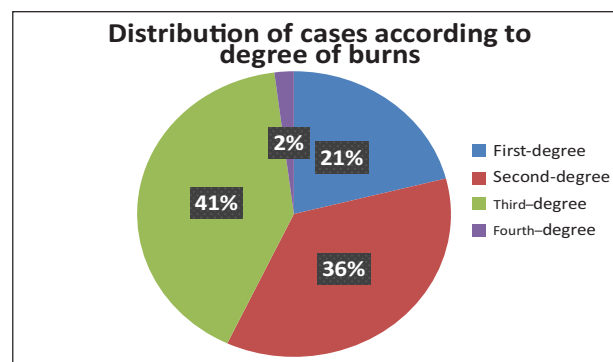
**Table 4:** Distribution of cases according to total body surface area % of burns

| Percentage of burns | No. of Patients |
|---------------------|-----------------|
| <20%                | 16 (16%)        |
| 21-40%              | 28 (28%)        |
| 41-60%              | 38 (38%)        |
| 61-80%              | 10 (10%)        |
| 81-100%             | 8 (8%)          |



**Table 5:** Distribution of cases according to degree of burns

| Degree of burn | N        |
|----------------|----------|
| First-degree   | 21 (21%) |
| Second-degree  | 36 (36%) |
| Third-degree   | 41 (41%) |
| Fourth-degree  | 2 (2%)   |



**Table 6:** Culture positivity among total samples

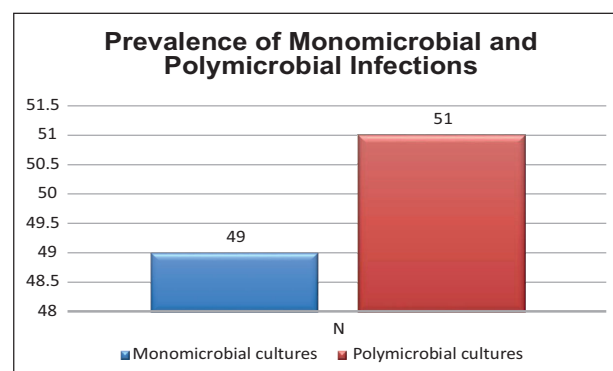
| Total no. of samples | Culture positives swabs | At admission | At 72 hrs | At 1 week |
|----------------------|-------------------------|--------------|-----------|-----------|
| 264                  | 180 (68%)               | 16 (6%)      | 91 (34%)  | 73 (27%)  |

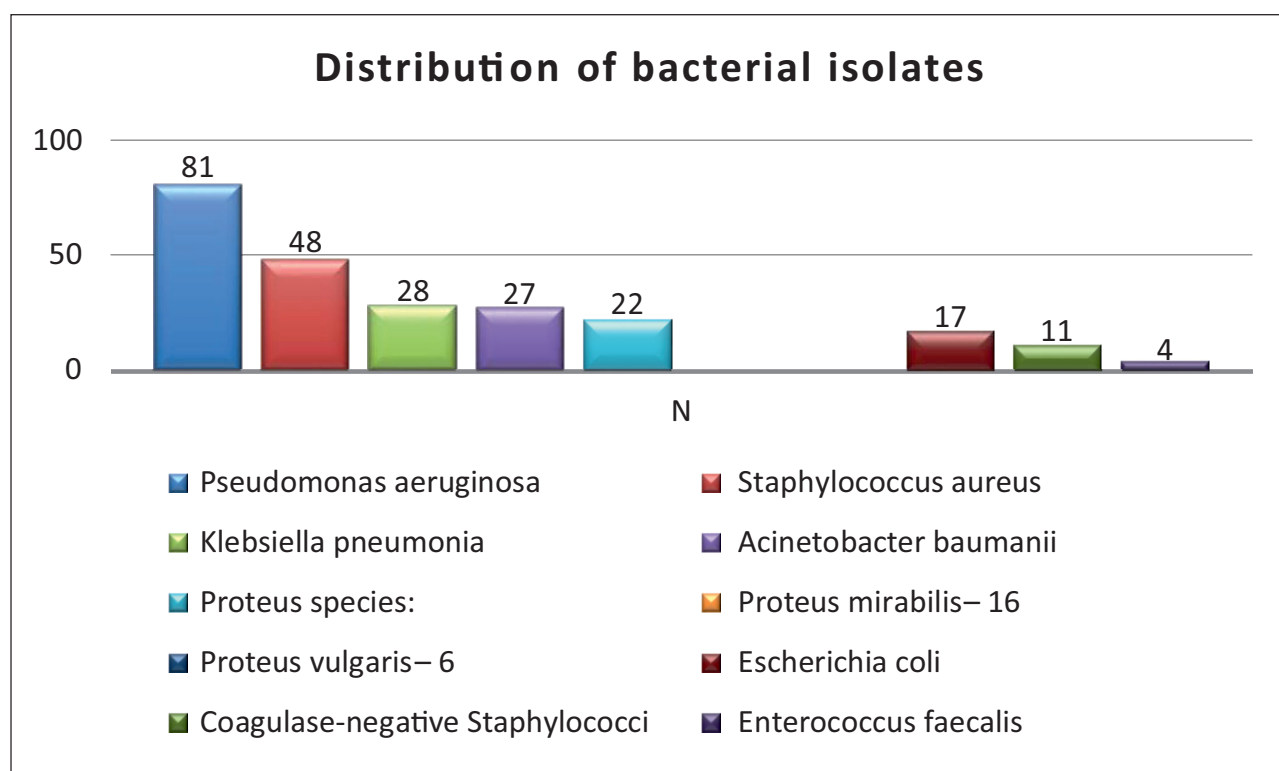
**Table 7:** Prevalence of Monomicrobial and Polymicrobial Infections

| Culture positivity     | N        |
|------------------------|----------|
| Monomicrobial cultures | 49 (49%) |
| Polymicrobial cultures | 51 (51%) |

**Table 8:** Distribution of bacterial isolates

| Organism                         | N          |
|----------------------------------|------------|
| <i>Pseudomonas aeruginosa</i>    | 81 (34.1%) |
| <i>Staphylococcus aureus</i>     | 48 (20.2%) |
| <i>Klebsiella pneumonia</i>      | 28 (11.7%) |
| <i>Acinetobacter baumannii</i>   | 27 (11.3%) |
| <b>Proteus species:</b>          | 22 (9.3%)  |
| Proteus mirabilis - 16           |            |
| Proteus vulgaris - 6             |            |
| <i>Escherichia coli</i>          | 17 (7.2%)  |
| Coagulase-negative Staphylococci | 11 (4.6%)  |
| <i>Enterococcus faecalis</i>     | 4 (1.6%)   |



**Table 8:** Antibiotic Sensitivity Pattern of Gram-Negative Isolates

| Organism      | AMP | CIP | AK  | GEN | CAZ | IMP | PIT | CAC | CTX | AT  | CO  |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| P. aeruginosa | 31% | 36% | 37% | 58% | 38% | 62% | 78% | 80% | 40% | 68% | 93% |
| E. coli       | 35% | 29% | 53% | 53% | 24% | 59% | 59% | 65% | 41% | NT  | NT  |
| K.pneumoniae  | 29% | 57% | 64% | 50% | 14% | 54% | 57% | 71% | 25% | NT  | NT  |
| Proteus spp.  | 23% | 41% | 55% | 41% | 59% | 73% | 77% | 73% | 27% | NT  | NT  |
| A. baumannii  | 37% | 26% | 37% | 26% | 30% | 59% | 48% | 56% | 30% | NT  | NT  |

**Table 9:** Antibiotic Sensitivity Pattern of Gram-Positive Isolates

| Organism    | AMP | AK  | TEI | CD  | CX  | LZ   | CIP | VA   | AZ  | LE  |
|-------------|-----|-----|-----|-----|-----|------|-----|------|-----|-----|
| S.aureus    | 42% | 56% | 90% | 65% | 36% | 100% | 37% | 100% | 77% | 60% |
| Cons        | 91% | 91% | NT  | NT  | 64% | 100% | 64% | 100% | 82% | 64% |
| Enterococci | 75% | 75% | NT  | NT  | NT  | NT   | 78% | 100% | NT% | NT  |

**Table 10:** Distribution Of MDR Strains Among the Bacterial Isolates:

| Total isolates | MDR strains | MRSA    | ESBL Producers | MBL Producers |
|----------------|-------------|---------|----------------|---------------|
| N              | No.         | No.     | No.            | No.           |
| 238 (100%)     | 163 (100%)  | 31(13%) | 81(34%)        | 51(21%)       |

## DISCUSSION

The present study was conducted in 100 patients with burn wounds admitted to the Burns ward, Department of Plastic Surgery, King George Hospital, Visakhapatnam, between August 2018 to September 2019.

Out of the 100 patients studied, 53% were females and 47% of patients were males. This correlated with the study of **Shilpi Gupta et al.**, with Males 48%-Females 52%, **Ritu K et al.**, with Males 40%-Females 60%, and with **Pujji et al.**<sup>7</sup> where males were 30%-Females were 70%.

In the present study, the most common age group involved in the burn injuries is between 20-40 years (46%). According to Sadeghi-Bazargani *et al*<sup>8</sup> The average age of the patient varies from 19 to 35 in the different studies they reviewed.

In the present study, flames were the most common type of burns, accounting for 82% of all cases. This finding correlates with studies of Saaiq *et al*.<sup>9</sup> (75.5%), Chaudhary N *et al*.<sup>10</sup> (64.2%), Agnihotri N *et al*.<sup>11</sup>, Taneja N *et al*.<sup>12</sup>, Kaur H *et al*.<sup>13</sup>, Jefferson L *et al*.<sup>14</sup>

Out of 100 cases of burn injuries studied, 16% were culture positive on the day of admission, and 100% culture positivity was seen from the swabs obtained after 72 hrs from the day of admission. This is because burn injuries are usually sterile immediately and up to 48 hours after injury.<sup>1</sup>

In this study, 49% of patient samples were mono microbial and 51% were poly microbial, according to Abbas HA *et al*.<sup>15</sup> where mono microbial infection was found in 53% of total cases, and polymicrobial infection in 47% of total cases.

Other studies reported a higher number of monomicrobial isolates. Ramakrishnan MK *et al*.<sup>16</sup> Kaushik R *et al*<sup>17</sup> and Dhar S *et al*.<sup>18</sup> who reported solitary isolation rates of 84%, 78%, and 58.42%, respectively.

In the Present study, out of 238 total isolates Gram Gram-negative organisms were 175(73.5%) and Gram-positive organisms were 63 (26.5%). This finding is correlated with the study of Chaudhary *et al*.<sup>10</sup> who reported 75.31% Gram-negative bacilli in total isolates, Gupta AK *et al*<sup>19</sup> Agnihotri N *et al*.<sup>11</sup>, Lari *et al*.<sup>20</sup>

In the present study, out of the total number of isolates (238), the predominant isolate (in both pure & mixed) was *Pseudomonas aeruginosa*, 34.1% (81). This correlates with the studies of Ekrami *et al*.<sup>21</sup> (37.5%) Ramakrishnan MK *et al*.<sup>16</sup> (41%), Mehta M *et al*.<sup>6</sup> (51.5%), Rajput A *et al*.<sup>22</sup> (55%), Biary I *et al*.<sup>23</sup> Nagesha CN *et al*.<sup>24</sup>, Nagoba BS *et al*.<sup>25</sup>, Lari AR *et al*.<sup>20</sup>, Song W *et al*.<sup>26</sup> Kaushik R *et al*.<sup>17</sup> It has been opined that with the advent of antibiotics against Gram-positive organisms, a significant rise in *Pseudomonas* infection of burned patients has occurred.<sup>24</sup>

The second most common isolate was *Staphylococcus aureus* (20.2%), again similar to reports from other studies by Ekrami *et*

*al*.<sup>21</sup> (20%) Rajput A *et al*.<sup>22</sup> (19.29%), Oncul O *et al*.<sup>27</sup> (18%), Guggenheim M *et al*.<sup>28</sup> (20.8%), Lari AR *et al*.<sup>20</sup>, Song W *et al*.<sup>26</sup>, Kaushik R *et al*.<sup>17</sup>, Ramakrishnan MK *et al*.<sup>16</sup>, Dhar S *et al*.<sup>18</sup>, Mehta M *et al*.<sup>6</sup>. This is in contrast to some other studies, especially from developed countries, which report *S. aureus* as the most predominant organism in burn patients.<sup>29</sup>

*Klebsiella pneumoniae* accounted for 11.7%, and it is correlated with that of Kaur *et al*.<sup>13</sup> (7.5%). Ekrami A *et al*.<sup>21</sup>, and Agnihotri N *et al*.<sup>11</sup>. *Proteus* species accounted for 9.3%, *Acinetobacter baumannii* accounted for 11.3% & correlates with Ekrami A *et al*. (10.4%), Chaudhary N *et al*.<sup>10</sup> (17.09%). *Escherichia coli* accounted for 7.2% of the total isolates. This low incidence of *E. coli* is in agreement with other studies in which the frequency of the organism does not exceed 5%,<sup>14,6</sup> Piperacillin + Tazobactam, Imipenem, Gentamycin, and Ciprofloxacin were the most sensitive drugs for Gram-negative isolates.

Linezolid, Vancomycin, Azithromycin, Amikacin, and Ciprofloxacin were found to be the most sensitive antibiotics for gram-positive isolates.

## STRENGTHS

1. The study provides contemporary data on the bacteriological profile and antibiotic resistance patterns among burn wound infections, serving as a valuable reference for updating empirical treatment protocols.
2. A major strength is the comparative analysis with data from a similar study conducted 18 years ago in the same institution, allowing for the assessment of trends and emerging resistance patterns over time.
3. Samples were collected at three different time points (at admission, 72 hours, and one week), enabling the observation of colonization dynamics and microbial progression in burn wounds.
4. The study included both Gram-positive and Gram-negative organisms, with detailed antimicrobial susceptibility profiles, giving a holistic view of the microbial spectrum in the burns unit.
5. Bacterial identification and antibiotic susceptibility testing were carried out

using well-established protocols and interpreted as per Clinical and Laboratory Standards Institute (CLSI) guidelines, ensuring reliability and reproducibility of results.

6. The study specifically identifies and quantifies Methicillin-Resistant *Staphylococcus aureus* (MRSA), Extended-Spectrum Beta-Lactamase (ESBL), and Metallo Beta-Lactamase (MBL) producers, which are crucial for infection control and therapeutic planning.

### Limitations:

1. The study was based solely on descriptive statistics without the use of inferential tests (e.g., Chi-square, p-values), which limits the ability to determine the statistical significance of observed trends or associations.
2. The data were collected from a single tertiary care hospital, which may not be representative of the broader regional or national trends in burn wound infections and resistance patterns.
3. Resistance mechanisms were identified using phenotypic methods only. Molecular methods (e.g., PCR) were not used to confirm the presence of resistance genes (e.g., *mecA*, *blaCTX-M*, *blaNDM*).
4. Some newer or last-resort antibiotics (e.g., daptomycin, tigecycline) were not included in the antibiotic susceptibility testing panel, which may affect the completeness of the resistance profile.

### CONCLUSION

The present study highlights the persistent and evolving threat of burn wound infections, particularly due to the high prevalence of multidrug-resistant (MDR) organisms. *Pseudomonas aeruginosa* emerged as the predominant isolate, followed by *Staphylococcus aureus* and other Gram-negative bacilli such as *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Proteus* species. A significant proportion of isolates were identified as ESBL, MBL, and MRSA producers, underscoring the growing challenge of antimicrobial resistance in burn units.

The findings emphasize the critical need for regular microbiological surveillance and

revision of empirical antibiotic policies based on local resistance patterns. Early identification and targeted therapy can significantly reduce infection-related complications and improve patient outcomes. The study also demonstrates that, despite advances in infection control and antimicrobial agents, burn wounds remain highly vulnerable to colonization and infection by opportunistic, often drug-resistant pathogens.

Therefore, an integrated approach that includes timely microbiological investigation, appropriate antibiotic stewardship, strict infection control measures, and awareness of local microbial trends is essential in the effective management of burn wound infections.

**Conflict of Interest:** The authors declare no conflict of interest.

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