# Prevalence and Antibiotic Resistance Patterns of Bacterial Infections in Dermatology Inpatients: A Cross-Sectional Study

**Running title:** Nosocomial infection in dermatology ward

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**Abstract**

**Background:** Nosocomial infection is among the most concerning issues among hospitalized patients. The present study investigated the frequency of bacterial infections and their antibiotic resistance pattern among hospitalized patients in the dermatology ward.

**Methods:** This cross-sectional study was conducted on patients admitted to the dermatology ward in Razi Hospital, Rasht, Iran, between 2018 and 2022. Demographic data and clinical characteristics of the 34 patients with bacterial infections were recorded and analyzed. The bacterial isolates were collected from skin and soft tissue, urinary tract, or bloodstream infections, and the clinical findings and outcomes of the patients were recorded.

**Results:** Thirty-four patients had positive results for bacterial culture. The mean age of the patients was 53.56±17.14 years, and 61.8% were female. The most frequent origin of the infection was the urinary tract. *Staphylococcus epidermidis* (*S. epidermidis*) and *Klebsiella* spp. were the most prevalent isolates. *Klebsiella* spp. and *Escherichia coli* (*E. coli*) were more common in patients aged <56 years and ≥56 years, respectively, and among ≥13 days and <13 days of hospitalization, respectively. Antibiotic resistance was high in *S. epidermidis* and *Pseudomonas aeruginosa* (*P. aeruginosa*)isolates, where showed resistance to all antibiotics.

**Conclusion:** This study revealed significant patterns of bacterial infections and antibiotic resistance in dermatology ward patients with *E. coli* and *Klebsiella* spp. Predominant in urinary tract infections and a diverse profile in skin and soft tissue infections.

**Keywords:** Bacterial infection; Urinary tract infection; Antibiotic resistance pattern; Soft tissue infection

## Introduction

Hospital-acquired infections (HAIs) pose a significant challenge in dermatology wards, contributing to increased morbidity, prolonged hospital stays, and elevated healthcare costs. Patients with dermatological conditions are particularly vulnerable to HAIs due to factors such as compromised skin barriers, immunosuppressive treatments, and extended hospitalization periods (1-3). In dermatology wards, common HAIs include surgical site infections, cellulitis, and device-associated infections. Risk factors for HAIs in these patients include chronic skin conditions, extensive wounds or burns, use of systemic corticosteroids or immunosuppressants, and invasive procedures (4,5).

Evidence showed the highest rates of pneumonia, urinary tract, hematologic, and surgical infections. *Enterococcus faecium* (*E. faecium)*, *Staphylococcus aureus* (*S. aureus*), *Klebsiella pneumoniae* (*K. pneumoniae*), *Acinetobacter baumannii* (*A. baumannii)*, *Pseudomonas aeruginosa* (*P. aeruginosa*), and *Enterobacter* spp., pose a significant threat within nosocomial infections (6). The burden of nosocomial infections in developing countries was reported to be as high as 15.5%, and among critically ill patients has been reported to reach 34.1% (7,8). The highest reported frequency of nosocomial infections has been related to Staphylococci from gram-positive, *Escherichia coli* (*E. coli*), and *P. aeruginosa* from gram-negative bacteria (8).

The rising prevalence of antibiotic resistance complicates treatment and increases the risk of poor outcomes and the further spread of resistant strains within healthcare settings. Multidrug resistance (MDR) bacteria can encompass resistance to various types of antibiotics, and factors contributing to the emergence and spread of MDR organisms include inappropriate antibiotic use, inadequate infection prevention and control practices, and the overuse of antibiotics in both human and animal settings (9,10). Commonly reported MDR organisms contribute to severe infections and evade the effects of commonly used antibiotics (11,12). The highest reported bacterial resistance in Iran was related to *A. baumannii* strains with 100% resistance to gentamicin, ampicillin, ceftriaxone, amikacin, and ceftriaxone. Carbapenems or polymyxins are the most effective antibiotics (13,14). Evidence suggested that patients with MDR nosocomial infections were primarily hospitalized, particularly in intensive care units (ICU). These MDR strains exhibited resistance to a wide range of antibiotics, indicating the need for enhanced surveillance to guide appropriate antibiotic usage and reduce the incidence of nosocomial infections (15,16). Due to the reported different frequencies of nosocomial infections in various wards of the hospital and due to the various antibiotic resistance patterns of these isolates (17,18), the present study aims to investigate the frequency of bacterial infections and their antibiotic resistance patterns among patients admitted to the dermatology ward of Razi Hospital in Rasht, Iran. This research will provide valuable insights for clinicians managing HAIs in dermatology patients by elucidating the prevalent pathogens and their resistance profiles.

## Methods

This cross-sectional study was conducted on 34 patients in Razi Hospital, Rash, Iran, dermatology ward between 2018 and 2022. The study was confirmed by the ethical committee of the Guilan University of the Medical Sciences [IR.GUMS.REC.1402.105]. Of 2,890 hospitalized patients with bacterial infections at Razi Hospital in Rasht, Iran, 34 were admitted to the dermatology ward and included in the study. All patients gave their written informed consent to participate in the study.

Demographical data and clinical characteristics were collected from the patients' archives. The data age, gender, underlying diseases (diabetes, hypertension, and cardiovascular diseases), the

origin of the infection (skin and soft tissue, urinary tract, or bloodstream), duration of hospitalization, outcomes of the patients, types of bacterial infection, and antibiotic resistance pattern were recorded. None of the patients had burn wounds or used immunosuppressive drugs and patients with autoimmune diseases or malignancies were excluded from the study. The standard biochemical and microbiological tests were applied to identify the positive isolates, and the antibiotic susceptibility of all isolates was determined following the Clinical and Laboratory Standards Institute (CLSI) guideline 2023 on Mueller-Hinton agar (Merck, Germany) (19). A panel of antobiotics including erythromycin (ERY), amikacin (AMK), penicillin (PEN), tetracycline (TET), gentamicin (GEN), doxycycline (DOX), ciprofloxacin (CIP), clindamycin (CLI), trimethoprim-sulfamethoxazole (SXT), imipenem (IPM), ceftazidime (CEF), cefepime (CFP), and nitrofurantoin (NIT) was used.

***Statistical analysis***

Variables were reported using number (percentage) and mean ± standard deviation (SD). All data were analyzed using the IBM SPSS Statistics version 21.

## Results

Out of 34 patients, 21 (61.8%) were females, and the mean age of the patients was 53.56±17.14 years (19-86 years). About 17 (50%) patients had underlying diseases, and 33 patients discharged from hospital. The frequency of total bacterial infection in the dermatology department of Razi Hospital, Rash, Iran, between 2018 and 2022 was 1.17%. In urinary tract infections, *E. coli* was the most prevalent pathogen (32.4%), followed by *Klebsiella* spp. (29.4%), *Staphylococcus epidermidis* (*S. epidermidis*). (14.7%), and *Enterobacter* spp. (11.8%). *Citrobacter* spp. (8.8%) and *P. aeruginosa* (2.9%) were also isolated from urinary tract infections. Wound infections showed a different profile, with *S. epidermidis*, *Enterobacter* spp., and *Klebsiella* spp. equally prevalent (28.6% each), and *Citrobacter* spp. was found in 14.2% of cases. Bloodstream infections were primarily caused by *S. epidermidis* (42.8%), with *Enterobacter* spp. and *Klebsiella* spp. each accounting for 28.6% of cases, Table 1.

In patients under 56 years old, *Klebsiella* spp. was most prevalent (35.4%), followed by *E. coli* (23.5%). However, in patients 56 years and older, *E. coli* was the most common pathogen (41.2%), followed by *Klebsiella* spp. (23.5%). Gender differences were also observed with *Enterobacter* spp. being most prevalent in males (30.8%), followed by *S. epidermidis* (23.1%), while in females, *Klebsiella spp.* was most common (38.1%), followed by *E. coli* (4.9%). Patients with underlying diseases had a higher prevalence of *Klebsiella* spp. (47.1%) and *E. coli* (23.5%), whereas those without underlying diseases showed a higher prevalence of *E. coli* (41.2%) and *Enterobacter* spp. (23.4%). The duration of hospitalization also affected pathogen distribution. For hospital stays less than 13 days, *E. coli* was most prevalent (50.0%), while for stays of 13 days or longer, *Klebsiella* spp. was most common (44.3%). Regarding patient outcomes, most patients were discharged with *E. coli* and *Klebsiella* spp. being the most prevalent pathogens (30.3% each) among discharged patients. Only one death was reported, associated with an *E. coli* infection, Table 1.

For *S. epidermidis*, ERY was the most resistant (100%), and GEN was the most sensitive (60%). *E. coli* was most resistant to SXT (54.5%) and most sensitive to AMK (92.7%). *Enterobacter* spp. Showed highest resistance to CFP (75%) and was fully sensitive to AMK, GEN, SXT, CIP, and NIT. *P. aeruginosa* was 100% resistant to all tested antibiotics, with no sensitivity observed. *Citrobacter* spp. was most resistant to SXT and NIT (both 100%) and most sensitive to IPM (100%). Also, *Klebsiella spp*. showed highest resistance to SXT (90%) and was most sensitive to AMK (60%) (Table 2).

## Discussion

Gram-negative bacteria cause most nosocomial infections. These bacteria have developed resistance to most antibiotics. This study showed that *E. coli* and *Klebsiella* spp. were the most frequently isolated bacteria in the dermatology ward of the hospital, and urinary tract infections were the most common infections among them. Most of the infections were among females, and the average duration of hospitalization of patients was 13 days, in which only one patient had expired. It has been reported that a long duration of hospitalization results in infections with ESBL-producing microorganisms (20), and more extended hospitalization is considered to determine the burden of nosocomial infections (21). Females typically exhibit more robust immune responses to antigens than males, leading to sex-based variations in autoimmune and infectious diseases. In some cases, such as urinary tract infections, females generally show greater susceptibility to bacterial infections than males (22,23).

Azimi et al.'s study showed that of 610 isolated bacteria, 53.2%, 22.9%, 21.6%, and 35.2% were *P. aeruginosa*, *A. baumannii*, *S. aureus,* and others, respectively. The mortality rate was 12%, and all patients had at least one positive result for *P. aeruginosa* or *A. baumannii* (24). Increased usage and resistance of broad-spectrum antimicrobial agents establish a link between consumption and resistance to these antibiotics. The ten-year observation period showed pan-resistance development in *K. pneumoniae*, potentially attributed to carbapenemase production. In contrast, ESBL production emerged as the prevalent resistance mechanism in *E. coli*, underscoring the need for ongoing surveillance and antibiotic stewardship initiatives to mitigate selection pressure and prevent further spread (25). A study by Iqbal et al. on pediatric patients with urinary tract infections reported that *E. coli* and *K. pneumonia* were the dominant extensively drug-resistant uropathogenic bacteria. These bacteria resisted the most commonly used classes of β-lactams, pyridopyrimidines, quinolones, and fluoroquinolone antibiotics (26).

The present study demonstrated that *E. coli* was highly susceptible to amikacin and nystatin and was resistant to trimethoprim-sulfamethoxazole. We observed that *Klebsiella* spp. was resistant to trimethoprim-sulfamethoxazole, imipenem, and ciprofloxacin and was susceptible to amikacin. Mirzarazi et al. reported that *E. coli* isolates were highly resistant to trimethoprim-sulfamethoxazole and *Klebsiella* spp. showed resistance to trimethoprim-sulfamethoxazole, ciprofloxacin, and nalidixic acid (27). Another study by Jalali et al. showed that the predominant pathogen identified was *E. coli*, present in 68.3% of urine samples, followed by *K. pneumonia*, detected in 31.7% of samples. They reported that regarding antibiotic resistance, *E. coli* isolates exhibited significant resistance to ceftriaxone and ampicillin. According to their results, *K. pneumonia* isolates, elevated resistance was observed for piperacillin, levofloxacin, ampicillin, cefotaxime, and trimethoprim-sulfamethoxazole, respectively (28). Resistance to antimicrobial drugs in *K. pneumoniae* is mediated by genes such as plasmid-mediated carbapenemases or enzymes that can hydrolyze all beta-lactam compounds (29).

Kariuki et al. demonstrated that ciprofloxacin non-susceptibility was prevalent in hospitalized discharged children of *E. coli* and *Klebsiella* spp. (30). Sharma et al. reported that *K. pneumoniae* rose from 7.5% in 2018 to 21.4% in 2022. Concurrently, the prevalence of extensively drug-resistant *K. pneumoniae* among mechanically ventilated ICU patients witnessed a notable increase from 62.5% in 2018 to 71% in 2022. The escalating antibiotic resistance in *K. pneumoniae* poses a significant threat in Asia, necessitating vigilant monitoring and control measures (29). Given the rising resistance to existing medications, addressing this challenge requires deliberate efforts to develop a new generation of antimicrobials. Regular monitoring and reporting of antibiotic resistance by healthcare institutions are crucial to managing this evolving concern.

Our results demonstrated that *S. epidermidis* was susceptible to gentamicin (60%) and was resistant to erythromycin (100%), penicillin (80%), clindamycin (80%), and trimethoprim-sulfamethoxazole (80%). Moreover, *P. aeruginosa* resisted all applied antibiotics (amikacin, gentamicin, trimethoprim-sulfamethoxazole, imipenem, cefepime, and ciprofloxacin). The results of the study by Khashai et al. showed that *A. baumannii*, *P. aeruginosa*, and *E. coli* were among the most common isolated bacteria, and the highest level of resistance against ampicillin was observed among isolates of *P. aeruginosa.* At the same time, it was sensitive to imipenem, and *E. coli* was sensitive to amikacin (31).

We observed that *Enterobacter* spp. was susceptible to most of the applied antibiotics (amikacin, gentamicin, trimethoprim-sulfamethoxazole, imipenem, ciprofloxacin, and nystatin), and the only antibiotics that showed resistance were cefepime. *Citrobacter* spp. was resistant to trimethoprim-sulfamethoxazole and nystatin. Yekani et al. reported that fosfomycin, carbapenems, and amikacin emerged as highly efficacious agents against Enterobacteriaceae. Conversely, quinolones, trimethoprim, and sulfamethoxazole are unsuitable for empirical therapy due to elevated resistance levels. Amikacin is particularly effective among aminoglycosides and may demonstrate enhanced efficacy in complex cases when employed alongside fosfomycin and carbapenems (32). Clinical *Citrobacter* spp. strains are often resistant to multiple classes of antibiotics. Infections by MDR *Citrobacter* strains have been associated with a higher rate of in-hospital mortality than susceptible strains (33).

While this study highlighted the prevalence of bacterial infections in dermatology wards, there are some limitations. The cross-sectional nature of the study was one of the limitations. Also, the association between patients' condition according to their type of underlying disease with the infection was not evaluated, which is suggested to be considered for future study.

## Conclusion

This study reveals significant patterns of bacterial infections and antibiotic resistance in dermatology ward patients. The findings highlighted that *E. coli* and *Klebsiella* spp. They predominantly caused urinary tract infections, while skin and soft tissue infections showed a more diverse profile. Concerning levels of antibiotic resistance were observed, particularly *in S. epidermidis*, *Klebsiella* spp., and *P. aeruginosa*. These results underscore the need for tailored infection prevention strategies and regular surveillance of local pathogen profiles and resistance rates.

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## Ethical Statement

All subjects gave their informed consent to participate in the study. All methods were carried out in accordance with relevant guidelines and regulations that is Declaration of Helsinki. The study was confirmed by the ethical committee of the Guilan University of the Medical Sciences [IR.GUMS.REC.1402.105].

## Conflicts of Interest

The authors declare that they have no competing interests.

## Author Contributions

H.S.E and H.E contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by T.Y, H.S.E., and Z.F. The first draft of the manuscript was written by H.S.E, T.Y, Z.F, M.P, and H.F conducted study literature and edited the final version of the manuscript. All authors approved the final version of the manuscript.

## Data Availability Statement

The datasets used and/or analyzed in the current study have been reported in the current study.

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**Table 1.** Demographical and clinical data of patients according to the frequency of isolated bacteria

| Variables | | Isolated bacteria n (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | ***Staphylococcus epidermidis*** | ***Escherichia coli*** | ***Enterobacter* spp.** | ***Pseudomonas aeruginosa*** | ***Citrobacter* spp.** | ***Klebsiella* spp.** |
| **Age** (Year) | < 56 | 3 (17.6) | 4 (23.5) | 3 (17.6) | 0 (0.0) | 1 (5.9) | 4 (35.4) |
| | ≥ 56 | 2 (11.7) | 7 (41.2) | 1 (5.9) | 1 (5.9) | 2 (11.8) | 4 (23.5) |
| **Gender** | Male | 3 (23.1) | 2 (15.4) | 4 (30.8) | 1 (7.7) | 1 (7.7) | 2 (15.3) |
| | Female | 2 (9.5) | 9 (4.9) | 0 (0.0) | 0 (0.0) | 2 (9.5) | 8 (38.1) |
| **Underlying disease** | Yes | 3 (17.6) | 4 (23.5) | 0 (0.0) | 0 (0.0) | 2 (11.8) | 8 (47.1) |
| | No | 2 (11.8) | 7 (41.2) | 4 (23.4) | 1 (5.9) | 1 (5.9) | 2 (11.8) |
| **Origin of the infection** | Urine | 0 (0.0) | 11 (55.0) | 0 (0.0) | 1 (5.0) | 2 (10.0) | 6 (40.0) |
| | Wound | 2 (28.6) | 0 (0.0) | 2 (28.6) | 0 (0.0) | 1 (14.2) | 2 (28.6) |
| | Blood | 3 (42.8) | 0 (0.0) | 2 (28.6) | 0 (0.0) | 0 (0.0) | 2 (28.6) |
| **Duration of hospitalization** (Day) | < 13 | 3 (18.8) | 8 (50.0) | 3 (18.8) | 0 (0.0) | 0 (0.0) | 2 (12.4) |
| | ≥ 13 | 2 (11.1) | 3 (16.7) | 1 (5.6) | 1 (5.6) | 3 (16.7) | 8 (44.3) |
| **Outcome** | Discarded | 5 (15.2) | 10 (30.3) | 4 (12.1) | 1 (3.0) | 3 (9.1) | 10 (30.3) |
| | Death | 0 (0.0) | 1 (100) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |

**Table 2.** Antibiotic resistance pattern of isolated bacteria

| Isolated bacteria | | Antibiotics % | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **ERY** | **AMK** | **PEN** | **TET** | **GEN** | **DOX** | **CLI** | **SXT** | **IPM** | **CEF** | **CFP** | **CIP** | **NIT** |
| ***Staphylococcus epidermidis*** | Resistant | 100 | 60.0 | 80.0 | 60.0 | 40.0 | 60.0 | 80.0 | 80.0 | - | - | - | - | |
| | Intermediate | 0.0 | 0.0 | 0.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | - | - | - | |
| | Susceptible | 0.0 | 40.0 | 20.0 | 20.0 | 60.0 | 40.0 | 20.0 | 20.0 | - | - | - | - | |
| ***Escherichia coli*** | Resistant | - | 27.3 | - | - | 40.0 | - | - | 54.5 | 18.2 | 36.4 | - | 40.0 | 9.1 |
| | Intermediate | - | 0.0 | - | - | 0.0 | - | - | 0.0 | 27.3 | 9.1 | - | 0.0 | 9.1 |
| | Susceptible | - | 92.7 | - | - | 60.0 | - | - | 45.5 | 54.5 | 54.5 | - | 60.0 | 81.8 |
| ***Enterobacter* spp.** | Resistant | - | 0.0 | - | - | 0.0 | - | - | 0.0 | 0.0 | - | 75.0 | 0.0 | 0.0 |
| | Intermediate | - | 0.0 | - | - | 0.0 | - | - | 0.0 | 25.0 | - | 0.0 | 0.0 | 0.0 |
| | Susceptible | - | 100 | - | - | 100 | - | - | 100 | 75.0 | - | 25.0 | 100 | 100 |
| ***Pseudomonas aeruginosa*** | Resistant | - | 100 | - | - | 100 | - | - | - | 100 | - | 100 | 100 | - |
| | Intermediate | - | 0.0 | - | - | 0.0 | - | - | - | 0.0 | - | 0.0 | 0.0 | - |
| | Susceptible | - | 0.0 | - | - | 0.0 | - | - | - | 0.0 | - | 0.0 | 0.0 | - |
| ***Citrobacter* spp.** | Resistant | - | 33.3 | - | - | 66.7 | - | - | 100 | 0.0 | 66.7 | - | 66.7 | 100 |
| | Intermediate | - | 0.0 | - | - | 0.0 | - | - | 0.0 | 0.0 | 0.0 | - | 33.3 | 0.0 |
| | Susceptible | - | 66.7 | - | - | 33.3 | - | - | 0.0 | 100 | 33.3 | - | 0.0 | 0.0 |
| ***Klebsiella* spp.** | Resistant | - | 40.0 | - | - | 50.0 | - | - | 90.0 | 70.0 | 60.0 | - | 70.0 | 50.0 |
| | Intermediate | - | 0.0 | - | - | 0.0 | - | - | 0.0 | 0.0 | 10.0 | - | 10.0 | 0.0 |
| | Susceptible | - | 60.0 | - | - | 50.0 | - | - | 10.0 | 30.0 | 30.0 | - | 20.0 | 50.0 |

Erythromycin (ERY), Amikacin (AMK), Penicillin (PEN), Tetracycline (TET), Gentamicin (GEN), Doxycycline (DOX), Ciprofloxacin (CIP), Clindamycin (CLI), Trimethoprim-Sulfamethoxazole (SXT), Imipenem (IPM), Ceftazidime (CEF), Cefepime (CFP), and Nitrofurantoin (NIT)