American Journal of
Biomedical Science & Research

www.biomedgrid.com
ISSN: 2642-1747

Research Article

Prevalence and Antibiotic Resistance Patterns of Multidrug-Resistant Gram-Negative Bacilli in Hospitalized Patients in Sweida, Syria

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To Cite This Article: *Dalia Aboufakher, Rita Zeinaldin, Racha Khatib, Rawa Khreit, Mohamed Sami Joha, et al. Prevalence and Antibiotic Resistance Patterns of Multidrug-Resistant Gram-Negative Bacilli in Hospitalized Patients in Sweida, Syria. Am J Biomed Sci & Res. 2025 26(3) AJBSR.MS.ID.003436,* **DOI:** 10.34297/AJBSR.2025.26.003436

Received: February 2, 2025; **Published:** March 25, 2025

Abstract

Multidrug-resistant Gram-negative bacilli represent a substantial public health challenge, particularly in developing nations, where their increasing prevalence has resulted in heightened healthcare expenditures and rising mortality rates. This study aims to explore the occurrence of Gram-negative bacilli in clinical specimens while assessing their susceptibility to various antibiotics. A total of 337 patient samples were collected from hospitals in Sweida, leading to the isolation and identification of bacterial strains. The findings revealed that Gram-negative bacilli were present in 216 samples, constituting 64.1% of the total analysed. Among these, Escherichia coli was the most frequently identified, accounting for 38%, followed by Enterobacter at 26.4%, Klebsiella at 25.5%, and Pseudomonas aeruginosa at 9.7%. Notably, all isolated strains exhibited multidrug resistance. A comprehensive analysis of the sensitivity of these isolates to various antibiotics was conducted. The study illuminated the significant prevalence of multidrug-resistant Gram-negative bacilli, underscoring the urgent need for preventative strategies. These strategies should focus on the judicious and targeted application of antibiotics to effectively curb the dissemination of these resistant strains. By addressing this critical issue, we can enhance public health outcomes and reduce the associated economic burdens.

Keywords: Gram-negative bacilli, Antibiotic, Resistance, Sweida, Syria

Introduction

Antibiotic-Resistant Multidrug-Resistant Organisms (MDROs) represent a critical public health challenge in contemporary society. The escalating resistance of pathogens to widely prescribed antibiotics complicates the identification and administration of effective treatments for a range of infections. According to data from the World Health Organization (WHO), the mortality rate associated with infections caused by multidrug-resistant organisms is twice that of infections due to non-resistant organisms, highlighting the severity of this issue [1-6].

The mechanisms behind bacterial resistance are multifaceted and often involve genetic factors. Some microorganisms develop resistance through inherent structural characteristics encoded in their genetic material, while others acquire resistance genes via mutations or horizontal gene transfer from other bacteria. Such genetic alterations can enhance bacteria's ability to withstand the effects of antibiotics, either by modifying their cellular structures to reduce drug penetration or by enabling them to incorporate resistance traits from neighbouring organisms [6-10].

Bacteria employ various strategies to counteract the effects of antibiotics. For example, certain species may alter their cell wall composition to limit the permeability of antibiotic molecules, thereby preventing these drugs from reaching critical intracellular targets. Additionally, some microbial cells utilize efflux pumps to expel antibiotic agents that have entered the cell, minimizing their therapeutic impact. Others may produce enzymes capable of degrading or chemically modifying antibiotics, rendering them ineffective. Furthermore, bacteria can also modify the structural targets within their own cells that antibiotics aim to disrupt, thereby evading the intended action of these drugs [10-17].

The misuse of antibiotics is a significant driving force behind the emergence of resistance. This problem is exacerbated by the inappropriate prescription of antibiotics, the reliance on broad-spectrum antibiotics without adequate clinical justification, and the overall overuse of these medications. Such practices not only contribute to the development of resistant strains but also facilitate their dissemination within communities [18-22].

Bacterial strains are categorized as multidrug-resistant when they exhibit resistance to at least one antibiotic from three or more distinct classes of drugs [23-28]. Unfortunately, in Syria, as in many other regions around the globe, antibiotics are often prescribed unnecessarily and inappropriately for a wide array of microbial infections, further complicating the public health landscape [29-35].

This research aims to investigate the prevalence of multidrug-resistant Gram-negative strains in hospitals located in the southern Syrian city of Sweida. Additionally, the study will assess the sensitivity of these strains to various antibiotic agents, contributing valuable data to address this pressing health concern [36-40].

Materials and Methods

This study employed a cross-sectional design, encompassing a total of 337 patients from whom various clinical specimens were collected. The sample types included 244 urine samples, 15 wound swabs, 12 pus samples, 11 bone swabs, 10 sputum samples, 11 burn swabs, 7 Cerebrospinal Fluid (CSF) samples, 6 ear swabs, 6 semen cultures, and 3 joint fluid samples. Additionally, one bedsore swab and one throat swab were also included. The researchers meticulously isolated and identified the pathogens present in these samples [41-44].

To initiate the analysis, the collected samples were cultured on blood agar plates and incubated at 37 °C for a duration of 24 hours. Following incubation, Colony-Forming Units (CFUs) were counted to determine bacterial growth. In cases where the CFU/mL exceeded 100,000, antibiotic susceptibility testing was performed using Mueller-Hinton Agar (MHA) to evaluate the effectiveness of various antibiotics against the isolated bacterial strains. This evaluation was conducted by measuring the zones of inhibition around antibiotic discs, which indicate the efficacy of the antibiotics in inhibiting bacterial growth [45-47].

The antibiotics tested in this study included a comprehensive range of agents: Amikacin (30 µg), Gentamicin (10 µg), Nitrofurantoin (300 µg), Ceftriaxone (30 µg), Ciprofloxacin (30 µg), Imipenem (10 µg), Meropenem (10 µg), Levofloxacin (5 µg), Nalidixic acid (30 µg), Cefpodoxime (30 µg), Cefuroxime (30 µg), Cefotaxime (30 µg), Cephalexin (30 µg), Cefixime (5 µg), Amoxicillin-clavulanic acid (30 µg), Colistin (10 µg), Trimethoprim-sulfamethoxazole (75 µg), Cefadroxil (30 µg), Cefepime (30 µg), and Ampicillin (10 µg). This broad selection of antibiotics allowed for a thorough assessment of the resistance profiles of the isolated pathogens, providing critical insights into the current state of antibiotic susceptibility in the studied population [48-52].

Results

The analysis of samples collected between November 2023 and March 2024 revealed that 216 out of the total samples (61%) contained Gram-negative bacilli. A detailed breakdown of these samples showed that 175 were urine samples, 8 were wound swabs, 7 were burn swabs, 7 were pus samples, 5 were bone swabs, 5 were sputum samples, 3 were joint fluid samples, 1 was a bed sore sample, and 1 was a Cerebrospinal Fluid (CSF) sample. Notably, no Gram-negative bacilli were found in ear swabs, seminal fluid, or throat swab cultures.

The demographic analysis indicated that the majority of patients were adults, totalling 182 (84%), while children accounted for 34 (16%). Among the adults and children, there were 134 females (62%) and 72 males (38%), highlighting a predominance of female patients in the sample population.

Among the isolated pathogens, Escherichia coli (E. coli) was the most prevalent, accounting for 83 isolates (38%). Of these, 80 isolates (approximately 96%) were derived from urine samples, while 3 isolates (4%) originated from wound swabs. All E. coli isolates exhibited complete resistance to cephalexin, cefadroxil, and ampicillin. However, they demonstrated significant susceptibility to several antibiotics, with sensitivity rates of 75% for amikacin, 76% for meropenem, 69% for gentamicin, 60% for nitrofurantoin, and 64% for cefepime (Figure 1).

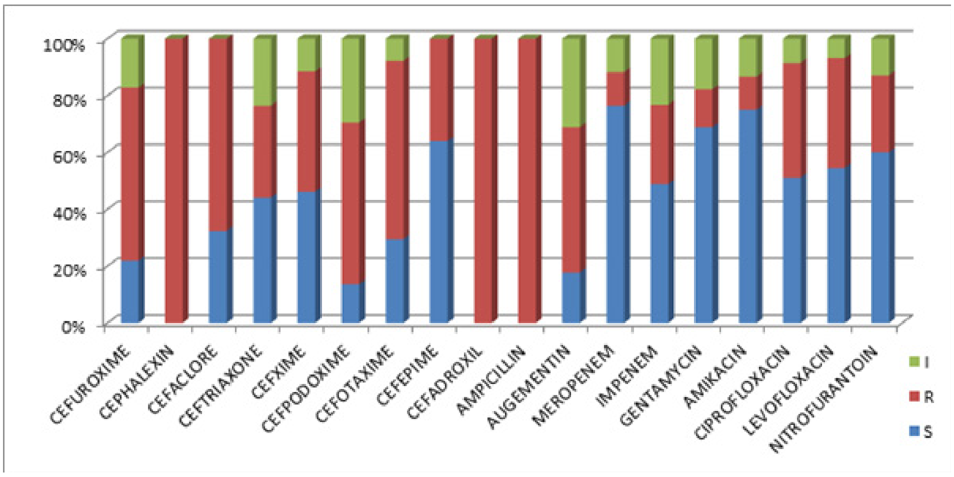

Figure 1: Susceptibility results of E. Coli isolates to studied antibiotics. S: susceptible, I: intermediate, R: resistant.

In addition, the study identified 57 isolates of Enterobacter species, representing 26% of the total isolates. The distribution of these isolates was as follows: 47 from urine samples (82.3%), 4 from bone swabs (7%), 2 from wound swabs (3.5%), 1 from a bed sore sample (1.8%), 1 from a burn swab (1.8%), 1 from a joint fluid sample (1.8%), and 1 from a sputum sample. All Enterobacter isolates exhibited complete resistance to cephalexin, cefadroxil, and ampicillin. Their sensitivity levels were notably high, with 80% for amikacin, 75% for meropenem, 70% for gentamicin, 60% for nitrofurantoin, 60% for cefepime, and 67% for colistin (Figure 2).

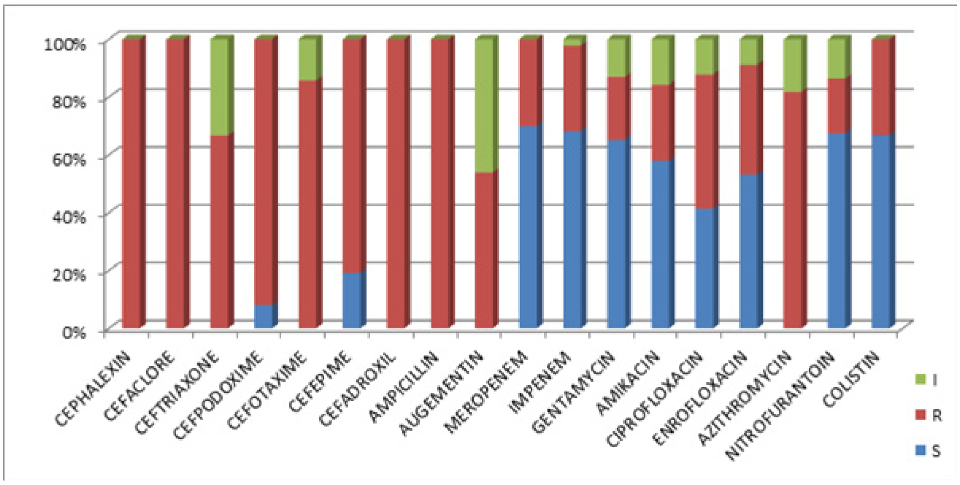

Figure 2: Susceptibility results of Enterobacter isolates to studied antibiotics. S: susceptible, I: intermediate, R: resistant.

Klebsiella species were identified in 55 isolates, comprising 25.5% of the total. Among these, 37 were from urine samples (67%), 5 from wound swabs (9%), 4 from burn swabs (7.2%), 4 from bone swabs (7.2%), 2 from sputum samples (3.6%), 1 from a cerebrospinal fluid (CSF) sample (1.8%), and 1 from a pus sample (1.8%). Similar to the other genera, all Klebsiella isolates showed complete resistance to cephalexin and cefadroxil. Their highest sensitivity was recorded for colistin at 88%, followed by nitrofurantoin at 52%, meropenem at 59%, and imipenem at 39% (Figure 3).

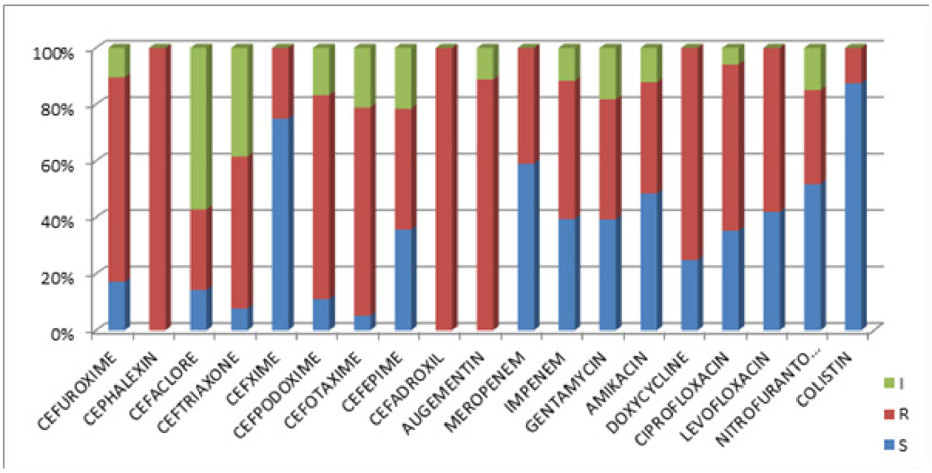

Figure 3: Susceptibility results of Klebsiella isolates to studied antibiotics. S: susceptible, I: intermediate, R: resistant.

Finally, the study identified 21 isolates (10%) of Pseudomonas aeruginosa, commonly referred to as blue pus bacteria. Among these, 11 isolates (52%) were obtained from urine samples, 2 from burn swabs (9%), 2 from sputum samples (9%), and 6 from pus samples (20%). These isolates exhibited complete resistance to cefixime, cefadroxil, cefotaxime, and cefuroxime. Nevertheless, they showed the highest sensitivity to colistin at 60%, followed by imipenem at 73%, meropenem at 50%, and cefepime at 50%. Sensitivity rates for amikacin, levofloxacin, and gentamicin were 45%, 38%, and 67%, respectively (Figure 4).

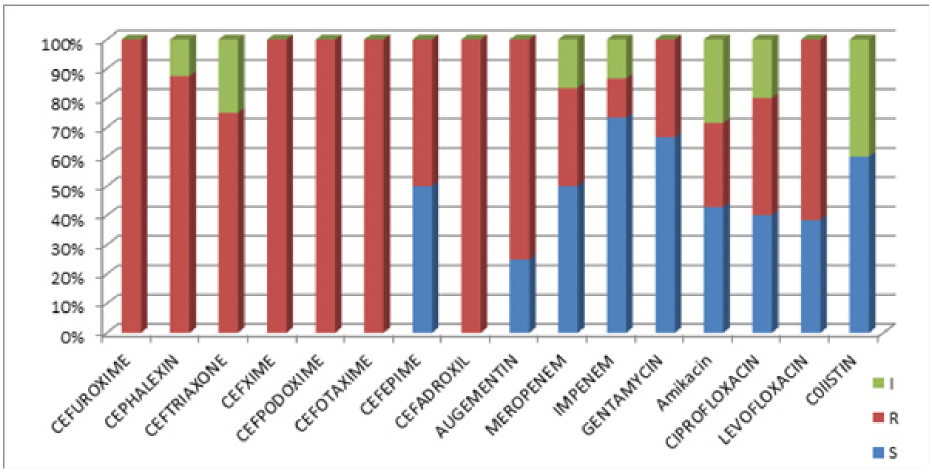

Figure 4: Susceptibility results of Pseudomonas aeruginosa isolates to studied antibiotics. S: susceptible, I: intermediate, R: resistant.

Discussion

The findings of this study indicate a significant prevalence of multidrug-resistant bacteria, particularly highlighting that resistance rates were higher in adults compared to children. Additionally, a notable disparity was observed in gender, with females exhibiting a greater prevalence of infections than males.

The results further demonstrated that Urinary Tract Infections (UTIs) were the most common clinical condition among the patient population. Specifically, 80% of the urine samples tested negative for Gram-positive bacteria, suggesting a predominant role of Gram-negative pathogens in these infections. Escherichia coli emerged as the primary causative agent, frequently associated with urinary tract infections, alongside gastrointestinal bacteria and Klebsiella species. Interestingly, while Klebsiella was the leading cause of infection in wound and burn cases, Pseudomonas aeruginosa was detected less frequently in these contexts.

The study revealed concerning levels of antibiotic resistance across all isolated strains, particularly against cephalosporins and fluoroquinolones, as well as commonly used over-the-counter antibiotics, which are often accessed without proper medical guidance. This misuse can significantly contribute to the development of resistance. However, most isolates demonstrated a higher sensitivity to broad-spectrum antibiotics such as meropenem, imipenem, and nitrofurantoin, suggesting these agents may still be effective options for treatment.

These findings are consistent with previous research that has documented rising rates of Gram-negative antibiotic resistance in various populations. In earlier reports [52-55], we highlighted similarly high rates of resistance and the phenomenon of multidrug resistance among bacterial strains in different settings.

This situation underscores the substantial challenges faced in identifying effective antibiotic therapies for treating infections caused by resistant pathogens in Syrian patients. The ready availability of antibiotics over the counter in Syria mirrors trends seen in many other countries, fostering inappropriate use and further complicating the resistance landscape [56-60].

Given the notable differences in antibiotic resistance profiles between E. coli and Klebsiella infections, the results emphasize the necessity for routine susceptibility testing, particularly in the context of urinary infections. Such testing allows for the identification of distinct resistance patterns among pathogens, which is crucial for informing treatment strategies and optimizing patient outcomes. By integrating these findings into clinical practice, healthcare providers can make more informed decisions regarding antibiotic selection, ultimately enhancing the effectiveness of treatment regimens [61-65].

Conclusion

This research aimed to examine the prevalence of Gram-negative infections among patient samples and to evaluate the resistance profiles of these pathogens to various antibiotics within hospitals in Sweden. The study's findings indicated alarmingly high resistance rates among the isolated Gram-negative bacteria, particularly against cephalosporins, which are commonly used to treat such infections. This resistance poses significant challenges for healthcare providers in effectively managing these infections. Among the antibiotics tested, meropenem emerged as a notably effective treatment option, exhibiting strong activity against all isolated Gram-negative bacteria. This highlights meropenem's potential as a critical therapeutic agent in the face of rising antibiotic resistance. However, the high resistance rates observed underscore the urgent need for ongoing surveillance and research to monitor trends in antibiotic resistance and to adapt treatment protocols accordingly.

Furthermore, the findings draw attention to the broader issue of antibiotic misuse and over-prescription in Syria, where antibiotics are often available without a prescription. To combat the growing threat of antibiotic resistance, it is imperative that regulatory measures be implemented to restrict antibiotic sales to prescription-only medications. Such regulations would help ensure that antibiotics are used judiciously, thereby reducing the likelihood of resistance development and preserving the effectiveness of existing antibiotics. This research not only contributes valuable insights into the state of Gram-negative infections and their resistance patterns but also emphasizes the critical need for stricter antibiotic regulations and enhanced stewardship efforts. By addressing these issues, we can improve treatment outcomes for patients and protect public health in the long term.

Acknowledgement

None.

Conflict of Interest

None.

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