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Random use of Antibiotics and prevalence of antibiotic resistant bacteria

Saleh Abdualkarim [1 *], Ahmed Basheer [2]
[1] Biology Department, Faculty of Science, Azzaytuna University, Tarhuna, Libya
[2] Higher national institute of medical sciences, Tarhuna Libya

الاستخدام العشوائي للمضادات الحيوية وانتشار البكتيريا المقاومة للمضادات الحيوية

صالح حسين عبد الكريم [1*]، احمد موسي بشير [2]
[1] قسم علوم الحياة، كلية العلوم، جامعة الزيتونة، ترهونة، ليبيا
[2] المعهد العالي الأهلي للعلوم الطبية، ترهونة، ليبيا

[*]Corresponding author: saleh.abdualkarim@yahoo.com

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Abstract:
This study evaluated the antimicrobial resistance patterns of bacterial isolates against a panel of commonly used antibiotics. Resistance percentages were calculated based on the number of resistant isolates relative to the total number of tests performed for each antibiotic. The results revealed considerable variability in resistance rates among the tested antibiotics. Cefuroxime demonstrated complete susceptibility (0% resistance), while gentamicin and cefotaxime showed low resistance rates of 17.4% and 19.0%, respectively. Moderate resistance levels were observed for ciprofloxacin and ceftriaxone, with resistance rates ranging between 22% and 30%, whereas trimethoprim–sulfamethoxazole, augmentin, and streptomycin exhibited relatively higher resistance rates ranging from 36% to 43%. In contrast, high resistance rates exceeding 50% were recorded for tetracycline (52.2%), erythromycin (55.6%), doxycycline (66.7%), amoxicillin (60%), and ampicillin– Cloxacillin (APX) 60%. The highest resistance level was observed for nalidixic acid (100%), indicating complete loss of efficacy

Keywords: Random use, Antimicrobial resistance, Bacterial isolates, Resistance rates, Nalidixic acid.

الملخص
هدفت هذه الدراسة إلى تقييم أنماط مقاومة المضادات الحيوية لدى العزلات البكتيرية تجاه مجموعة من المضادات الحيوية شائعة الاستخدام. وقد تم حساب نسب المقاومة اعتمادًا على عدد العزلات المقاومة مقارنةً بإجمالي عدد الاختبارات المُجراة لكل مضاد حيوي. أظهرت النتائج وجود تباين ملحوظ في معدلات المقاومة بين المضادات الحيوية المدروسة. حيث أظهر السيفوروكسيم حساسية كاملة (0% مقاومة)، في حين سجّل كل من الجنتاميسين والسيفوتاكسيم معدلات مقاومة منخفضة بلغت 17.4% و19.0% على التوالي. ولوحظت مستويات مقاومة متوسطة لكل من السيبروفلوكساسين والسيفترياكسون، حيث تراوحت معدلات المقاومة بين 22% و30%. في المقابل، أظهرت كل من التريميثوبريم–سلفاميثوكسازول، والأوجمنتين، والستربتومايسين معدلات مقاومة أعلى نسبيًا تراوحت بين 36% و43%. أما معدلات المقاومة المرتفعة التي تجاوزت 50% فقد سُجلت لكل من التتراسيكلين (52.2%)، والإريثرومايسين (55.6%)، والدوكسيسيكلين (66.7%)، والأموكسيسيلين (60%)، بالإضافة إلى الأمبيسيلين–كلوكساسيلين60% . وسُجلت أعلى نسبة مقاومة لحمض الناليديكسيك (100%)، مما يشير إلى فقدان كامل لفعاليته العلاجية.

الكلمات المفتاحية: الاستخدام العشوائي، المقاومة الحيوية، العزلات البكتيرية، معدلات المقاومة، حمض الناليديكسيك.

Introduction

Antibiotics are chemical substances that inhibit the growth of microorganisms or destroy them, particularly bacteria. They represent an important group of antimicrobial agents widely used in the treatment and prevention of infectious diseases caused by pathogenic microorganisms (1). Since their discovery, antibiotics have played a critical role in modern medicine and have significantly reduced morbidity and mortality associated with bacterial infections (2). The discovery of antibiotics dates back to the pioneering work of Alexander Fleming, who identified penicillin in 1928 from the fungus *Penicillium notatum*. This discovery marked a revolutionary turning point in the treatment of bacterial infections and opened the way for the development of numerous antimicrobial drugs (3). Later, the term "antibiotic" was introduced by Selman Waksman in 1942 to describe substances produced by microorganisms that inhibit the growth of other microorganisms even at very low concentrations (4). Antibiotics belong to a broader class of antimicrobial compounds that include natural, semi-synthetic, and synthetic agents used to combat microbial infections. Most antibiotics have relatively small molecular weights, usually less than 2000 Daltons, which allows them to penetrate bacterial cells and interfere with essential biological processes such as cell wall synthesis, protein synthesis, nucleic acid replication, or metabolic pathways (5). Despite their therapeutic importance, the inappropriate or excessive use of antibiotics has led to the emergence of antibiotic-resistant bacteria, which is currently considered one of the most serious global public health threats (6). In Libya, as in the other developing countries, improper use of antibiotic commonly occur at different health facilities which recently became a serious threat to public health and human development worldwide. Monitoring bacterial susceptibility patterns to antibiotics is therefore essential for guiding appropriate treatment strategies and reducing the spread of antimicrobial resistance (7). Laboratory analysis of bacterial cultures and antibiotic susceptibility testing plays a fundamental role in identifying pathogenic microorganisms and determining the most effective antibiotics for treating infections. Such studies are particularly important in clinical laboratories because they provide valuable epidemiological information regarding local patterns of bacterial resistance and antibiotic effectiveness (8).

Aim of this study

The present study aimed to evaluate the antimicrobial susceptibility patterns of bacterial isolates obtained from clinical samples in Tarhuna and Msallata, Libya. Specifically, the study sought to:

1. Determine the prevalence of antibiotic resistance among bacterial isolates recovered from routine clinical cultures.
2. Assess the effectiveness of commonly prescribed antibiotics against these isolates using laboratory susceptibility data.
3. Identify antibiotics with high resistance rates that may no longer be suitable for empirical therapy.
4. Provide evidence-based insights to support rational antibiotic use and improve awareness regarding antimicrobial misuse in the study area.

Materials and Methods

Study Design and Setting

This retrospective observational study was conducted using laboratory records collected from medical laboratories located in Tarhuna and Msallata, Libya. The study analyzed microbiological data recorded over a one-year period (January–December 2020).

Sample Selection and Inclusion Criteria

Laboratory records were reviewed, and bacterial isolates were included in the study based on the following criteria:

Positive bacterial growth confirmed by culture
Availability of antibiotic susceptibility testing results
Samples obtained from patients clinically suspected of bacterial infections.

Study Samples

A total of 44 non-duplicate bacterial isolates were included in this study. These isolates were obtained from different clinical specimens (e.g., urine, wound swabs, and other biological samples) submitted to the laboratory by patients with physician-authorized request forms and subsequently processed in the following laboratories.

Al-Zahra Laboratory (Tarhuna)
Al-Nisoon Clinic Laboratory (Tarhuna)
A private medical laboratory in Msallata .

Microbiological Procedures
Bacterial identification and antimicrobial susceptibility testing were performed as part of routine laboratory diagnostics. Although specific protocols varied slightly between laboratories, all procedures followed standard microbiological practices, including:
Isolation of Bacteria Using Culture Media
Bacterial isolation was performed using appropriate culture media selected based on the type of clinical specimen. For stool samples, selective and differential media including Salmonella–Shigella (SS) agar and MacConkey agar were used. Urine samples were cultured on Blood agar, a general-purpose medium for the isolation of a wide range of bacteria, as well as MacConkey agar for the detection of Gram-negative organisms (such as *Escherichia coli*), and Cystine Lactose Electrolyte Deficient (CLED) agar. Blood samples were initially inoculated into blood culture bottles containing broth media for enrichment. Following incubation and detection of microbial growth, subcultures were performed on Blood agar and Chocolate agar. Nasal and ear swab specimens were cultured on Blood agar as a primary isolation medium, MacConkey agar was also used when Gram-negative bacterial infection was suspected. All inoculated media were incubated under appropriate conditions (temperature and atmospheric requirements) depending on the suspected organism.

Bacterial Identification and Antibiotic Susceptibility Testing
Bacterial identification was carried out based on colony morphology and standard biochemical tests. Antibiotic susceptibility testing was performed using commonly applied methods, particularly the disk diffusion technique, on nutrient culture media. The results were interpreted and categorized as susceptible or resistant.

Data Processing and Analysis
Collected data were organized into structured tables for analysis. Antibiotic susceptibility results were categorized as: **Resistant (R and S+)**: indicating reduced or no effectiveness
Susceptible (S++ / S+++): indicating effective antibiotic activity
Resistance rates (%) were calculated using the formula: (Number of resistant isolates / Total number of tests) × 100

Table (1) Antibiotic Susceptibility Results of Bacterial Isolates

Antibiotic	No. of Tests (n)	Resistant Isolates (R + S+)	Susceptible Isolates (S++ / S+++)
Cefuroxime (CXM)	3	0	3
Gentamicin (CN)	23	4	19
Cefotaxime (CTX)	21	4	17
Ciprofloxacin (CIP)	9	2	7
Ceftriaxone (CRO)	17	5	12
Trimethoprim–Sulfamethoxazole (SXT)	22	8	14
Augmentin (AMC)	7	3	4
Streptomycin (S)	7	3	4
Tetracycline (TE)	23	12	11
Erythromycin (E)	27	15	12
Ampicillin + Cloxacillin (APX)	5	3	2
Amoxicillin (AX)	5	3	2
Doxycycline (DO)	3	2	1
Nalidixic acid (NA)	5	5	0

Results and Discussion

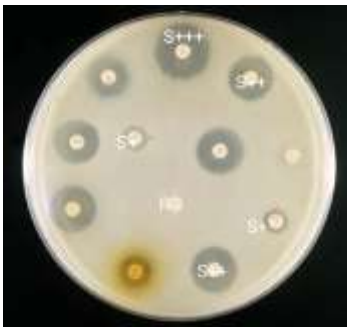

Figure (1) Bacterial culture, the symbols **R** and **S+** in the culture results indicate bacterial resistance to the tested antibiotic, meaning that the antibiotic is considered ineffective against the bacterial isolate.

Resistance percentages were calculated based on the number of isolates showing resistance (R and S+) relative to the total number of tests performed for each antibiotic, the resistance percentages of each antibiotic are shown in table (2) .

Table 2. Antibiotic Susceptibility Profile of Bacterial Isolates Recovered from Clinical Cultures.

Antibiotic	Number of Tests (n)	Resistant Isolates (R + S+)	Susceptible Isolates (S++ / S+++)	Resistance Rate (%)
Cefuroxime (CXM)	3	0	3	0.0
Gentamicin (CN)	23	4	19	17.4
Cefotaxime (CTX)	21	4	17	19.0
Ciprofloxacin (CIP)	9	2	7	22.2
Ceftriaxone (CRO)	17	5	12	29.4
Trimethoprim–Sulfamethoxazole (SXT)	22	8	14	36.4
Augmentin (AMC)	7	3	4	42.9
Streptomycin (S)	7	3	4	42.9
Tetracycline (TE)	23	12	11	52.2
Erythromycin (E)	27	15	12	55.6
Ampicillin + Cloxacillin (APX)	5	3	2	60.0
Amoxicillin (AX)	5	3	2	60.0
Doxycycline (DO)	3	2	1	66.7
Nalidixic acid (NA)	5	5	0	100.0

The antimicrobial susceptibility analysis demonstrated **considerable variability in resistance patterns** among the tested antibiotics, consistent with regional and global reports on antimicrobial. Such variations in antimicrobial resistance among clinical bacterial isolates have been widely reported in recent surveillance studies conducted in North Africa and the Middle East [9,10]. In the present study, Cefuroxime (CXM) showed **0% resistance**, indicating excellent activity against the tested isolates. This finding aligns with regional studies reporting sustained effectiveness of certain cephalosporins against Gram-negative bacteria[11]. Gentamicin (17.4%) and Cefotaxime (19.0%) exhibited **low resistance rates**, suggesting that these antibiotics remain reliable therapeutic options. Similar trends have been reported in Libya and neighboring regions, particularly for aminoglycosides [12,13]. Moderate resistance levels were observed for **Ciprofloxacin** and **Ceftriaxone**, with resistance rates ranging between **22% and 33%**. These results are consistent with recent studies conducted in Libya and neighboring countries, which reported ciprofloxacin resistance rates ranging between **16% and 30%** among clinical isolates [14]. Similarly, ceftriaxone resistance levels between **13% and 29%** have been documented in recent Libyan hospital studies [15]. In addition, **Trimethoprim–Sulfamethoxazole, Augmentin, and Streptomycin** demonstrated moderate resistance levels. Several regional studies have also reported increasing resistance to these antibiotics due to their widespread use in clinical settings and community treatments [16]. In contrast, high resistance rates were observed for **Tetracycline and Erythromycin**, exceeding **50%** among the tested isolates. Similar resistance patterns have been widely reported in North African surveillance studies, where tetracycline resistance has increased significantly due to long-term antibiotic exposure in both human medicine and agriculture [17]. Furthermore, **Amoxicillin and Ampicillin–Cloxacillin** exhibited resistance rates of **60%**, which may reflect the frequent and sometimes inappropriate prescription of β-lactam antibiotics in many healthcare systems. Studies conducted in Libya and Egypt have similarly reported high resistance levels to amoxicillin among clinical bacterial isolates [14,18]. The highest resistance level observed in this study was for **Nalidixic acid (100%)**, indicating that this antibiotic is no longer effective against the tested bacterial isolates. Resistance to nalidixic acid has been widely reported and is often associated with chromosomal mutations affecting bacterial DNA gyrase enzymes, leading to resistance to quinolone antibiotics [19].

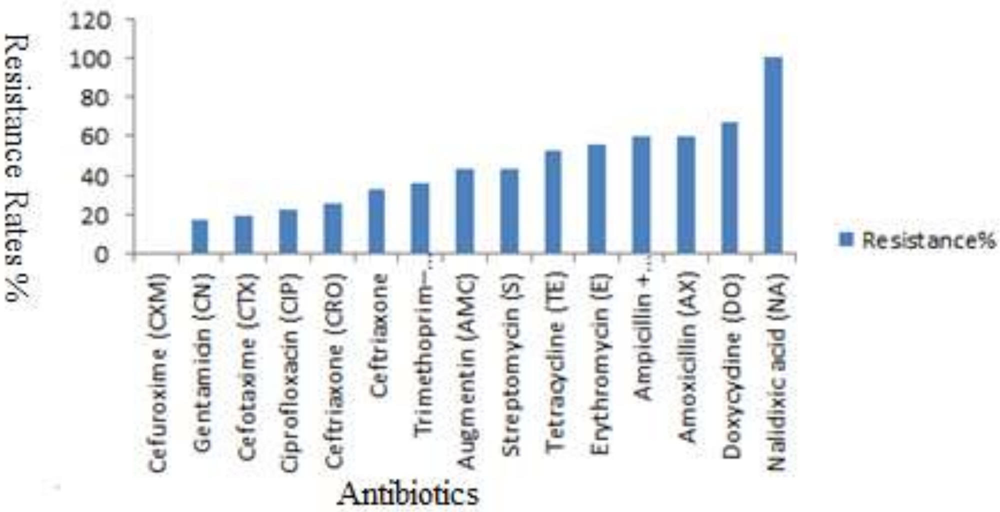

Figure (1) Resistance of each antibiotic included in the study as percentage.

Overall, the findings of this study indicate that Gentamicin, Cefotaxime, Ciprofloxacin, and Ceftriaxone remain among the most effective antibiotics against the tested isolates, whereas Nalidixic acid, Amoxicillin, Tetracycline, and Erythromycin showed high resistance levels. Despite providing valuable insights, this study has some limitations such as small sample size (n = 44), which limits the generalizability of the findings, and data were collected from a limited number of laboratories, which may not fully represent the regional resistance patterns. Therefore, the findings should be interpreted with caution, and larger-scale studies are recommended to confirm these results. These findings highlight the urgent need for continuous antimicrobial resistance surveillance and stricter antibiotic stewardship programs in Libya. Rational prescription practices and increased public awareness are essential to prevent further spread of resistant bacterial strains [20].

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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