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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგ-ლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენ-ტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემა-ჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტო-სურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სუ-რათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხო-ური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანე-ლის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შე-ჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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Содержание:

ANTIBIOGRAM OF URINARY CATHETER-ASSOCIATED BACTERIAL PATHOGENS IN INTENSIVE CARE UNIT, KING KHALID GENERAL HOSPITAL, HAFER AL-BATEN, SAUDI ARABIA

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Abstract.

Background: Patients in intensive care units are more susceptible to catheter-associated urinary tract infections (CAUTIs) caused by drug resistant bacteria. **Methods:** This retrospective study was done to determine the antibiogram of Urinary Catheter-associated Bacterial Pathogens in the Intensive Care Unit, at King Khalid General Hospital, Saudi Arabia, using full automated MicroScan walkaway 96 plus Beckman Coulter. **Results:** Among the identified bacteria, *Escherichia coli* and *Klebsiella pneumoniae* were the most prevalent, accounting for 33.7% (29/86) and 23.3% (20/86), respectively. High resistance was documented against ciprofloxacin 75.6% (65/86), cefuroxime 69.8% (60/86), levofloxacin 68.6% (59/86) and amoxicillin/clavulinic acid 65.1% (56/86), but Colistin showed high activity against the isolated bacteria with low resistance rate 5.81 % (5/86). Frequency of multi-drug-resistant bacteria revealed a rate of 65.1% (56/86). Resistance to piperacillin/tazobactam and cefuroxime was significantly associated with length of stay in the intensive care unit, duration of antimicrobial use, and catheterization duration with a $p < 0.05$. Also, the results strongly indicated that resistance to all cephalosporins examined was significantly associated with long stay in ICU. **Conclusion:** The identified bacteria among CAUTIs displayed resistance to at least one agent in three or more antimicrobial groups, indicating high resistance of common prescribed antibacterial agent in the study area.

Key words. Antibiogram, urinary catheter-associated bacteria, multidrug resistance.

Introduction.

Antimicrobial resistance is a growing global phenomenon that threatens patient survival and increases rates of infection, treatment failure, and death [1]. In order to reduce antimicrobial resistance, activating antimicrobial stewardship is crucial [2]. Antimicrobial stewardship forms the foundation upon which appropriate interventions to combat antimicrobial resistance are built. In the same context, the basic information required to intervene to address the resistance problem includes knowledge of the indications for antimicrobials use, the types of common pathogenic bacteria, and existing resistance mechanisms [3-5].

A urinary catheter is used to pass urine directly from the bladder in certain medical conditions such as fainting, urinary retention, and tumors. However, a urinary catheter is a foreign body that contributes to the development of urinary tract infections, especially in intensive care patients [6]. Most patients in intensive care units develop catheter-associated urinary tract infections, leading to prolonged length of stay and antimicrobial [7]. It is virtually impossible to avoid catheter-associated infections due to the nature of the catheter as a foreign body, the patient's health condition, and adherence to infection control measures related to catheter fixation guidelines [8,9].

The most important cause of urinary tract infections in hospitals is the fixation of the urinary catheter, the hypothesis of the transmission of pathogens increases throughout the period of use and the absence of infection control measures [10]. Infections in surgical sites (infections after surgery) and catheter-acquired urinary tract infections are the most important diseases related to hospitals at the global level [11,12]. Documents indicate an alarming emergence of drug-resistant and multidrug-resistant urinary tract pathogens [13,14]. In fact, catheter-associated urinary tract infections are often caused by drug-resistant bacteria, so the multidrug resistance hypothesis is strong [15]. Studying resistance patterns to drugs used to treat catheter-associated urinary tract infections helps determine the prevalence of resistant bacteria and the appropriate selection of effective drugs [16].

Gram-negative bacteria are important predominant causative agents of catheter-associated urinary tract infections, followed by Gram-positive bacteria [17]. *Escherichia coli* is reported to be the most common species worldwide, followed by less common species such as *Klebsiella pneumoniae, enterococcus, Staphylococcus aureus*, Proteus, and *Pseudomonas aeruginosa* [18,19]. AMR is mainly attributed to four specific resistant microorganisms commonly acquired in healthcare settings [20]. These include Escherichia coli and *Klebsiella pneumoniae* that exhibit resistance to third-generation cephalosporins, Methicillin-resistant *Staphylococcus aureus* (MRSA), and *Pseudomonas aeruginosa* resistant to carbapenems [21,22]. Multidrug-resistant bacteria in catheter-related infections present significant concerns due to limited treatment options and the risk of therapeutic failure. According to many published data multidrug-resistant pathogens are defined by resistance to at least one agent from three or more distinct antimicrobial groups [23,24].

In fact, the study of catheter-associated urinary tract infections (CAUTIs) is part of the National Survey of Hospital-Acquired Infections in Saudi Arabia, and therefore the results of this study can be compared and strategies such as antibiotic use policies evaluated.

The present retrospective study aimed to identify the bacterial species contributing to catheter-associated urinary tract infections and analyze the resistance to the antimicrobial agents used. Understanding the spectrum of pathogens causing multidrug-resistant infections, their antimicrobial resistance profiles and their origin within hospitals is critical for effective treatment strategies and infection control measures in hospitals.

Materials and Methods.

Study settings:

This study was conducted at King Khalid General Hospital in Saudi Arabia, located in the city of Hafer Al-Baten, and followed a retrospective design to achieve its objective. Bacterial profile, infection risk factors and antibiogram were evaluated from ICU patients with catheter-associated urinary tract infections in the period from January 2022 to December 2023. The findings aimed to highlight the most common bacterial species causing catheter-associated urinary tract infections (CAUTIs) in the intensive care unit (ICU), analyze the effective antimicrobials, and detect the rate of multidrug resistance.

Adult ICU participants aged 30 to 90 years, who had been in a urinary catheter for more than 48 hours, and who presented with symptoms of catheter-associated urinary tract infections, were enrolled in the current study. Patient data were recorded according to the risk factors for infection, length of stay in the intensive care unit, duration of antimicrobial use, and catheter age.

Primary isolation of bacterial species performed using Blood agar and CLED agar medium and the mixed infection were subculture, while identification was accomplished by MicroScan Dried Gram-Negative Breakpoint Combination Panels. These panels were used to assess sensitivity to antimicrobial agents and identify both aerobic and facultative anaerobic Gram-negative bacilli at the species level. Procedures included panel preparation, bacterial inoculums adjustment, rehydration/inoculation, and incubation. The RENOK system, equipped with Inoculators-D, was utilized for rehydration and inoculation steps. The panels were incubated for 16 hours at 35°C. The Biotype Lookup Software Program facilitates the identification of bacterial species. Drug sensitivity was determined by comparing the minimum inhibitory limit (MIC) of an antimicrobial for bacteria with the achievable concentration in blood or urine, according to the interpretive breakpoints described in the CLSI (2023) document. Multi-drug resistance (MDR) was characterized by acquired non-sensitivity to at least one agent across three or more antimicrobial categories.

The Negative Breakpoint Combo 50 is a microbiological diagnostic panel that was used for identification and susceptibility assessment of Gram-negative bacteria. Antimicrobial agents used in this study are shown below in (Table 3).

Statistical analysis:

Statistics of study findings were accomplished using SPSS statistic version 23. Descriptive analysis of socio-demographics, bacterial species and antimicrobial resistance were presented as frequency. Association between antimicrobial resistance and length of stay in ICU, duration of antimicrobial use and catheterization was evaluated by chi-square test in which a p-value of < 0.05 was considered significant.

Results.

As shown in (Table 1), intensive care unit participants ranged in age from 30 to 90 years, with a mean age ± standard deviation of 68.32 ± 10.86 years. In terms of gender distribution, the majority of cases were males 64.7% (44/68), while the percentage of females was 35.4% (24/68). The age groups (less than 30 years) and (more than 60 years) represented 20.6% (14/68) and 79.4% (54/68) of the frequency, respectively. Participants' length of stay in the ICU was categorized as less than two weeks 76.5% (52/68) and more than two weeks 23.5% (16/68), while the duration of antimicrobial use was recorded as less than 10 days 73.5% (50/68) and more than 10 days 26.5 (18/68). Among the ICU patients studied, the most common comorbidities were diabetes mellitus 73.5% (50/68), followed by hypertension 64.7% (44/68). The results showed that silicone catheters 82.4% (56/68) were more commonly used than Foley catheters, and that 50% (34/68) of ICU patients had catheterization for more than one week.

Table 1. Baseline data of ICU participants. No = 68.

Parameter	**N = (%)**
Sex:	
Male	44 (64.7)
Female	24 (35.3)
Total	68 (100)
Age group:	
Less than 60 yrs	14 (20.6)
More than 60 yrs	54 (79.4)
Total	68 (100)
Length of stay in ICU	
Less than 2 weeks	52 (76.5)
More than 2 weeks	16 (23.5)
Total	68 (100)
Duration of Antimicrobials Use:	
Less than 10 days	50 (73.5)
More than 10 days	18 (26.5)
Total	68 (100)
Comorbidities:	
Diabetes Mellitus	50 (73.5)
Hypertension	44 (64.7)
Cardiovascular disease	10 (14.7)
Urinary tract infection	20 (29.4)
Others	58 (85.3)
Total	68 (100)
Catheterization:	
Catheter type:	
Foley	12 (17.6)

Table 2. Frequency of bacterial species isolated from catheter-associated urinary tract infections in ICU patients. No = 86.

Bacterial species	**Frequency (%)**
Acinetobacter baumannii/haemolyticus	2 (2.3)
E. cloacae	3 (3.5)
E. coli	29 (33.7)
E. faecalis	6 (7.0)
K. aerogenes	2 (2.3)
K. pneumoniae	20 (23.3)
M. morganii	4 (4.7)
P. aeruginosa	9 (10.5)
P. alcalifaciens	1 (1.2)
P. mirabilis	10 (11.6)

Table 3. Overall resistance of isolated bacterial species causing catheter-associated urinary tract infections in intensive care unit patients. No 86.

Antimicrobial	**Resistance n (%)**
Amoxicillin/Clavulanate	56 (65.1)
Piperacillin/Tazobactam	32 (37.2)
Cefuroxime	60 (69.8)
Cefotaxime	57 (66.3)
Ceftazidime	52 (60.5)
Cefepime	48 (55.8)
Cefoxitin	49 (57)
Meropenem	32 (37.2)
Imipenem	36 (41.9)
Ertapenem	48 (55.8)
Amikacin	36 (41.9)
Gentamicin	41 (47.7)
Tobramycin	57 (66.3)
Ciprofloxacin	65 (75.6)
Levofloxacin	59 (68.6)
Norfloxacin	60 (69.8)
Tetracycline	48 (55.8)
Tigecycline	34 (39.5)
Monobactam	57 (66.3)
Trimethoprim/Sulfamethoxazole	60 (69.8)
Colistin	5 (5.81)
Nitrofurantoin	51 (59.3)

Table 4. Resistance patterns of bacterial species isolated from patients studied in the intensive care unit. (n = 86).

	***Acinetobac ter baumannii/ haemolytic us* (n = 2)**	**E. cloacae (n= 3)**	**E. coli (n =29)**	**E. faecalis (n=6)**	**K. aeroge nes (n=2)**	**K. pneum oniae n=20)**	**M. morga nii (n=4)**	**P.aer uginosa (n=9)**	**P.al calif aciens (n=1)**	**P.m irabilis (n=10)**
Amox/KClav	2	3	14	4	2	14	2	7	0	8
Piperacilli n/ Tazobactam	2	3	8	4	0	14	0	0	0	2
Cefuroxime	0	3	17	4	2	15	4	7	0	8
Ceftazidime	2	3	14	4	2	14	0	4	1	8
Cefepime	2	3	14	4	1	18	0	4	0	2
Cefoxitin	0	3	13	4	2	14	0	7	0	6
Meropenem	2	3	7	4	0	12	0	0	0	4
Imipenem	2	3	7	4	0	8	4	0	0	8
Ertapenem	0	3	12	4	0	14	0	7	1	7
Monobactam	2	3	15	4	2	14	0	6	1	10
Amikacin	2	3	9	4	2	10	0	2	0	4
Gentamicin	0	3	9	4	2	10	0	5	0	8
Tobramycin	2	3	19	4	2	17	0	4	0	6
Ciprofloxacin	2	3	21	2	2	19	4	4	0	8
Levofloxacin	2	3	18	2	2	16	2	6	0	8
Norfloxacin	2	3	19	2	2	18	0	6	0	8
Tetracycline	2	3	12	4	2	11	2	6	0	6
Tigecycline	2	3	2	4	2	4	4	6	0	7
Trimeth/Sulfa	2	3	17	4	2	13	4	7	0	8
Colistin	0	0	3	0	0	1	0	0	0	1
Nitrofurantoin	0	3	8	6	2	14	4	4	0	10

Table 5. Association between resistance of antimicrobials and Length of stay in ICU, Duration of Antimicrobial Use and catheterization among ICU patients.

Antimicrobial	Length of stay in ICU P value	Duration of Antimicrobial Use P value	Duration of catheterization P value
Amoxicillin/Clavulanate	.069	.354	.017
Piperacillin/Tazobactam	.001	.006	.001
Cefuroxime	.006	.003	.010
Cefotaxime	.002	.034	.321
Ceftazidime	.021	.136	.699
Cefepime	.005	.041	.484
Cefoxitin	.008	.057	.070
Meropenem	.944	.431	.450
Imipenem	.103	.857	.368
Ertapenem	.078	.283	.412
Monobactam	.001	.018	.200
Amikacin	.033	.632	.172
Gentamicin	.157	.400	.573
Tobramycin	.002	.034	.148
Ciprofloxacin	.537	.396	.912
Levofloxacin	.006	.003	.240
Norfloxacin	.011	.147	.568
Tetracycline	.169	.077	.872
Tigecycline	.837	.109	.172
Trimethoprim/Sulfamethoxazole	.147	.085	.240
Colistin	.764	.528	.317
Nitrofurantoin	.945	.618	.131

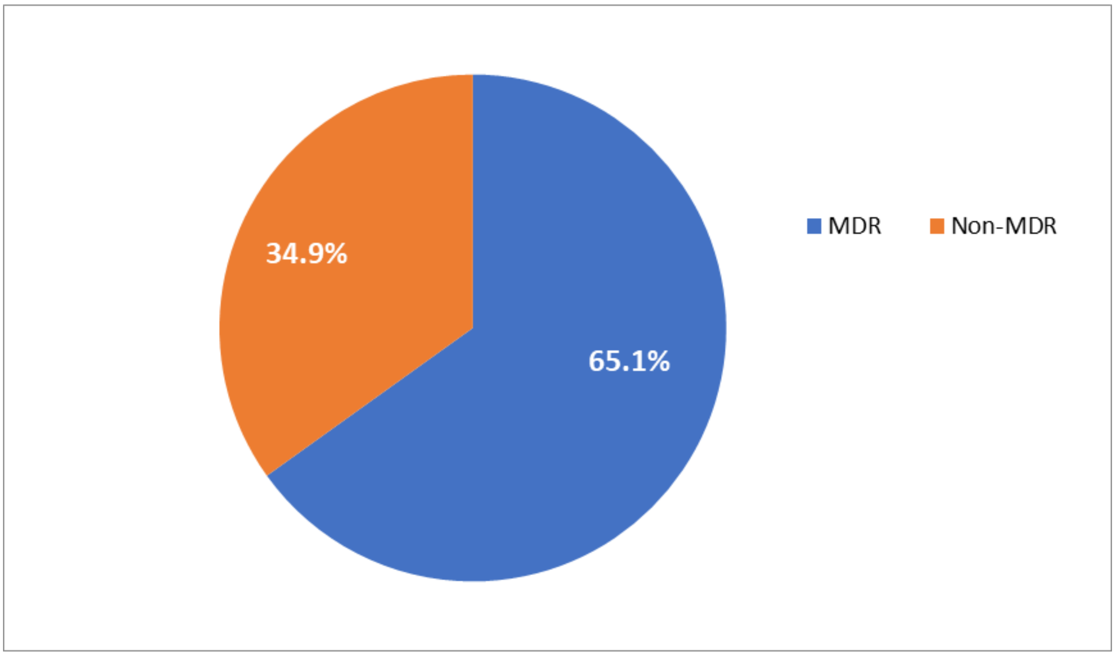

Figure 1. *Frequency of multi-drug resistant bacteria causing catheter-associated urinary tract infections in intensive care unit patients. No 86. MDR: Multi-drug resistant; Non-MDR: Non-multidrug resistant.*

In total, ten non-fastidious bacterial species were isolated as pathogens of catheter-associated urinary tract infections (Table 2). The overall number of identified strains was 86. *Escherichia coli* and *Klebsiella pneumoniae* were the most prevalent, accounting for 33.7% (29/86) and 23.3% (20/86), respectively. Less common species were P. mirabilis at 11.6% (10/86) and P. aeruginosa at 10.5% (9/86). The polymicrobial infection was detected in 36.76% (25/68) of patients.

The classes of penicillin examined showed variable resistance; the resistance rate to amoxicillin/clavulanate was higher (65.1%) than to piperacillin/tazobactam (37.2%). The current sensitivity results showed that, bacterial resistance to cephalosporins was at near levels; isolated bacteria revealed the highest resistance to cefuroxime at 69.8% followed by Cefotaxime at (66.3%). Carbapenems sensitivity was best with meropenem, with 37.2% resistance while ertapenem resistance was 55.8%. Amikacin recorded the lowest resistance frequency among the aminoglycoside group at 41.9%, making it the most effective aminoglycoside in the present study, in the same group, tobramycin showed poor efficacy, with resistance reaching 66.3%. Regarding fluoroquinolones sensitivity, the isolated bacterial species showed high resistance against the studied antimicrobial; Ciprofloxacin resistance showed the highest rate among all antimicrobials tested, at 75%. Among the tetracyclines, tigecycline yielded a low resistance against bacterial species of 39.5%. Other antimicrobial agents from different classes resulted in similar resistance levels such as monobactam of 66.3%, antrimethoprim/sulfamethoxazole 69,8% and nitrofurantoin 59.3%. The colistin resistance rates reveal 5.81%.

The total number of bacterial species isolated from ICU patients was 86 isolates; complete resistance was observed among the three *E. cloacae* stains, while the two *Acinetobacter baumannii/haemolyticus* stains showed susceptibility to only five antimicrobial classes. *Escherichia coli* and *Klebsiella pneumoniae* were the predominant species. Furthermore, *Klebsiella pneumoniae* strains were almost completely resistant to ciprofloxacin. Fortunately, *Pseudomonas aeruginosa* was fully susceptible to piperacillin/tazobactam, meropenem, and imipenem. P. mirabilis expressed complete resistance to monobactam and Nitrofurantoin antimicrobials (Table 4).

(Table 5) represents the relationship between antimicrobial resistance, length of stay in the intensive care unit, duration of antimicrobial use, and catheterization among ICU patients. Piperacillin/tazobactam and cefuroxime resistance were significantly associated with length of stay in the intensive care unit, duration of antimicrobial use, and catheterization with p value of less than 0.05. The results strongly indicated that resistance to all cephalosporins examined was significantly associated with longer ICU stay; p values for Cefuroxime, Cefotaxime, Ceftazidime, Cefepime and Cefoxitin equal 0.006, 0.002, 0.021, 0.005 and 0.008 respectively. Drugs such as monobactam, tobramycin, and levofloxacin, all of which belong to different classes of antimicrobials, were significantly associated with length of ICU stay and duration of antimicrobial use, while their association with catheterization was not statistically significant.

Discussion.

Studies have confirmed that catheter-associated urinary tract infections (CAUTIs) occur commonly in hospital settings [25]. and are usually caused by resistant bacterial pathogens [26]. Studying the bacterial pathogens associated with urinary catheters in the intensive care unit aids treatment by isolating pathogens and determining their antimicrobial resistance patterns.

Regarding gender, this study noted a slight variation in the frequency of catheter-associated UTI among the studied cases, with males recording a higher frequency, however, females are known to be more susceptible to both urinary tract infections and catheter-associated UTIs [27]. Data related to the duration of stay in intensive care units (ICUs) indicates a diverse patient demographic within critical care settings. The considerable variation, ranging from as little as three days to an extensive 146 days, underscores disparities in disease severity, the complexity of required medical interventions, and recovery trajectories among the study subjects.

The current study revealed a population with a high incidence of chronic diseases, especially diabetes and hypertension. This observation is important because both conditions are considered risk factors for different types of infections, including urinary tract infections. Since diabetes affects nearly three-quarters of people, its role in compromising immune function is well documented. Chronic diabetes affects the activity of phagocytic white blood cells, cell-mediated immunity, and the production of immunomodulatory cytokines [28,29]. Also, diabetic patients who suffer from neurological disorders that result in incomplete emptying of the bladder, which increases the chances of survival and spread of pathogenic bacteria [30]. The results of this study showed that, a large percentage of participating patients suffered from high blood pressure, which in turn weakens the body's immunity and blood vessel function [31]. On the other hand, the results showed a lower rate of cerebrovascular accidents (CVAs) at 14.7% among participants, indicating a limited risk of urinary tract infections. However, cerebrovascular accidents are associated with complications such as neurogenic bladder.

Positively, the study observed a greater use of silicone catheters compared to conventional latex foley catheters. In line, several studies have promoted the use of silicone catheters to reduce bacterial colonization as well as biofilm formation [32].

Most cases 79.4% (54/68) in the current study had 14 days or less catheterization period and this is recommended standardly [33]. Prolonged catheter therapy is a risk factor for the development of infections [34]. The 20.6% (14/68) of patients who underwent catheterization for more than 14 days represent a group at particular risk for catheter-associated urinary tract infections and associated complications. Prolonging the duration of the catheter without replacing it is also a risk factor because it acts as a foreign body that helps germs adhere and reach internal organs [35]. Therefore, further investigation is necessary to identify improvement opportunities in clinical protocols and adherence to timely intervention practices.

The current study showed that *Escherichia coli* was the predominant isolate in catheter-associated urinary tract infections (CAUTIs), accounting for 33.7% (29/86) of cases.

This rate is due to its ability to attach to the urinary catheter through various virulence factors, such as fimbriae [36]. After *Escherichia coli, Klebsiella pneumoniae* represents 23.3% (20/86) of isolates and is similarly known as an important urinary pathogen, particularly due to its ability to form biofilms on medical devices [37]. The combined dominance of these two Gram-negative bacteria, which together represent over half of the isolated strains, underscores the necessity for broad-spectrum empirical antimicrobials that can effectively target these common uropathogens when initiating treatment for suspected CAUTIs. Notably, *Pseudomonas aeruginosa* is particularly challenging to combat due to its intrinsic resistance mechanisms and its ability to produce biofilms. Moreover, the isolation of *Enterococcus faecalis* 7% (6/86) and *Acinetobacter baumannii/haemolyticus* 2.3% (2/86) raises additional concerns. Acinetobacter species are notorious for their multi-drug resistance and are frequently linked to severe hospital-acquired infections with high morbidity and mortality rates. Although *Enterococcus faecalis* is sometimes perceived as less virulent, it presents a significant treatment challenge due to increasing resistance to vancomycin and other antimicrobials, particularly in immunocompromised patients or those with prolonged hospital stays.

The increasingly resistance rate of 65.1% observed for Amoxicillin/Clavulanate suggests that a substantial proportion of bacterial isolates examined in this study have developed mechanisms to circumvent its antibacterial effects. This combination was formulated to address resistance conferred by prevalent beta-lactamase enzymes, integrating a broad-spectrum penicillin (amoxicillin) with a beta-lactamase inhibitor (clavulanate). In contrast, the lower resistance rate of 37.2% associated with Piperacillin/Tazobactam implies that this antimicrobial remains a more reliable alternative against the identified bacterial strains. Tazobactam acts as a potent inhibitor of several significant beta-lactamases, some of which may render Amoxicillin/Clavulanate ineffective [38]. The comparatively lower utilization of narrower-spectrum antibiotics, such as Ciprofloxacin, Cefixime, Ceftaxon, Cefuroxime, and Ceftazidime, could suggest either an urgent demand for broader coverage or a reflection of the severity of infections encountered by this patient population. However, without additional context regarding these clinical situations, it is challenging to ascertain the appropriateness of these prescribing habits.

The results articulated in this analysis delineate a concerning landscape of cephalosporin resistance among bacterial species associated with catheters. The resistance rates observed for Cefuroxime (69.8%) and Cefotaxime (66.3%) indicate a marked decline in their efficacy as reliable empirical therapy options for treating catheter-related infections within this specific context.

Carbapenems represent a crucial category of broad-spectrum beta-lactam antibiotics, playing a significant role in treating severe infections [39]. The observed rise in carbapenem resistance among catheter-associated bacteria raises concerns, yet the data also reveal marked differences in susceptibility among the various carbapenem agents [40]. Specifically, Meropenem stands out with a resistance rate of 37.2%, suggesting it is the most reliable option for empirical therapy in cases of severe catheter-related infections. Relying on Ertapenem as a primary carbapenem in this context could lead to a considerable incidence of treatment failures when faced with resistant pathogens or infections caused by organisms outside its effective range [41].

The increasing rates of carbapenem resistance underscore the urgent necessity for robust antibiotic stewardship programs aimed at preserving the effectiveness of these critical antimicrobials.

Among the aminoglycosides assessed in this investigation, Amikacin exhibits the lowest resistance rate at 41.9%. This finding underscores Amikacin's significant clinical relevance. The dominant mechanism of resistance affecting various aminoglycosides, such as Gentamicin and Tobramycin, suggests an inherent stability in Amikacin that may contribute to its superior performance. Notably, Tobramycin demonstrates a substantial resistance rate of 66.3%. These observations highlight a pronounced decline in Tobramycin's efficacy against bacterial isolates from catheter sources. The high resistance rate likely reflects the widespread presence of enzymatic inactivation or alternative resistance mechanisms that particularly target Tobramycin [42]. In contrast, Tigecycline exhibits a more advantageous profile, characterized by a lower resistance rate (39.5%). Colistin exhibited a relatively good susceptibility rate among *E. coli* (10.34%) and *K. pneumoniae* (5%). Our findings are disagreement with previous studies conducted in West Africa [43] and Nigeria [44]. Infections caused by colistin-resistant Enterobacteriaceae are an emerging challenge in Saudi Arabia [45]. A colistin-resistant strain of *K. pneumoniae* (63.1%) was also reported in Pakistan [46]. Additionally, in multidrug-resistant (MDR) E. coli isolates from both commercial poultry and humans, colistin resistance was detected in 78.6% and 48.1% of isolates, respectively [47]. The high prevalence of mcr genes in *E. coli* may further contribute to broader antibiotic resistance concerns [47]. These differences may be due to a high restriction of antibiotic prescription in Saudi Arabia and emerge of plasmid-mediated mcr genes.

This study also examined the relationship between antimicrobial resistance and length of stay in the intensive care unit, duration of antimicrobial use, and catheterization. The results confirmed the relationship between antimicrobial resistance and length of stay in the intensive care unit, and a significant association was observed with resistance to several antimicrobials. Evidence suggests that prolonged stays in intensive care require more surgical procedures and greater use of antimicrobials [48]. In addition, monitoring of antimicrobial resistance among urinary tract isolates indicated increased resistance in bacterial agents isolated from patients with catheters compared to those without [49].

The frequency of multidrug-resistant (MDR) bacteria in catheter-related infections presents significant concerns due to the limited options for treatment and the risk of therapeutic failure. The widespread use of broad-spectrum antibiotics in healthcare settings has facilitated the survival and expansion of these resistant strains. One mechanism that exacerbates antibiotic resistance is the formation of biofilms by catheter-associated bacteria, which not only prevents the penetration of drugs but also creates a conducive environment for bacterial growth and the horizontal transfer of resistance genes [50]. The fight against MDR involves not only addressing resistant infections but also preventing the further emergence and spread of resistance, which poses a threat to the treatment of all bacterial infections. Enhancing antimicrobial stewardship and improving diagnostic capabilities are essential for managing both sensitive and resistant infections [51]. It was discovered in the study that 65.1% of identified bacteria displayed resistance to at least one agent in three or more antimicrobial groups. This finding indicates that there is a significant occurrence of multidrug resistance associated with catheterization. It is important to note that the implications of such widespread MDR are multifaceted and carry substantial consequences for the management of patients and healthcare systems [51].

Conclusion.

The emergence of multi-drug resistance, which poses a threat to the treatment of all bacterial infections. These situations indicate that antimicrobial stewardship and improving diagnostic capabilities are essential for managing both sensitive and resistant infections. This finding indicates that there is a significant occurrence of multidrug resistance associated with catheterization in the study area. It is important to note that the implications of such widespread MDR are multifaceted and carry substantial consequences for the management of patients and healthcare systems. Hence, there is an urgent need for multicenter, routine surveillance of bacterial infections in intensive care units to help reduce the emergence and spread of antibiotic resistance.

Limitation of the Study.

This study utilized univariate analysis, and potential confounding factors were not adjusted for, which limits causal inference. In addition, due to resource limitations, re-confirmation using the micro-volume liquid dilution method could not be performed in this study.

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Conflict of Interest.

The authors disclose no conflict of interest.

Funding Source Statement.

None.

Author's Contribution.

All listed authors contributed significantly to the work and approved its publication.

Data Availability.

All analyzed data used in this study are included in the manuscript.

Ethical Approval.

The study was approved by the Permanent Committee of Ethics of Jouf University and registered on 03/10/1434 H.

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