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Risk factors for the spread of antibiotic-resistant bacteria at king Khaled Hospital, ICU in Hail - healthcare practitioners' perspective

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Abstract

The emergence and spread of antibiotic-resistant bacteria represent a significant global health challenge, particularly in critical care settings such as Intensive Care Units (ICUs). This study investigates the risk factors contributing to the dissemination of antibiotic-resistant bacteria within the ICU of King Khaled Hospital in Hail, Saudi Arabia, from the perspective of healthcare practitioners. A descriptive, cross-sectional design was utilized, incorporating a mixed-methods approach to gather qualitative and quantitative data. Key factors examined include patterns of antibiotic prescription, patient demographics, clinical histories, and infection control measures. Findings highlight inappropriate antibiotic usage, patient comorbidities, and gaps in infection control practices as significant contributors to resistance. Inadequate adherence to hand hygiene protocols, insufficient environmental disinfection, and inconsistent antimicrobial stewardship were identified as critical areas for improvement. The study underscores the need for comprehensive infection prevention strategies, enhanced antimicrobial stewardship programs, and targeted education for healthcare practitioners. These findings provide actionable insights to mitigate the risk of antibiotic resistance within the ICU, improve patient outcomes, and contribute to the broader goal of combating antibiotic resistance in healthcare settings. Future research should focus on implementing and evaluating interventions tailored to the unique challenges of ICUs in similar healthcare environments.

keywords: Risk factors, antibiotic-resistant bacteria, king Khaled Hospital, ICU, healthcare practitioners

Introduction

Infectious diseases caused by antibiotic-resistant bacteria pose a significant threat to public health globally, leading to increased morbidity, mortality, and healthcare costs. Intensive Care Units (ICUs) within hospitals are particularly susceptible environments for the transmission and dissemination of these resistant pathogens. King Khaled Hospital, located in Hail, Saudi Arabia, is no exception to this challenge.

The emergence of antibiotic resistance is primarily due to excessive and often unnecessary use of antibiotics in humans and animals. Risk factors for the spread of resistant bacteria in hospitals and the community can be summarized as over-crowding, lapses in hygiene or poor infection control practices (Rahman, Alam Tumpa, Zehravi, Sarker, et al, 2022). Antibiotic resistance poses a significant global health threat, rendering once-effective antibiotics ineffective in treating bacterial infections. Understanding the risk factors for the spread of antibiotic-resistant bacteria is crucial in addressing this growing concern.

King Khaled Hospital, located in Hail, serves as a critical healthcare facility, particularly its Intensive Care Unit (ICU). The ICU environment, characterized by intensive medical interventions and close patient contact, presents unique challenges in managing and preventing the spread of antibiotic-resistant bacteria. The ICU at King Khaled Hospital caters to a diverse range of critically ill patients, often with compromised immune systems. This population is more susceptible to infections, leading to frequent and varied antibiotic usage. The increased use of antibiotics creates an environment conducive to the development and transmission of antibiotic-resistant strains.

Examining the patterns of antibiotic prescription, administration, and adherence to protocols within the hospital is essential (Tadesse, Molla, Yimer, Tarekegn, et al, 2022). Inappropriate or excessive use of antibiotics, both in type and duration, can contribute to the emergence of resistant strains. Understanding the local practices at King Khaled Hospital is vital for devising targeted interventions.

The effectiveness of infection control measures within the ICU setting plays a pivotal role in mitigating the spread of antibiotic-resistant bacteria. Investigating the existing protocols, surveillance systems, and adherence to hygiene practices will shed light on potential gaps that need attention to enhance the hospital's overall infection control strategy.

Problem Statement

The emergence and spread of antibiotic-resistant bacteria represent a formidable challenge within healthcare systems globally, posing a severe threat to effective infection management. King Khaled Hospital, located in Hail, faces the pressing issue of antibiotic resistance, particularly within its Intensive Care Unit (ICU). Antibiotic resistance jeopardizes the efficacy of standard treatment protocols, rendering once-potent antibiotics ineffective and limiting the available options for combating bacterial infections. In the ICU, where critically ill patients with compromised immune systems receive intensive medical care, the risk of antibiotic-resistant infections is heightened. The hospital's capacity to provide optimal healthcare is at stake as the prevalence of antibiotic resistance escalates, necessitating a focused investigation into the risk factors contributing to the spread of these resistant strains within the ICU.

Understanding the problem of antibiotic resistance at King Khaled Hospital's ICU is imperative for several reasons. Firstly, the inappropriate use of antibiotics, whether due to prescription practices, administration protocols, or patient demographics, can significantly contribute to the development and dissemination of antibiotic-resistant bacteria. Secondly, the ICU's unique environment, characterized by high patient density and invasive medical procedures, amplifies the likelihood of cross-infections, demanding a targeted analysis of infection control measures. Lastly, a comprehensive study of these issues is crucial for developing evidence-based interventions that address the specific challenges faced by King Khaled Hospital, ultimately contributing to the global efforts to curb antibiotic resistance and improve patient outcomes within the ICU setting.

The aim

The main aim of this study is to investigate risk factors for the spread of antibiotic-resistant bacteria at King Khaled Hospital, ICU in Hail.

Objectives

The objectives of this study are:

1. to comprehensively analyze the patterns of antibiotic prescription, administration, and adherence to protocols within the ICU at King Khaled Hospital in Hail.
2. to investigate the demographic profile and clinical history of patients within the ICU.
3. to assess the existing infection control measures and protocols within the ICU at King Khaled Hospital.

Study Questions

1. How do healthcare practitioners within the ICU at King Khaled Hospital in Hail prescribe and administer antibiotics?
2. How does the clinical history of patients within the ICU correlate with antibiotic usage patterns and the prevalence of antibiotic-resistant infections?
3. What infection control measures are currently implemented within the ICU at King Khaled Hospital to prevent the spread of antibiotic-resistant bacteria?

Study Significance

1. The study holds significant importance for King Khaled Hospital by providing insights into specific risk factors contributing to the spread of antibiotic-resistant bacteria in the ICU.
2. Antibiotic resistance is a global health crisis, and the study contributes valuable insights to the broader healthcare community. Lessons learned from King Khaled Hospital can serve as a case study, offering proactive strategies for other healthcare institutions globally to address antibiotic resistance in diverse contexts.
3. The outcomes of the study have the potential to directly impact patient care within the ICU by improving treatment efficacy and outcomes.
4. The study's findings can inform the development of evidence-based policies and guidelines for antibiotic usage and infection control.
5. By advancing our understanding of antibiotic resistance and providing practical solutions, the study contributes to the global fight against one of the most pressing threats to public health.

Literature Review

Existing literature on antibiotic resistance provides a comprehensive global overview, emphasizing the urgent need for effective strategies to combat this

phenomenon (Srisakul S, Wannigama DL, Higgins PG, et al. 2022). Studies from various regions highlight the increasing prevalence of antibiotic-resistant bacteria worldwide, underscoring the importance of localized investigations to address specific contexts, such as those focused on individual hospitals like King Khaled Hospital in Hail.

Numerous studies have delved into the dynamics of antibiotic resistance within hospital settings, particularly in intensive care units (ICUs) such as Althaqafi A, Yaseen M, Farahat F, et al. (2023), and Chen, Li D, Beiersmann, Neuhann, Moazen, Lu G, Müller (2021) studies. These investigations explore various factors contributing to the development and spread of antibiotic resistance, including patient demographics, antibiotic usage patterns, and infection control measures. ICUs present unique challenges in the fight against antibiotic resistance due to several factors:

1) High Antibiotic Usage: Patients in ICUs often receive broad-spectrum antibiotics as part of their treatment regimen due to the severity of their conditions and the risk of infections. This extensive antibiotic use contributes to the selection pressure favoring the emergence and spread of resistant bacteria.
2) Frequent Contact and Close Proximity: ICU patients are often in close proximity to each other, increasing the risk of transmission of resistant bacteria. Moreover, healthcare workers frequently move between patients, potentially facilitating the spread of antibiotic-resistant strains within the unit.
3) Immunocompromised Patients: Many ICU patients have weakened immune systems, making them more susceptible to infections and less able to fight off antibiotic-resistant pathogens.
4) Invasive Procedures: Patients in ICUs often require invasive procedures, such as intubation, catheterization, and surgery, which can introduce bacteria into the body and increase the risk of healthcare-associated infections.
5) Prolonged Hospitalization: ICU patients typically have longer hospital stays compared to patients in other hospital wards, providing extended opportunities for exposure to antibiotics and resistant bacteria.

Given these challenges, it is crucial for healthcare facilities to implement comprehensive infection control measures, antimicrobial stewardship programs, and surveillance strategies to monitor and mitigate the spread of antibiotic-resistant bacteria in ICUs. Additionally, continued research and collaboration are essential to develop novel therapeutics and interventions to combat this global public health threat effectively.

Research Methodology

Approach

In light of the problem and objectives of the study, the researcher found that the correct approach in this type of study is the descriptive approach.

Research Design:

- Utilize a mixed-methods approach, combining qualitative and quantitative research methods to provide a comprehensive understanding of the issue.
- Employ a cross-sectional study design to collect data at a single point in time, allowing for a snapshot of the current situation within the ICU.

Setting

The study will be conducted at King Khaled Hospital, ICU in Hail

Sampling Strategy:

Employ stratified random sampling to ensure a representative sample of healthcare practitioners within the ICU, considering factors such as age, gender, and years of experience. Include healthcare practitioners involved in antibiotic prescription and administration for a holistic view of antibiotic usage patterns.

Data Collection Methods:

Using the questionnaire (study tool) to collect data and information about the research topic from the point of view of health practitioners, including those who work to prescribe antibiotics in the intensive care unit.

Inclusion Criteria:

- Include all nurses working in the ICU during the study period.
- Involve healthcare practitioners directly responsible for antibiotic prescription and administration within the ICU.

Variables and Measurements:

- Dependent variables include the prevalence of antibiotic-resistant bacteria within the ICU.
- Independent variables encompass demographic factors, and antibiotic prescription and administration practices.

Data Analysis:

The process of choosing the method and method necessary to analyze data statistically is one of the matters that plays a prominent role in the researcher's arrival at the intended and desired results. To achieve the objectives of the study and analyze the data collected, the Statistical Package for the Social Sciences (SPSS) program was used, and this was done according to the following methods:

1) Frequencies and percentages to identify the personal and functional characteristics of the study sample, and determine the responses of its members to the statements of the main themes included in the study.
2) The arithmetic means and standard deviation to determine the extent of the study sample members' responses to each of the axes and each of the themes' statements.

Results and discussion

Table (1) showed the personal characteristics of the members of the study sample, in terms of results contained therein indicate that (27.8%) of the study sample are male, and (72.2%) of them are female.

Table (1)

Frequencies and percentages of the study sample by gender

(Sample size = 36)

Sex	Frequencies	percentages
Male	10	27.8
Female	26	72.2
Total	36	100.0

This table shows that there is a positive effect between the sample of the study for female because (72.2%) of them are female. This gives the answers inclined to favor females. The following chart shows the above results.

Table (2)

Years of experience

Years of experience	Frequency #	Percentage %
1-3 years	8	22.2
4-6 years	17	47.2
7-9 years	5	13.9
10 years or more	6	16.7
Total	36	100.0

The results of Table No. (2) indicate that (47.2%) of the total members of the study sample have a total practical experience in their field of work of (between 4-6) years, while the percentage of members of the study sample whose practical experience is (1-3) years was (22.2%).

Results related to the first study question: "How do healthcare practitioners within the ICU at King Khaled Hospital in Hail prescribe and administer antibiotics?"

Table (3)

Descriptive statistics of the study sample directions for How do healthcare practitioners within the ICU at King Khaled Hospital in Hail prescribe and administer antibiotics? (Sample size = 36)

Paragraph	Mean	standard deviations	Rank
In critically ill patients where a rapid initiation of therapy is essential, empiric antibiotic therapy may be initiated before the results of culture and sensitivity tests are available.	4.19	83.8	1
Based on the patient's clinical condition and the results of diagnostic tests, healthcare practitioners select appropriate antibiotics.	4.08	83.5	2
Patients receiving antibiotic therapy in the ICU are closely monitored for clinical response to treatment, adverse effects, and the development of antibiotic resistance.	4.02	83.3	3
Healthcare practitioners in the ICU assess patients thoroughly to determine if antibiotic therapy is necessary.	3.83	82.7	4
Empiric therapy is typically broad-spectrum and covers a wide range of potential pathogens commonly encountered in ICU-acquired infections.	3.74	82.2	5
Once culture and sensitivity results are available, healthcare practitioners may adjust the antibiotic regimen based on the specific pathogens identified and their susceptibility patterns.	3.15	81.8	6
Antibiotics are administered according to established dosing guidelines, taking into account factors such as	3.03	81.6	7

the patient's weight, renal function, and the pharmacokinetic properties of the antibiotics.			
The choice of antibiotics is guided by factors such as the suspected or confirmed pathogen, local antibiotic resistance patterns, the severity of the infection, the patient's allergies, and comorbidities.	2.97	80.6	8
The duration of antibiotic therapy varies depending on the type and site of infection, the patient's clinical response, and other individual factors.	2.85	80.2	9
Total	3.58	82.3	***

This table shows the statistical mean is (3.58) and standard deviation is (82.3). It is noted from this table that paragraph " In critically ill patients where a rapid initiation of therapy is essential, empiric antibiotic therapy may be initiated before the results of culture and sensitivity tests are available" ranked first with a mean (4.19) and a standard deviation (83.8), and the paragraph "Based on the patient's clinical condition and the results of diagnostic tests, healthcare practitioners select appropriate antibiotics" came in second place with a mean (4.08) and a standard deviation (83.3), and the paragraph "The choice of antibiotics is guided by factors such as the suspected or confirmed pathogen, local antibiotic resistance patterns, the severity of the infection, the patient's allergies, and comorbidities" came in (8) ranked with a mean (2.97) and a standard deviation (80.6), and the paragraph "The duration of antibiotic therapy varies depending on the type and site of infection, the patient's clinical response, and other individual factors" came in last rank with a mean (2.85) and standard deviation (80.2).

Results related to the second study question: "How does the clinical history of patients within the ICU correlate with antibiotic usage patterns and the prevalence of antibiotic-resistant infections?"

Table (4)

Descriptive statistics of the study sample directions for How does the clinical history of patients within the ICU correlate with antibiotic usage patterns and the prevalence of antibiotic-resistant infections?

(Sample size = 36)

Paragraph	Mean	standard deviations	Rank
Previous exposure to antibiotics can affect the choice of antibiotics and treatment outcomes in the ICU.	3.67	81.2	1
Severity of illness and the presence of critical conditions often require the use of broad-spectrum antibiotics in the intensive care unit which may lead to increased antibiotic use and selective pressure for antibiotic resistance.	3.54	80.4	2
Certain conditions, such as chronic obstructive pulmonary disease (COPD) can increase the risk of infection and the potential use of antibiotics	3.35	78.7	3
Certain conditions, such as immunosuppression, can increase the risk of infection and the potential use of antibiotics	3.32	78.6	4

The availability of microbiological data, including culture and sensitivity results, plays a critical role in guiding antibiotic therapy in the ICU.	2.99	78.5	5
Certain conditions, such as diabetes can increase the risk of infection and the potential use of antibiotics	2.87	78.2	6
Healthcare exposures contribute to the spread of resistant strains within healthcare settings and can impact antibiotic prescribing practices in the ICU.	2.73	77.9	7
Total	3.27	79.1	***

This table shows the statistical mean is (3.27) and standard deviation is (79.1). It is noted from this table that paragraph “Previous exposure to antibiotics can affect the choice of antibiotics and treatment outcomes in the ICU" ranked first with a mean (3.67) and a standard deviation (81.2), and the paragraph "Severity of illness and the presence of critical conditions often require the use of broad-spectrum antibiotics in the intensive care unit which may lead to increased antibiotic use and selective pressure for antibiotic resistance" came in second rank with a mean (3.54) and a standard deviation (80.4) and the paragraph "Certain conditions, such as diabetes can increase the risk of infection and the potential use of antibiotics" came in (6) ranked with a mean (2.87) and a standard deviation (78.2), and the paragraph “Healthcare exposures contribute to the spread of resistant strains within healthcare settings and can impact antibiotic prescribing practices in the ICU." came in last rank with a mean (2.73) and standard deviation (78.5).

Results related to the third study question: “What infection control measures are currently implemented within the ICU at King Khaled Hospital to prevent the spread of antibiotic-resistant bacteria?”

Table (5)

Descriptive statistics of the study sample directions for What infection control measures are currently implemented within the ICU at King Khaled Hospital to prevent the spread of antibiotic-resistant bacteria?

(Sample size = 36)

Paragraph	Mean	standard deviations	Rank
Regular and thorough cleaning and disinfection of the ICU environment, including high-touch surfaces and medical equipment, help prevent the transmission of antibiotic-resistant bacteria.	3.51	78.2	1
Cleaning protocols strictly followed, and appropriate disinfectants effective against these bacteria should be used.	3.45	78.1	2
We committed wearing gloves and gowns when entering the patient's room and ensuring proper disposal of personal protective equipment after use.	3.34	77.8	3
Rigorous hand hygiene practices are fundamental in preventing the spread of antibiotic-resistant bacteria.	3.26	77.6	4
Patients known or suspected to be colonized or infected with antibiotic-resistant bacteria may be placed under	3.15	77.3	5

contact precautions.			
The antibiotics used in empirical therapy are changed periodically based on local resistance patterns.	3.08	76.9	6
Antibiotic stewardship programs involve comprehensive strategies such as antimicrobial formulary restriction, pre-authorization requirements for certain antibiotics	2.99	76.3	7
Antibiotic stewardship programs involve comprehensive strategies such as regular review of antibiotic prescriptions, and education for healthcare providers regarding appropriate antibiotic use.	2.93	75.4	8
Routine surveillance for antibiotic-resistant bacteria involves screening patients upon admission and periodically thereafter, as well as screening healthcare workers for colonization.	2.88	75.2	9
Healthcare workers in the ICU receive education and training on infection control practices, including proper hand hygiene, personal protective equipment use, and environmental cleaning.	2.79	74.9	10
In some cases, patients colonized or infected with antibiotic-resistant bacteria may be placed in single rooms or cohorted with other patients with the same organism to prevent transmission to other patients.	2.77	74.3	11
Total	3.16	77.2	

This table shows the statistical mean is (3.16) and standard deviation is (77.2). It is noted from this table that paragraph "Regular and thorough cleaning and disinfection of the ICU environment, including high-touch surfaces and medical equipment, help prevent the transmission of antibiotic-resistant bacteria" ranked first with a mean (3.51) and a standard deviation (78.2), and the paragraph "Cleaning protocols strictly followed, and appropriate disinfectants effective against these bacteria should be used." came in second rank with a mean (3.45) and a standard deviation (78.1), and the paragraph " Healthcare workers in the ICU receive education and training on infection control practices, including proper hand hygiene, personal protective equipment use, and environmental cleaning" came in the (10) rank with a mean (2.79) and standard deviation (74.9) , and the paragraph "In some cases, patients colonized or infected with antibiotic-resistant bacteria may be placed in single rooms or cohorted with other patients with the same organism to prevent transmission to other patients" came in last rank with a mean (2.77) and standard deviation (74.3).

Conclusion and recommendations

In conclusion, this paper delved into the investigation of risk factors contributing to the spread of antibiotic-resistant bacteria within the ICU of King Khaled Hospital in Hail, focusing on healthcare practitioners' perspectives. Through this exploration, we have shed light on the unique challenges faced in combating antibiotic resistance within this critical healthcare setting.

Our findings underscore the importance of understanding the dynamics of antibiotic resistance from the viewpoint of frontline healthcare professionals. Their insights into patient care practices, antibiotic prescribing habits, infection control

measures, and the overall healthcare environment provide valuable context for identifying and addressing factors contributing to the proliferation of antibiotic-resistant bacteria.

By highlighting these risk factors, our study contributes to the body of knowledge aimed at enhancing strategies for infection prevention and antimicrobial stewardship in ICUs. It underscores the need for comprehensive interventions that address not only clinical practices but also broader systemic and organizational factors influencing antibiotic resistance.

Moving forward, collaborative efforts between healthcare practitioners, policymakers, researchers, and public health authorities are essential to implement effective measures for mitigating the spread of antibiotic-resistant bacteria. Through continued research, education, and advocacy, we can strive towards preserving the efficacy of antibiotics and safeguarding the health and well-being of patients within intensive care settings and beyond.

Recommendations

Based on the findings of our investigation into risk factors for the spread of antibiotic-resistant bacteria at King Khaled Hospital ICU in Hail from the perspective of healthcare practitioners, the following recommendations are proposed:

1. Enhanced Infection Control Measures: Implement stringent infection control protocols, including strict adherence to hand hygiene practices, proper disinfection of equipment and surfaces, and appropriate use of personal protective equipment (PPE) to minimize the transmission of antibiotic-resistant bacteria among patients and healthcare workers.
2. Antimicrobial Stewardship Programs: Develop and implement antimicrobial stewardship programs aimed at optimizing antibiotic use within the ICU. This includes promoting judicious prescribing practices, conducting regular antimicrobial susceptibility testing, and monitoring antibiotic consumption to prevent overuse and misuse of antibiotics, which can contribute to the development of resistance.
3. Education and Training: Provide ongoing education and training programs for healthcare practitioners on the principles of antimicrobial stewardship, infection prevention, and control measures. This should include training on the proper use of antibiotics, identification of antibiotic-resistant pathogens, and strategies for preventing their spread.
4. Surveillance and Monitoring: Establish robust surveillance systems to monitor the prevalence and trends of antibiotic-resistant bacteria within the ICU. Regular surveillance of bacterial isolates, antimicrobial susceptibility patterns, and infection rates can help identify emerging resistance patterns and guide appropriate interventions.
5. Interdisciplinary Collaboration: Foster collaboration among healthcare practitioners, including physicians, nurses, pharmacists, microbiologists, and infection control specialists, to develop comprehensive strategies for combating antibiotic resistance. Interdisciplinary teamwork is essential for implementing multifaceted interventions and promoting a culture of antimicrobial stewardship and infection prevention.

6. Resource Allocation: Allocate adequate resources, including funding, personnel, and infrastructure, to support infection control initiatives and antimicrobial stewardship efforts within the ICU. This may involve investing in laboratory facilities, antimicrobial susceptibility testing equipment, and staffing levels to ensure effective implementation of recommended interventions.
7. Community Engagement: Engage with the broader community, including patients, families, and community healthcare providers, to raise awareness about the importance of antibiotic stewardship and infection prevention. Educating the public about the risks associated with antibiotic resistance and promoting responsible antibiotic use can help reduce the spread of resistant bacteria both within the hospital and the community.

By implementing these recommendations, King Khaled Hospital ICU in Hail can strengthen its efforts to combat antibiotic resistance and safeguard the health and well-being of patients while promoting the prudent use of antibiotics for future generations.

References

1. Althaqafi A, Yaseen M, Farahat F, et al. (April 08, 2023) Risk Factors for Infection with Multidrug-Resistant Gram-Negative Bacteria in a Tertiary Care Hospital in Saudi Arabia: A Case-Control Study. Cureus 15(4): e37291. DOI 10.7759/cureus.37291
2. Chen Q, Li D, Beiersmann C, Neuhann F, Moazen B, Lu G, Müller O (2021). Risk factors for antibiotic resistance development in healthcare settings in China: a systematic review. Epidemiology and Infection, 149, e141, 1–10. https://doi.org/10.1017/, S0950268821001254
3. Fernández-Martínez, N.F.; Cárcel-Fernández, S.; De la Fuente-Martos, C.; Ruiz-Montero, R.; Guzmán-Herrador, B.R.; León-López, R.; Gómez, F.J.; Guzmán-Puche, J.; Martínez-Martínez, L.; Salcedo-Leal, I. (2022), Risk Factors for Multidrug-Resistant Gram-Negative Bacteria Carriage upon Admission to the Intensive Care Unit. Int. J. Environ. Res. Public Health, 19, 1039. https://doi.org/10.3390/ ijerph19031039
4. Izadi S, Mohaghegh MA, Ghayour-Najafabadi Z, et al. Frequency and molecular identification of cryptosporidium species among immunocom
5. Kueakulpattana N, Wannigama DL, Luk-in S, et al. Multidrug-Resistant Neisseria gonorrhoeae infection in heterosexual men with reduced susceptibility to ceftriaxone, first report in Thailand. Sci Rep. 2021;11(1). doi:10.1038/S41598-021-00675-Y7.
6. Maugeri, A., Barchitta, M. & Agodi, A. (2023), Association between quality of governance, antibiotic consumption, and antimicrobial resistance: an analysis of Italian regions. Antimicrob Resist Infect Control 12, 130. https://doi.org/10.1186/s13756-023-01337-6
7. Srisakul S, Wannigama DL, Higgins PG, et al. Overcoming addition of phosphoethanolamine to lipid a mediated colistin resistance in Acinetobacter baumannii clinical isolates with colistin-sulbactam combination therapy. Sci Rep. 2022;12(1). doi:10.1038/S41598-022-15386-1
8. Rahman MM, Alam Tumpa MA, Zehravi M, Sarker MT, Yamin M, Islam MR, Harun-Or-Rashid M, Ahmed M, Ramproshad S, Mondal B, Dey A, Damiri F,

Berrada M, Rahman MH, Cavalu S. (2022), An Overview of Antimicrobial Stewardship Optimization: The Use of Antibiotics in Humans and Animals to Prevent Resistance. Antibiotics (Basel). 2022 May 16;11(5):667. doi: 10.3390/antibiotics11050667. PMID: 35625311; PMCID: PMC9137991.

9. Shein AMS, Wannigama DL, Higgins PG, et al. Novel Colistin-EDTA Combination for Successful Eradication of Colistin-Resistant Klebsiella Pneumoniae Catheter-Related Biofilm Infections. Sci Rep. 2021;11(1). doi:10.1038/S41598-021-01052-58.
10. Tacconelli E, Carrara E, Savoldi A, et al.: Discovery, research, and development of new antibiotics: the WHO priority list of antibiotic-resistant bacteria and tuberculosis. Lancet Infect Dis. 2018, 18:318-27. 10.1016/S1473-3099(17)30753-3
11. Tadesse TY, Molla M, Yimer YS, Tarekegn BS, Kefale B. Evaluation of antibiotic prescribing patterns among inpatients using World Health Organization indicators: A cross-sectional study. SAGE Open Med. 2022 May 14;10:20503121221096608. doi: 10.1177/20503121221096608. PMID: 35600711; PMCID: PMC9118891.