

Prevalence of Gram-negative and Gram-positive Bacteria and Antibiotic Resistance Rates at a Military Hospital in Riyadh Region

Nehad Jaser Ahmed^{1,2,*}, Mohammad Abdalla³, Hadeel Alahmadi³, Abdul Haseeb⁴, Amer Hayat Khan²

¹Department of Clinical Pharmacy, College of Pharmacy, Prince Sattam Bin Abdulaziz University, Al-Kharj, SAUDI ARABIA.

²Discipline of Clinical Pharmacy, School of Pharmaceutical Sciences, Universiti Sains Malaysia, George Town, Penang, MALAYSIA.

³Microbiology Section, Department of Pathology, Alkharj Military Industrial Corporation Hospital, Alkharj, SAUDI ARABIA.

⁴Clinical Pharmacy Department, College of Pharmacy, Umm AlQura University, Mecca, SAUDI ARABIA.

ABSTRACT

Aim: This study aimed to investigate the prevalence of gram negative and gram positive bacteria in addition to the investigation of antibiotic resistance rates in 2021 at a military hospital in Riyadh Region. **Materials and Methods:** This observational study included the retrospective review of bacterial isolates from 1st of January 2021 to 30th of June 2021. **Results:** Most of the infections were caused by gram negative bacteria (64.52%). The most common gram negative bacteria were *Escherichia coli* (43.63%) followed by *Pseudomonas aeruginosa* (20.52%). The most common gram positive bacteria were *Staphylococcus aureus* isolates (71.74%). The study also showed that *Acinetobacter baumannii* was a pandrug-resistant bacterium and *Enterobacter cloacae*, *Proteus mirabilis*, *Morganella morganii*, and *Enterococcus faecalis* bacteria were multidrug resistant. **Conclusion:** There was a high resistance for some bacteria to numerous antibiotics. Antibiotic susceptibility testing is an essential guide

for physicians to help them in the selection of the suitable antibiotic for bacterial infections.

Key words: Antibiotic resistance, Antimicrobial resistance, Gram negative bacteria, Gram positive bacteria, Multidrug-resistant bacteria, Prevalence.

Correspondence

Mr. Nehad Jaser Ahmed,^{1,2}

¹Clinical Pharmacy Department, College of Pharmacy, Prince Sattam Bin Abdulaziz University, Al-Kharj, SAUDI ARABIA.

²Discipline of Clinical Pharmacy, School of Pharmaceutical Sciences, Universiti Sains Malaysia, George Town, Penang, MALAYSIA.

Email id: pharmdnehadjaser@yahoo.com

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INTRODUCTION

Antibiotics can save lives, but when antibiotics are used, they can cause adverse effects and can lead to antibiotic resistance.¹ In Saudi Arabia, the rate of antibiotics misuse is complicated and high mainly because before several years, antibiotics were available to everyone as over the counter medications by pharmacies.² Alrasheedy *et al.* stated that nationwide ban on the sale of antibiotics without a prescription was implemented currently by Saudi Ministry of Health; nevertheless, antibiotics dispensing without a written prescription is still frequent.²

The misuse of antibiotics is known to increase the development of bacterial resistance to antibiotics.^{3,4} Yitayeh *et al.* stated that the effectiveness of the available antibiotics is decreased and bacterial resistance to different antibiotics is increased globally.⁵ In the United States, it is estimated that about two million patients develop a bacterial infection that is resistant to antibiotics annually and that more than 23 thousands deaths are related to these infections.⁶ Antibiotic resistance results in an increase in hospital stay, mortality, morbidity, and healthcare costs in addition to limiting the number of effective antimicrobial agents.⁷⁻⁹

Escherichia coli, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Streptococcus pneumoniae*, *Staphylococcus aureus*, and *Salmonella* spp. are frequently isolated microbes from infections in the community and clinical settings;¹⁰ they are the most serious antibiotic resistant microorganisms recently.¹¹

To to guide antimicrobial therapy and predict the efficacy of the antimicrobial agents, antimicrobial susceptibility testing results should be used. Therefore, this study aimed to investigate the prevalence of gram

negative and gram positive bacteria in addition to the investigation of antibiotic resistance rates in 2021 at a military hospital in Riyadh Region.

MATERIALS AND METHODS

This observational study included the retrospective review of bacterial isolates from 1st of January 2021 to 30th of June 2021. This study was conducted at military hospital in Riyadh Region that is tertiary hospitals provide medical services in different sections obstetrics, paediatrics, gynecology, general surgery, ophthalmology, neurology, dental medicine, dialysis unit, psychiatry, and otolaryngology. This observational study was approved by the ethical committee in the military hospital with a log number of 4101728. The results of the pathogenic bacteria recovered from various microbiological samples (such as wound, blood, and urine) were included in the study and the cultures before or after the study period were excluded.

The data were collected by pathology department/microbiology section in the military hospital. After data collection, antimicrobial susceptibility report was prepared for the bacterial isolates. The data included the number and percentages of gram negative and gram positive bacteria and the resistance rate of bacteria to different antimicrobials. The descriptive data were shown as numbers and percentages.

RESULTS

Most of the infections were caused by gram negative bacteria (64.52%). The number of gram negative and gram-positive bacteria is shown in Table 1. *Escherichia coli* were the most common bacteria (43.63%) followed by *Pseudomonas aeruginosa* (20.52%) and *Klebsiella pneumoniae*

(16.73%). Percentages of gram-negative and isolates were summarized in Tables 2, 3.

Table 4 shows the susceptibility rate of gram-negative bacteria to different antibiotics. The resistance of *Escherichia coli* was more than 50% only to ampicillin (susceptibility rate=34%). Similarly, the resistance rate of *Klebsiella pneumoniae* was high only to ampicillin (susceptibility rate=1%) and Nitrofurantoin (susceptibility rate=37%). The resistance

of *Enterobacter cloacae* was high to several antibiotics particularly ampicillin (susceptibility rate=0%), co-amoxiclav (susceptibility rate=0%), cefazolin (susceptibility rate=0%) and ceftazidime (susceptibility rate=0%). The resistance of *Proteus mirabilis* was also high for several antibiotics mainly to ampicillin (susceptibility rate=29), nitrofurantoin (susceptibility rate=0%), and ceftriaxone (susceptibility rate=37%).

Morganella morganii was highly resistant to ampicillin, ampicillin/sulbactam, amoxicillin/clavulanate, cefuroxime, norfloxacin and nitrofurantoin. The resistance of *Morganella morganii* to all of these antibiotics was 100%. The resistance of *Pseudomonas aeruginosa* was low to all of the tested antibiotics. The resistance of *Acinetobacter baumannii* was high (more than 50%) for all of the tested antibiotics.

Table 5 shows the susceptibility rate of gram-positive bacteria to different antibiotics. *Staphylococcus aureus* was highly resistant to penicillin (susceptibility rate=2%) and ampicillin (susceptibility rate=2%). *Enterococcus faecalis* was highly resistant to erythromycin (susceptibility rate=5%), tetracycline (susceptibility rate=24%) and rifampin (susceptibility rate=50%). *Staphylococcus epidermidis* was highly resistant to penicillin (susceptibility rate=5%), ampicillin (susceptibility rate=5%), oxacillin (susceptibility rate=23%), azithromycin (susceptibility rate=29%) and erythromycin (susceptibility rate=26%).

Table 1: Number and percentage of gram positive and gram negative bacteria.

Micro-organisms	Number of bacteria isolates	Percentage
Gram Negative bacteria	502	64.52
Gram positive bacteria	276	35.48
Total	778	100.00

Table 2: Number and percentage of gram-negative bacterial isolates.

Micro-organism	Number of bacteria	Percentage
<i>Escherichia coli</i>	219	43.63
<i>Pseudomonas aeruginosa</i>	103	20.52
<i>Klebsiella pneumoniae</i>	84	16.73
<i>Proteus mirabilis</i>	35	6.97
<i>Acinetobacter baumannii</i>	28	5.58
<i>Morganella morganii</i>	17	3.39
<i>Enterobacter cloacae</i>	16	3.18
Total	502	100.00

Table 3: Number and percentage of gram-positive bacterial isolates.

Micro-organism	Number of bacteria	Percentage
<i>Staphylococcus aureus</i>	198	71.74
<i>Staphylococcus epidermidis</i>	44	15.94
<i>Enterococcus faecalis</i>	34	12.32
Total	276	100.00

DISCUSSION

Most of the infections were caused by gram negative bacteria. The most common gram-negative bacteria were *Escherichia coli* isolates followed by *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* isolates. *Staphylococcus aureus* and *Staphylococcus epidermidis* were the most common gram-positive bacteria. A previous study showed that some bacteria such as *Klebsiella pneumoniae*, *Enterococcus faecium*, *Acinetobacter baumannii*, *Staphylococcus aureus*, *Enterobacter*, and *Pseudomonas aeruginosa*, that is known as ESKAPE pathogens, cause nearly half the infections that were caused by bacteria in a Public Hospital in Alkharj.¹² Ahmed stated that among a military hospital in Riyadh Region, about 75.77% of infections were caused by gram negative bacteria and that the most common microorganisms were *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Klebsiella pneumoniae*.¹³

Table 4: The susceptibility rate of gram-negative bacteria to different antibiotics.

Organism	Ampicillin	Amp-Sulb	Co-amoxiclav	Pip/Taz	Cefazolin	Cefepime	Ceftriaxone	Ceftazidime	Cefuroxime	Ceftazidime	Aztreonam	Ertapenem	Imipenem	Meropenem	Gentamicin	Tobramycin	Amikacin	Ciprofloxacin	Levofloxacin	Norfloxacin	TMP-SMX	Nitrofurantoin	Colistin
<i>Escherichia coli</i>	34	51	76	94	52	55	55	92	53	54	53	97	99	98	87	84	96	69	72	68	68	96	NA
<i>Klebsiella pneumoniae</i>	1	68	80	90	71	68	65	82	63	65	58	86	95	90	86	79	90	79	85	80	74	37	NA
<i>Enterobacter cloacae</i>	0	12	0	81	0	69	50	0	12	56	56	62	75	88	75	81	88	69	75	50	88	17	NA
<i>Proteus mirabilis</i>	29	43	63	91	55	63	37	80	49	49	57	86	NA	94	43	49	74	40	54	50	40	0	NA
<i>Morganella morganii</i>	0	0	0	88	NA	76	NA	76	0	59	76	100	6	100	82	59	94	53	53	0	35	0	NA
<i>Pseudomonas aeruginosa</i>	NA	NA	NA	72	NA	66	NA	NA	NA	67	60	NA	67	72	68	80	77	72	73	58	NA	NA	86
<i>Acinetobacter baumannii</i>	NA	25	NA	NA	NA	21	NA	NA	NA	21	NA	NA	0	21	36	36	36	21	25	NA	21	NA	NA

*TMP-SMX: Trimethoprim/Sulfamethoxazole, Amp-Sulb: Ampicillin/sulbactam, Co-amoxiclav: Amoxicillin/clavulanate, Pip/Taz: Piperacillin-tazobactam

Table 5: The susceptibility rate of gram-positive bacteria to different antibiotics.

#	Penicillin	Ampicillin	Oxacillin	Vancomycin	Teicoplanin	Daptomycin	Gentamicin	Azithromycin	Erythromycin	Tetracycline	Ciprofloxacin	levofloxacin	Nitrofurantoin	Clindamycin	TMP-SMX	Rifampin	Q-D	Linezolid	Fosfomycin
<i>Staphylococcus aureus</i>	2	2	51	100	NA	95	85	65	65	85	65	68	100	82	94	96	96	96	95
<i>Enterococcus faecalis</i>	94	88	NA	97	100	100	NA	NA	5	24	71	74	87	NA	NA	50	NA	100	NA
<i>Staphylococcus epidermidis</i>	5	5	23	100	NA	98	57	29	26	77	57	59	NA	67	75	95	89	100	95

*TMP-SMX: Trimethoprim/Sulfamethoxazole, Q-D: Quinupristin-dalfopristin

Ahmed and Khan reported that in a University Hospital in Al-Kharj, the most common bacteria were *Escherichia coli* (26.58%), *Klebsiella pneumoniae* (16.45%) and that the percentages of *Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* were 13.92%, 12.65% and 12.65% respectively.¹⁴ Moreover, Masoud *et al.* found that Najran Area, the most prevalent bacteria isolated were *Escherichia coli* (35.63%), *Klebsiella pneumoniae* (18.08%), and *Staphylococcus aureus* (14.89%).¹⁵ Hamid *et al.* revealed that among pathogens causing infections in the Aseer regions, the main etiological agents were *Escherichia coli* isolates, *Klebsiella pneumoniae* isolates, *Enterococcus* spp. isolates and *Staphylococcus aureus* isolates.¹⁶ Aly and Balkhy reported that among clinical isolates from Gulf countries, the most prevalent bacteria were *Escherichia coli* (44%), followed by *Klebsiella pneumoniae* (20%), *Pseudomonas aeruginosa* (18.7%), Methicillin-resistant *Staphylococcus aureus* (5.4%), and *Acinetobacter* (5%).¹⁷

The present study showed that the resistance rate of several pathogens was very high. Regarding gram negative bacteria, *Enterobacter cloacae* was very high to several antibiotics particularly ampicillin, co-amoxiclav, cefazolin and ceftazidime (susceptibility rate to all of these antibiotics=0%). Davin-Regli and Pagès stated that *Enterobacter cloacae* has an intrinsic resistance to ampicillin, amoxicillin, ceftazidime, and first generation cephalosporins, due to constitutive AmpC β -lactamase production and that it shows a high resistance to broad spectrum cephalosporins.¹⁸ Moreover, Malek *et al.* stated that multidrug resistant *Enterobacter* species are one of the common bacteria that cause hospital-acquired infections.¹⁹

The resistance of *Proteus mirabilis* was also high for several antibiotics mainly to ampicillin, nitrofurantoin, and ceftriaxone. A previous study in Taiwan revealed a reduced susceptibility of *Proteus mirabilis* to several broad spectrum antibiotics, such as ciprofloxacin and third generation cephalosporins, in the past decade.²⁰ In contrast to that Tsai *et al.* informed that *Proteus mirabilis* is expected to be sensitive to broad-spectrum penicillins (such as piperacillin and ticarcillin), ampicillin, first generation cephalosporins, second generation cephalosporins, third generation cephalosporins, aztreonam, and imipenem.²¹

In the present study, *Morganella morganii* was highly resistant to ampicillin, ampicillin/sulbactam, amoxicillin/clavulanate, cefuroxime, norfloxacin and nitrofurantoin. So, *Enterobacter cloacae*, *Proteus mirabilis*, and *Morganella morganii* bacteria were multidrug resistant; multidrug resistant was defined as acquired resistance to at least one antimicrobial in three or more different antimicrobial classes.²² Monnet and Richard reported that the *Morganella morganii* is generally resistant to amoxicillin-clavulanic acid combination, to cephalothin, and to ampicillin and that *Morganella morganii* bacteria are usually susceptible to other antibiotics active against gram negative bacilli.²³ Liu *et al.*

reported that infections with *Morganella morganii* are mostly worrisome epidemiologically due to the organism's inducible resistance to Beta-lactams.²⁴

Furthermore, the resistance of *Acinetobacter baumannii* was high for all of the tested antibiotics. So, *Acinetobacter baumannii* was a pandrug-resistant bacterium (pandrug-resistant was defined as resistant to all antimicrobials in all antimicrobial groups). But the susceptibility of *Acinetobacter baumannii* to colistin, which was considered as one of the last therapeutic options for treatment of the multiresistant *Acinetobacter baumannii* infection,²⁵ was not tested. Ahmed *et al.* that in Public Hospital in Alkharj, *Acinetobacter baumannii* bacteria were extensively drug resistant but its resistance was low to colistin.¹² Dent *et al.* stated that 247 72% of *Acinetobacter baumannii* isolates were multidrug resistant and that 58% of isolates were highly resistant to ampicillin-sulbactam, amikacin, and imipenem.²⁶ Eliopoulos *et al.* reported that among *Acinetobacter* isolates, an increasing antimicrobial resistance rate has been documented.²⁷

Regarding gram positive bacteria, *Enterococcus faecalis* was highly resistant to erythromycin, tetracycline, and rifampin. Zaheer *et al.* found that the resistance rate of *Enterococcus* spp. to macrolides and tetracyclines was high.²⁸ Kristich *et al.* reported that all *enterococci* show a reduced susceptibility to ampicillin and penicillin, along with high rate of resistance to semi-synthetic penicillins and cephalosporins.²⁹ Jia *et al.* stated that a high prevalence of resistance to ampicillin, penicillin, rifampin, levofloxacin, erythromycin, fosfomycin, furadantin, and ciprofloxacin was detected in *Enterococcus* species.³⁰

Staphylococcus epidermidis was highly resistant to penicillin, ampicillin, oxacillin, azithromycin, and erythromycin. So these bacteria were multidrug resistant. Chabi and Momtaz found that *Staphylococcus epidermidis* strains harbored a high resistance rate against penicillin, erythromycin, tetracycline, trimethoprim-sulfamethoxazole, and cefazolin.³¹

CONCLUSION

This study provides essential data on antimicrobial resistance of bacterial isolates in a military hospital from 1st of January 2021 to 30th of June 2021. The study showed that *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Klebsiella pneumoniae* were common bacteria. The study also showed that *Acinetobacter baumannii* was a pandrug-resistant bacterium and *Enterobacter cloacae*, *Proteus mirabilis*, *Morganella morganii*, and *Enterococcus faecalis* bacteria were multidrug resistant. Consequently, Antibiotic susceptibility testing is an essential guide for physicians to help them in the selection of the suitable antibiotic for bacterial infections.

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