Surveillance of Antimicrobial Resistance in Iraq: A Comprehensive Data Collection Approach

Dhurgham K. Al-Fahad[1], Jawad A. Alpofead[2], Mahmoud A. Chawsheen[3,4†], Ahmed A. Al-Naqshbandi[5], and Ali T. Abas[1]

[1]Department of Pharmaceutical Sciences, College of Pharmacy, University of Thi-Qar, Nasiriyah, 64001, F.R. Iraq.

[2]Department of Pharmaceutical Chemistry, College of Pharmacy, University of Thi-Qar, Nasiriyah, 64001, F.R. Iraq.

[3]Department of General Sciences, Faculty of Education, Soran University, Erbil, 44008, Kurdistan Region-F.R. Iraq.

[4]Medical Research Center, Hawler Medical University, Erbil, 44001, Kurdistan Region-F.R. Iraq.

[5]Department of Laboratory, Rizgary Teaching Hospital, Erbil, 44001, Kurdistan Region-F.R. Iraq.

***Abstract*—Antimicrobial resistance (AMR) generates serious negative impacts on health-care systems worldwide, and Iraq is not an exception. To uncover the prevalence of AMR and to visualize the magnitude of the multidrug-resistant (MDR) dilemma in Iraqi hospitals, this study is carried out. A total of 11592 clinical records from ten different health-care facilities in seven Iraqi provinces are collected and analyzed. Our data show that 4984 (43.0%) of all clinical samples are negative for bacterial growth. In adults, Gram-negative bacteria (GNB) represented 48.9% and Gram-positive bacteria (GPB) represented 51.1% of clinical isolates; in children, GNB represented 60.8% and GPB represented 39.2%. Furthermore, in adults, *Klebsiella pneumoniae* (30.1%) and *Staphylococcus aureus* (40.8%) are among the most common GNB and GPB isolates, respectively. In children, *K. pneumoniae* (37.9%) and *Staphylococcus haemolyticus* (41.8%) are the most common GNB and GPB, respectively. Adults' samples showed that *Escherichia coli* and *Proteus mirabilis* were the most resistant GNB; *S. aureus* and *Staphylococcus epidermidis* are among the most resistant GPB. In children, *K. pneumoniae* is found to be the most resistant GNB. This study confirms the persistence of antimicrobial resistance and multidrug-resistant gram negative and gram positive bacteria in adults and children alike. Ampicillin and oxacillin have been recognized as ineffective drugs in adults, and ampicillin, nafcillin, cefoxitin, and benzylpenicillin have been found to be highly resisted by pathogenic bacteria in children. The outcomes of this study confirm the necessity of conducting AMR surveillance on a regular basis and establishing national antibiotic prescription guidelines to manage AMR development in Iraq.**

***Index Terms*—Antimicrobial resistance, Multidrug resistant, *Klebsiella pneumoniae, Staphylococcs aureus, Escherichia coli,* Surveillance of AMR.**

I. Introduction

Antimicrobial resistance (AMR) is recognized as one of the global public health threats facing humanity (WHO, 2021). AMR is higher among populations of low- and middle-income countries in comparison with wealthy ones (Allel, et al., 2023). For decades now, AMR has been attracting more attention from researchers and policymakers worldwide for becoming an economic burden on the public health sector and for being linked to prolonged illnesses, extended hospitalization, and higher mortality rates (World Bank, 2017). Besides death, AMR may pose potential damage to humans, animals, plants, and food security alike (Murray, et al., 2022).

AMR could be defined as the failure of antibiotics to kill or inhibit microbial growth, and as a consequence, affected microorganisms become resistant to drugs that used to be effective in the past. Among the critical known factors involved in the emergence of AMR is the overuse of antibiotics and unnecessary clinical prescriptions (Coque, et al., 2023). At the molecular level, AMR is either intrinsic or acquired, and the latter is part of an evolutionary process taking place in microorganisms through mutations or horizontal gene transfer of mobile genetic elements from other microorganisms (Martínez, Coque and Baquero 2014).

The Middle East, like other regions of the world, suffers from AMR, but at different levels (Borgio, et al., 2021; Yıldız, et al., 2023; Torumkuney, et al., 2022a; Ruan,

ARO-The Scientific Journal of Koya University
Vol. XII, No 2 (2024), Article ID: ARO.11689. 15 pages
DOI: 10.14500/aro.11689
Received: 02 July 2024; Accepted: 27 October 2024
Regular research paper; Published: 19 November 2024
†Corresponding author's e-mail: mahmoud.hassan@soran.edu.iq

et al., 2023). The severity of AMR among the populations is reflected by the countermeasures that have been taken by local authorities to overcome or diminish this problem (Hassan, et al., 2023; Torumkuney, et al., 2022b). Iraq, like its neighboring countries, also suffers from AMR. AMR may have been growing worse in this country due to several factors, including political and economic instability, a lack of national antimicrobial guideline usage, and the challenging task of recovering the antibiotic prescription history of patients who visited hospitals for treatment. Meanwhile, troubling signs have been reported through several studies, suggesting the seriousness of this problem in Iraq (Häsler, et al., 2018; Raouf, et al., 2022; Abou Fayad, et al., 2023).

Studies on various regions and infection sites among Iraqi patients revealed differing rates of AMR and MDR pathogenic bacteria. Multidrug-resistant (MDR) *Enterococcus faecalis* and *Acinetobacter baumannii*, along with other Gram-positive bacteria (GPB) and Gram-negative bacteria (GNB), were isolated from patients with urinary tract infections (UTI) (Al-Jumaily and Zgaer, 2016; Al-Naqshbandi, et al., 2019). *Klebsiella pneumoniae* is linked to community-acquired pneumonia (Raouf, et al., 2022) and is the most common antibiotic-resistant pathogen identified in swabs from the nasal, oral, and groin regions of refugees recently immigrated to Germany (Häsler, et al., 2018). Methicillin-resistant *Staphylococcus aureus* and *Staphylococcus epidermidis* were isolated from patients with wound infections (Al-Naqshbandi, et al., 2021). MDR *Streptococcus parasanguinis* and *A. baumannii* were isolated from patients with lower respiratory tract infections (Chawsheen, Al-Naqshbandi and Abdulqader, 2020). MDR *Escherichia coli* has been isolated from various specimens, including urine, stool, blood, wound swabs, ear swabs, pus, abscess, sputum, and body fluids (Al-Hasani, Al-Rubaye, and Abdelhameed, 2023).

From what was mentioned earlier, there is clearly enough evidence suggesting the presence of AMR within Iraqi communities and, unfortunately, the existence of MDR pathogens as well. Most of the previous studies covered AMR-related pathogens only and in limited areas, such as a certain city or province. In this project, we aimed to investigate the prevalence and antimicrobial susceptibility, AMR rates, and MDR bacterial pathogens among local communities in seven different Iraqi provinces: Baghdad, Al-Anbar, Wasit, Babil, Maysan, Al-Najaf, and Dhi-Qar. This may help us to polymerize a comprehensive vision of the real scale of the AMR problem in Iraq. Moreover, a study like this one is a necessity to assist the health sector's policymakers in adopting legislation that culminates in issuing the National Antimicrobial Guidelines. Issuing such guidelines is, by itself, a crucial step toward overcoming or diminishing the AMR problem.

II. Materials and Methods

A. Data Collection

A retrospective study was conducted on 11592 clinical records for samples collected during the period of July 2019–April 2021 from ten public hospitals and two private laboratories in seven Iraqi provinces, as follows: Baghdad Hospital, Central Children Hospital, and Al-Buraq Lab (in Baghdad province); Al-Ramadi Hospital and Al-Ramadi Children Hospital (in Al-Anbar province); Al-Karama Hospital (in Wasit province); Babylon Hospital (in Babil province); Al-Sadr General Hospital (in Maysan province); Al-Hakeem Hospital, Al-Sadar Hospital, and Al-Amal Lab (in Al-Najaf province); and Al-Hussain Hospital (in Dhi-Qar) province (Fig. 1). Clinical specimens were collected from different sites, including urine, blood, stool, and swabs (wound, ear, nasal, oral, throat, and high vaginal swab), in addition to body fluids and discharges (ascites fluid, semen, pus, sputum, abscess, nipple discharges, and synovial fluid).

B. Bacterial Culture and Identification

At all collection facilities, standard laboratory techniques were applied. After transferring clinical samples into the facilities' laboratories, samples were inoculated on Blood, MacConkey, Chocolate, Salmonella Shigella, Xylose Lysine Deoxycholate, and Thiosulfate–citrate–bile salts–sucrose agars, according to the type of specimens. During the inoculation process, striking methods (based on the type of specimen) were used to spread the specimens' inoculums on agar plates, and afterward, the plates were incubated overnight at 37°C. Aerobic bacterial growths were identified according to colony characteristics and Gram's staining by applying the Bhatia and Ichhpujani protocol (Bhatia and Ichhpujani, 2008). Identification of GPB, GNB, and antimicrobial sensitivity tests was performed following VITEK®2 compact system protocols using AST kits: VITEK®2 GN with reference numbers GN222, GN 69, 71, 76, and 82 and VITEK®2 GP Reference P580, P592, ST01, and ST03.

C. Antibiotics

The above-mentioned health-care facilities have used VITEK®2 kits to investigate the following antibiotics: AM-Ampicillin, AMC-Amoxicillin/Clavulanic Acid, AN-Amikacin, ATM-Aztreonam, CAZ-Ceftazidime, C-Chloramphenicol, FOX-Cefoxitin, CRO-Ceftriaxone, CFM-Cefixime, CIP-Ciprofloxacin, CS-Colistin, CT-Ceftolozane/Tazobactam, CTX-Cefotaxime, CXMA-Cefuroxime axetil, CZA-Ceftazidime/Avibactam, CZ-Cefazolin, DO-Doxycycline, DOR-Doripenem, ETP-Ertapenem, FEP-Cefepime, FT-Nitrofurantoin, GM-Gentamicin, IPM-Imipenem, LEV-Levofloxacin, MEM-Meropenem, MNO-Minocycline, MUP-Mupirocin, MXF-Moxifloxacin, Nafcillin, OFL-Ofloxacin, P-Benzylpenicillin, PEF-Pefloxacin, TZP-Piperacillin/Tazobactam, PIP-Piperacillin, RA-Rifampicin, SAM-Ampicillin/Sulbactam, SPI-Piperacillin/Sulbactam, SXT-Trimethoprim/Sulfamethoxazole, TCC-Ticarcillin/Clavulanic Acid, TE-Tetracycline, TGC-Tigecycline, TIC-Ticarcillin, TMP-Trimethoprim, and TM-Tobramycin.

D. Data Analysis

In regard to the recovered isolates' dominancy and abundance, data were presented in percentages (%). When the resistance rate of recovered isolates toward a specific

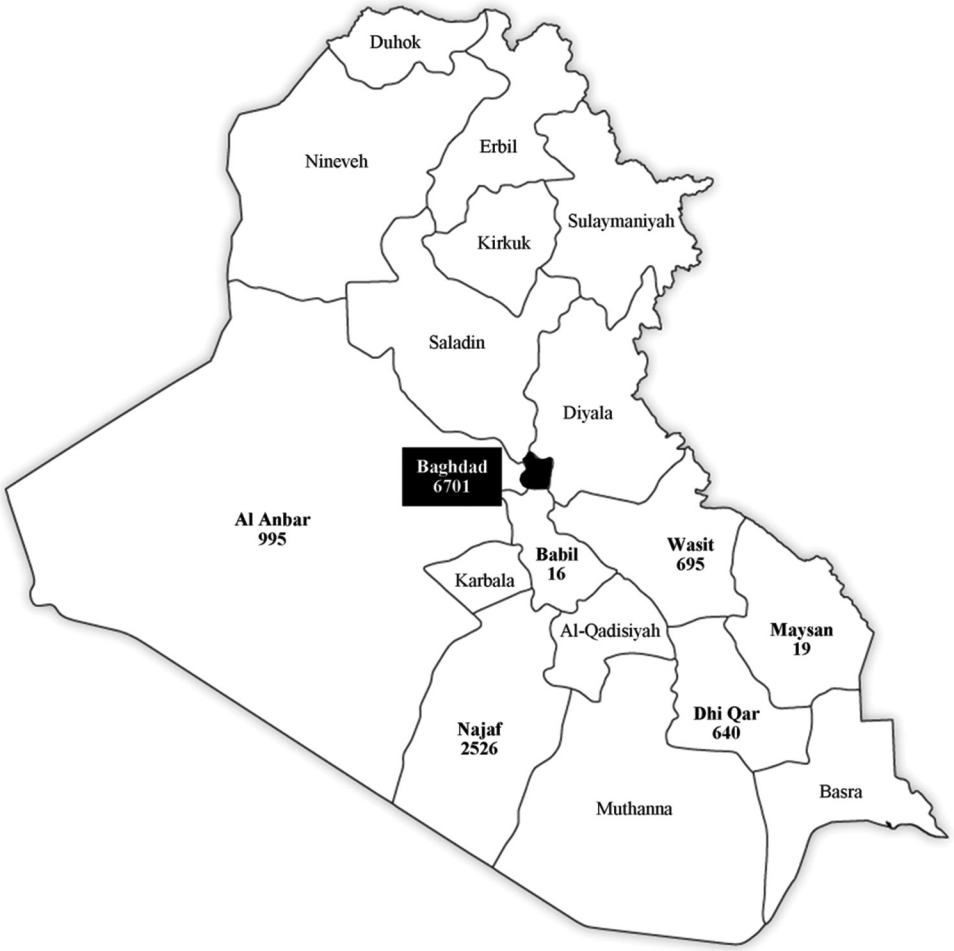

Fig. 1. Map of Iraq and the administrative units (governorates). Numbers showing clinical cases in each of the seven governorates that data were collected from. The original "plain" map was sourced from www.burningcompass.com, and details were added by the authors.

antibiotic was ≥70%, they were considered to be resistant bacteria. For the collective antibiotic resistance in GPB and GNB, we also classified antibiotics that were resisted by 90% or more of the isolates as highly resisted drugs. The above-mentioned criteria were used in accordance with Al-Naqshbandi, et al. (2019).

III. Results and Discussion

A. Results

Our analysis of the collected data from the Iraqi hospitals revealed that out of 11592 tested clinical samples, 4984 (43.0%) were negative for bacterial growth, and the rest generated 3274 (49.5%) Gram-negative and 3334 (50.5%) Gram-positive pathogenic bacteria. Out of the total number of pathogenic isolates, 6248 (94.6%) were recovered from adults, and 360 (5.4%) were from children patients. From all recovered pathogenic GNB, 3055 (93.3%) of them were from adults and 219 (6.7%) of them were from children patients. Out of all pathogenic GPB isolates, 3193 (95.8%) were recovered from adults and 141 (4.2%) from children. In adults alone, GNB presented 48.9% and GPB 51.1% of the 6248 clinical isolates. In children only, GNB presented 60.8% and GPB 39.2% of 360 clinical isolates (Table I).

TABLE I
The Distribution of Pathologic Bacterial Growth in Clinical Samples from Patients Treated at Iraqi Health-Care Facilities

All clinical cases	No. of pathogenic bacteria (%)	No. of negative growth (%)	Total (%)
	6608 (57.0)	4984 (43.0)	11592 (100)
Pathogenic isolates	No. (%)	Adults out of total	Children out of total
GNB	3274 (49.5)	3055 (93.3)	219 (6.7)
GPB	3334 (50.5)	3193 (95.8)	141 (4.2)
Total	6608	6248 (94.6)	360 (5.4)
	Adults only	Type of bacteria	No. of isolates
	6248 (94.6)	GNB	3055 (48.9)
		GPB	3193 (51.1)
	Children only	Type of bacteria	No. of isolates
	360 (5.4)	GNB	219 (60.8)
		GPB	141 (39.2)

GNB: Gram-negative bacteria; GPB: Gram-positive bacteria

The data also show that *K. pneumoniae* and *S. aureus* are among the most common GNB and GPB isolates, respectively, among the adult patients who attended Iraqi hospitals. In adult patients, it was also observed that the least detected GNB was *Acinetobacter haemolyticus*, and the least detected GPB was *Streptococcus alactolyticus*

http://dx.doi.org/10.14500/aro.11689

TABLE II
PREVALENCE OF GNB AND GPB IN ISOLATED SAMPLES OBTAINED FROM ADULTS AND CHILDREN PATIENTS IN IRAQI HEALTH-CARE FACILITIES

Adults						Children patients					
GNB	No.	%	GPB	No.	%	GNB	No.	%	GPB	No.	%
Klebsiella pneumoniae	921	30.1	*Staphylococcus aureus*	1304	40.8	*Klebsiella pneumoniae*	83	37.9	*Staphylococcus haemolyticus*	59	41.8
Pseudomonas aeruginosa	862	28.2	*Enterococcus faecalis*	443	13.9	*Pseudomonas aeruginosa*	51	23.3	*Staphylococcus aureus*	52	36.9
Acinetobacter baumannii	307	10	*Staphylococcus epidermidis*	417	13.1	*Acinetobacter baumannii*	37	16.9	*Staphylococcus epidermidis*	30	21.3
Proteus mirabilis	270	8.8	*Staphylococcus haemolyticus*	411	12.9	*Proteus mirabilis*	25	11.4	Total	141	100
Enterobacter cloacae	166	5.4	*Streptococcus agalactiae*	213	6.7	*Enterobacter cloacae*	23	10.5			
Salmonella typhi	88	2.9	*Staphylococcus hominis*	191	6	Total	219	100			
Serratia marcescens	82	2.7	*Streptococcus pneumoniae*	99	3.1						
Klebsiella oxytoca	65	2.1	*Enterococcus faecium*	78	2.4						
Sphingomonas paucimobilis	58	1.9	*Streptococcus alactolyticus*	19	0.6						
Morganella morganii	37	1.2	*Staphylococcus saprophyticus*	18	0.6						
Enterobacter aerogenes	34	1.1	Total	3193	100						
Acinetobacter lwoffii	26	0.9									
Citrobacter freundii	24	0.8									
Serratia fonticola	21	0.7									
Pseudomonas fluorescens	19	0.6									
Pseudomonas luteola	19	0.6									
Shigella dysenteriae	16	0.5									
Achromobacter denitrificans	14	0.5									
Escherichia coli	14	0.5									
Acinetobacter haemolyticus	12	0.4									
Total	3055	100									

GNB: Gram-negative bacteria; GPB: Gram-positive bacteria

and *Staphylococcus saprophyticus* (Tables II, S1-S3). *K. pneumoniae* was the predominant Gram-negative bacillus identified in pediatric patients, similar to adults. In regard to GPB, unlike adult patients, children showed *Staphylococcus haemolyticus* as the most common pathogenic bacteria. For children, the GNB, *Enterobacter cloacae*, and the GPB, *S. epidermidis*, were among the least detected pathogens (Tables II and S3).

The most resistant GNBs toward antibiotics in adults were *E. coli* and *Proteus mirabilis*. Whereas the first one was resistant to ampicillin, ceftriaxone, cefazolin, cefepime, and cefoxitin, the second one was resistant to ampicillin, trimethoprim/sulfamethoxazole, tetracycline, trimethoprim, and colistin. Furthermore, the GNBs that were resistant only to one type of antibiotic were *A. baumannii* (resistant to cefazolin), *Klebsiella oxytoca* (resistant to ampicillin), *Morganella morganii* (resistant to trimethoprim/sulfamethoxazole), and *Serratia marcescens* (resistant to cefazolin). Meanwhile, the most resistant GPB toward antibiotics in adults were *S. aureus*, *S. epidermidis*, *S. haemolyticus*, and *Staphylococcus hominis*, as they were all resistant to erythromycin, oxacillin, and benzylpenicillin. The least resistant GPBs were *Enterococcus faecium* and *Streptococcus agalactiae*, as they were both resistant only to tetracycline (Tables III and S1-S3).

In children, the situation was different, as the most resistant GNB was *K. pneumoniae* for resisting ampicillin, chloramphenicol, and cefoxitin, and the least resistant one was *Pseudomonas aeruginosa* for resisting nafcillin antibiotic only. Furthermore, for children, *S. epidermidis* and *S. haemolyticus* were the only spotted resistant pathogenic GPBs that were resistant to benzylpenicillin (Tables III and S3).

Collectively, while the most resisted antibiotic in GNB of the pathogenic isolates recovered from adults and children patients was ampicillin, the most resisted antibiotic in GPB was oxacillin in adults and benzylpenicillin in children (Table IV).

Nitrofurantoin was the least resisted antibiotic by GNB in adult and children isolates, being tolerated only by 5.8% and 10% of the isolates, respectively. For GPB isolates recovered from adults and children, linezolid and doripenem were the least resisted by 6.8% and 21.3%, respectively (Table IV).

B. Discussion

The prevalence and rates of AMR among human populations vary, and this is due to socioeconomic factors, the rate of antibiotic consumption, access to clean water, sanitation, the rate of vaccination, and an efficient health-care system (Sriram, et al., 2021; Allel, et al., 2023). Lately, alarming signals of AMR have arisen in Iraq, necessitating thorough investigations to understand the scale of this dilemma. To better understand this issue and to cover as many clinical cases as possible, we have collected data from different public hospitals and private laboratories in Iraq. At the end of the collection process, a total of 11592 clinical records were retrieved and analyzed.

Our investigations showed that out of all recorded cases (from adults and children), 4984 were negative for bacterial growth (Table I). This may indicate that 43.0% of all clinical cases who suffered from certain health conditions were not caused by pathogenic bacteria, but still, their samples went through microbiology laboratories for suspected bacterial infections. In spite of the fact that this rate may be somehow

TABLE III
THE MOST RESILIENT GNB AND GPB WERE RECOVERED FROM BOTH ADULT AND CHILDREN PATIENTS IN IRAQI HEALTH-CARE FACILITIES*

GNB isolated from adults	Resisted antibiotics				
Escherichia coli	AM-Ampicillin	CRO-Ceftriaxone	CZ-Cefazolin	FEP-Cefepime	FOX-Cefoxitin
Proteus mirabilis	AM-Ampicillin	SXT-Trimethoprim/ Sulfamethoxazole	TE-Tetracycline	TMP-Trimethoprim	CS-Colistin
Klebsiella pneumoniae	AM-Ampicillin	CZ-Cefazolin	PIP-Piperacillin	TIC-Ticarcillin	
Serratia fonticola	CIP-Ciprofloxacin	CRO-Ceftriaxone	CZ-Cefazolin	LEV-Levofloxacin	
Enterobacter cloacae	CS-Colistin	CZ-Cefazolin	FOX-Cefoxitin		
Pseudomonas aeruginosa	AM-Ampicillin	CZ-Cefazolin	DOR-Doripenem		
Enterobacter aerogenes	CRO-Ceftriaxone	CZ-Cefazolin			
Morganella morganii	AM-Ampicillin	CZ-Cefazolin			
Salmonella typhi	AM-Ampicillin	CZ-Cefazolin			
Acinetobacter baumannii	CZ-Cefazolin				
Klebsiella oxytoca	AM-Ampicillin				
Morganella morganii	SXT-Trimethoprim/ Sulfamethoxazole				
Serratia marcescens	CZ-Cefazolin				
GPB isolated from adults	Resisted Antibiotics				
Staphylococcus aureus	E-Erythromycin	OX1-Oxacillin	P-Benzylpenicillin		
Staphylococcus epidermidis	E-Erythromycin	OX1-Oxacillin	P-Benzylpenicillin		
Staphylococcus haemolyticus	E-Erythromycin	OX1-Oxacillin	P-Benzylpenicillin		
Staphylococcus hominis	E-Erythromycin	OX1-Oxacillin	P-Benzylpenicillin		
Enterococcus faecium	E-Erythromycin	LEV-Levofloxacin			
Staphylococcus saprophyticus	E-Erythromycin	OX1-Oxacillin			
Streptococcus pneumoniae	E-Erythromycin	TE-Tetracycline			
Enterococcus faecalis	E-Erythromycin	TE-Tetracycline			
Streptococcus alactolyticus	E-Erythromycin	TE-Tetracycline			
Enterococcus faecium	TE-Tetracycline				
Streptococcus agalactiae	TE-Tetracycline				
GNB isolated from in Children patients	Resisted Antibiotics				
Klebsiella pneumoniae	AM-Ampicillin	C-Chloramphenicol	FOX-Cefoxitin		
Acinetobacter baumannii	FOX-Cefoxitin	Nafcillin			
Enterobacter cloacae	FOX-Cefoxitin	Nafcillin			
Pseudomonas aeruginosa	Nafcillin				
GPB isolated from Children patients	Resisted Antibiotics				
Staphylococcus epidermidis	P-Benzylpenicillin				
Staphylococcus haemolyticus	P-Benzylpenicillin				

*This table displays only the isolates that have shown a resistance of 70% or higher to the specified antibiotic (s)

scary, similar and even higher ones have been reported in previous studies (Ibrahim, 2018; Al-Naqshbandi, et al., 2019; Allami, et al., 2021). The number of negative results may eventually cause tremendous pressure on hospitals with regard to time, effort, and resources. Thus, physicians may need to be more careful before deciding which cases should be sent to laboratories for analysis.

Our data also show that the distribution of the recovered isolates into GNB and GPB in adults was different than what has been seen in children, with 48.9% of GNB and 51.1% of GPB recovered from adults and 60.8% of GNB and 39.2% of GPB recovered from children (Table I). In this context, previous studies have shown that these values vary and fluctuate depending on age, sex, and site of infection (Lambers, et al., 2006; Allami, et al., 2021). Even within children, these fluctuations could be detected easily. For instance, Li, et al. (2021) reported that GPB represented more than 60% of all microorganisms isolated from cerebrospinal fluids; Dharmapalan, et al. (2017) explained in their study that 53.3% of bacteremia is promoted by GNB; Le Doare, et al. (2015) suggested that 66% of all isolates recovered from children suffering from sepsis were of GNB; Ibrahim, (2018) uncovered that GNBs were isolated from more than 80% of all clinical cases attended intensive care units (ICU); and Salman, et al. (2022) concluded that GNB is more common in UTI.

Our analysis of children's patients' data also showed that the most common GNB and GPB were *K. pneumoniae* and *S. haemolyticus*, respectively. Moreover, the least detected GNB and GPB were *E. cloacae* and *S. epidermidis*, respectively. These findings were somehow consistent with previous studies, but the site of infection was found to be the most crucial factor in determining the prevalence of the recovered microorganism. GNBs such as *E. coli*, *Klebsiella* spp., *Shigella* spp., and *Pseudomonas* spp. are usually associated with digestive tract problems, and GPBs are rarely reported to be involved in such cases (Lambers, et al., 2006; Allami, et al., 2021). For the high rates of *Klebsiella* spp. detection (besides other multidrug-resistant [MDR] GNB) in children, Labib, et al. (2018) and Ibrahim, (2018) reported similar results for cases attending ICUs. Furthermore, Badry, Jameel and Mero (2014) reported that *Klebsiella* spp. placed second, after *E. coli*, for diarrheal children attending

TABLE IV
THE OVERALL RESISTANCE OF ISOLATED GNB AND GPB TO ANTIMICROBIALS IN SAMPLES COLLECTED FROM ADULT AND CHILDREN PATIENTS WHO WERE ADMITTED TO IRAQI HEALTH-CARE FACILITIES

Adults							
GNB				GPB			
Antimicrobial	R%	Antimicrobial	R%	Antimicrobial	R%	Antimicrobial	R%
AM-Ampicillin	91.1	GM-Gentamicin	36.5	OX1-Oxacillin	86	MXF-Moxifloxacin	4.9
TMP-Trimethoprim	80	CAZ-Ceftazidime	35.7	P-Benzylpenicillin	83.9	DAP-Daptomycin	4
CZ-Cefazolin	77.8	FOS-Fosfomycin	35	E-Erythromycin	74.9	TGC-Tigecycline	1.5
DOR-Doripenem	72	FOX-Cefoxitin	35	FOS-Fosfomycin	68.2	FT-Nitrofurantoin	0.4
SPI-Piperacillin/Sulbactam	68	LEV-Levofloxacin	33	TE-Tetracycline	60.5		
CZA-Ceftazidime/Avibactam	66	TZP-Piperacillin/Tazobactam	31.6	CTX-Cefotaxime	34		
CT-Ceftolozane/Tazobactam	64	ETP-Ertapenem	31.6	MUP-Mupirocin	31.5		
TIC-Ticarcillin	62.2	CS-Colistin	30.9	CIP-Ciprofloxacin	30.3		
CRO-Ceftriaxone	57.1	ATM-Aztreonam	30.5	CM-Clindamycin	28.3		
PIP-Piperacillin	54	FEP-Cefepime	29.8	CRO-Ceftriaxone	25.4		
SAM-Ampicillin/Sulbactam	52.1	MNO-Minocycline	29.6	LEV-Levofloxacin	24.5		
SXT-Trimethoprim/Sulfamethoxazole	51	MXF-Moxifloxacin	27.3	FA-Fusidic Acid	21.4		
C-Chloramphenicol	50	IPM-Imipenem	24.6	GM-Gentamicin	20.4		
TE-Tetracycline	50	PEF-Pefloxacin	24.3	RA-Rifampicin	18.9		
AMC-Amoxicillin/Clavulanic Acid	44.8	MEM-Meropenem	24.2	SXT-Trimethoprim/sulfamethoxazole	18.9		
TCC-Ticarcillin/Clavulanic Acid	41	AN-Amikacin	21.9	TM-Tobramycin	18.3		
CXMA-Cefuroxime Axetil	40.9	TGC-Tigecycline	13	AM-Ampicillin	14		
CXM-Cefuroxime	40.9	FT-Nitrofurantoin	5.8	C-Chloramphenicol	12.1		
TM-Tobramycin	38.5			VA-Vancomycin	10.6		
CFM-Cefixime	38.1			TEC-Teicoplanin	8.6		
CIP-Ciprofloxacin	37.2			LNZ-Linezolid	6.8		

Children patients					
GNB				GPB	
Antimicrobial	R%	Antimicrobial	R%	Antimicrobial	R%
AM-Ampicillin	96.9	DO-Doxycycline	30.2	P-Benzylpenicillin	81.6
Nafcillin	87.8	ATM-Aztreonam	20.5	SXT-Trimethoprim/Sulfamethoxazole	29.2
FOX-Cefoxitin	77.8	RA-Rifampicin	19.2	DO-Doxycycline	25.8
CRO-Ceftriaxone	46.7	FT-Nitrofurantoin	10	SAM-Ampicillin/Sulbactam	21.8
C-Chloramphenicol	39			DOR-Doripenem	21.3
SXT-Trimethoprim/Sulfamethoxazole	37.5				
TIC-Ticarcillin	34.6				

R, Resistance; Percentages of R = (number of tests with R response/total number of tests)*100

hospitals in Duhok city. In a study that involved the isolation of bacteria from the blood stream of the pediatric population in India, *K. pneumoniae* and *S. aureus* placed first, GNB and GPB, respectively (Dharmapalan, et al., 2017).

This study also revealed that the most abundant GNB among adult patients was *K. pneumoniae*, and the least detected one was *A. haemolyticus*. For GPB in adults, the most common bacteria were *S. aureus*, and the least detected ones were *S. alactolyticus* and *S. saprophyticus*. As we explained with children's data, the site of infection in adults also plays an important role in explaining and comparing the prevalence of the above-mentioned GNB and GPB. Accordingly, in UTI patients, *E. coli* and *S. haemolyticus* were found to be the most prevalent GNB and GBP, respectively (Al-Naqshbandi, et al., 2019). While Raoofi, et al. (2023) reported that *E. coli* is the most dominant GNB in patients attending southern Iran hospitals, the majority of their data were extracted from UTI patients' records (Raoofi, et al., 2023). In a previous study of ours that covered isolates recovered from wound infections, GNB such as *E. coli* and *P. aeruginosa* and GPB such as *S. aureus* and *S. epidermidis* were found to be the dominant pathogenic bacteria (Al-Naqshbandi, et al., 2021). In patients with lower respiratory tract infections, GNBs such as *A. baumannii* and *S. marcescens* and GPBs such as *S. parasanguinis* were among the most dominant pathogen isolates recovered in Erbil (Chawsheen, et al., 2020). Al-Jebouri and Mdish (2019) showed that GPBs were isolated from more than half of patients diagnosed with bacteriospermia, and the most dominant one was *S. aureus*. GNBs such as *E. coli*, *E. faecalis*, *K. pneumoniae*, *S. saprophyticus*, *P. mirabilis*, and *Neisseria gonorrhoeae* were also recovered from the semen of patients suffering from infertility problems (Al-Jebouri and Mdish, 2019).

We also evaluated the response of the detected pathogenic bacteria to a variety of antibiotics. Our data show that the most resilient GNB recovered from adults were *E. coli* and *P. mirabilis*, as the first one was resistant to ampicillin, ceftriaxone, cefazolin, cefepime, and cefoxitin, and the second one was resistant to ampicillin, trimethoprim/sulfamethoxazole, tetracycline, trimethoprim, and colistin. On the other hand, the most resilient GPBs were *S. aureus*, *S. epidermidis*, *S. haemolyticus*, and *S. hominis*, as all

of them were resistant to erythromycin, oxacillin, and benzylpenicillin. In regard to GNB recovered from children, *K. pneumoniae* was the most resilient, being resistant to ampicillin, chloramphenicol, and cefoxitin. *S. epidermidis* and *S. haemolyticus* were GPB recovered from children, and both were resistant to benzylpenicillin (Table S3). For the way that GNBs responded to ampicillin, previous studies reported similar results to ours. However, for the other antibiotics and bacteria, different results were reported. These studies indicated that antibiotics that were found to be ineffective in the Iraqi environment do not necessarily have the same outcomes in other countries (that is, the pathogenic isolates of the Iraqi environments are not identical to the same type of bacteria in other places in the world, and they do not respond to antibiotics in a similar way). This is mainly a reflection of the quality of health-care systems and the antibiotic prescribing guidelines that have been applied in these counties, which have definitely played a crucial role in diminishing AMR (Dharmapalan, et al., 2017; Li, et al., 2021; Alhumaid, et al., 2021). Furthermore, our findings clearly indicate the presence of MDR pathogenic bacteria among children and adult patients alike in Iraqi communities, and this is in agreement with previous studies reporting the same problem in the same or other locations within Iraq (Chawsheen, et al., 2020; Al-Naqshbandi, et al., 2021; Allami, et al., 2021; Hamza and Omran, 2022; Al-Hasani Al-Rubaye and Abdelhameed, 2023).

E. coli, for instance, is well known for being resistant to a wide range of antibiotics and at higher rates to ampicillin (Nji, et al., 2021). The mechanisms by which this bacterium acquires resistance toward different antibiotics include extended-spectrum β-lactamases, carbapenemases, 16S rRNA methylases, plasmid-mediated quinolone resistance genes, and mcr genes (Poirel, et al., 2018). Another study reported that in several clinical cases, *E. coli*, *P. mirabilis*, and *K. pneumoniae* showed the existence of plasmid ampC (pAmpC) in their genetic makeup (Santiago, et al., 2020).

For GPB, Xu, et al. (2020) reported in their study that many of their isolates of *S. epidermidis* and *S. aureus*, bearing MRSE, were associated with high resistance to penicillin and cefoxitin. The underlying mechanisms by which *S. aureus* and *S. epidermidis* show resistance toward antibiotics involve the following virulence genes: Staphyloxanthin crtN, hemolysin genes, capsular cap8H, toxic shock toxin tst, enterotoxin sea, mecA, dfrG, tet, ermA, ermB, and ermC (Ogundipe, et al., 2020; Derakhshan, Navidinia and Haghi, 2021; Mazloumi, Akbari and Yousefi, 2021).

Our evaluation of antibacterial resistance for all tested antibiotics "collectively" revealed that ampicillin, trimethoprim, cefazolin, and doripenem were resisted by 91.1, 80, 77.8, and 72%, respectively, of all GNB in adults. Our data also show that oxacillin, benzylpenicillin, and erythromycin were resisted by 86, 83.9, and 74.9%, respectively, by all GPB isolates. Among the children, these rates were different, as ampicillin, nafcillin, and cefoxitin were resisted by 96.9, 87.8, and 77.8%, respectively, by all GNBs, and benzylpenicillin was resisted by 81.6% of GPB (Table IV). These data suggest that the above-mentioned antibiotics are becoming inefficient in treating infections caused by related pathogenic bacteria, and their prescriptions should be avoided through establishing a national guideline to overcome the AMR problem in Iraq.

The ineffectiveness of benzylpenicillin in fighting microorganisms isolated from children is a worldwide phenomenon that may require a profound measure to overcome it (Sivasankar, Goldman and Hoffman, 2023). Moreover, nitrofurantoin was found to be the least resisted antibiotic by GNB and GPB in adult and children patients. Accordingly, this drug could be recognized as the most effective drug against both GNB and GPB and may play an important role in eradicating the most resilient pathogenic bacteria in Iraqi hospitals. Nevertheless, this performance could be due to the low consumption and prescription rates of this antibiotic in Iraqi communities in comparison with other drugs, as a recent study indicates the emergence of AMR among UTI patients in association with this nitrofurantoin (Vallée, et al., 2023).

There is another threat that participates in accelerating AMR development, which is the spread of pandemics. The empirical approach to treating patients during the COVID-19 outbreak through unnecessary antibiotic prescriptions or usage, either by ordinary people or professionals, was found to contribute effectively to AMR progression (Raoofi, et al., 2023; Rehman, 2023).

To promote health-care system efficiency in evaluating AMR in Iraq, the above-mentioned points should be taken seriously by the Ministry of Health. Moreover, by all means, the establishment of a uniform national antibiotic prescription guideline is a necessity to overcome the AMR challenge in this country; otherwise, it may get out of control and become a live-threat problem in the near future.

Limitation of the study

The authors of this study encountered the challenge of non-uniform records when collecting data from hospitals and laboratories in different governorates. Accordingly, they were unable to compare rates of prevalence of bacteria that are normally associated with certain sites of infection to their rates in previous studies "easily." In addition, the targeted hospitals and laboratories have been using different AST kits of VITEK®2 compact systems, which has further complicated the interpretation of the extracted data.

IV. Conclusion

The outcome of this study indicates that more than 40% of clinical cases were not caused by bacterial infection, and it also confirms the persistence of AMR among Iraqi communities. This study uncovered the existence of GNB- and GPB-MDR pathogens in adults and children patients, respectively. Whereas in adults, *E. coli*, *P. mirabilis*, *K. pneumoniae*, *Serratia fonticola*, *E. cloacae*, *P. aeruginosa*, *S. aureus*, *S. epidermidis*, *S. haemolyticus*, and *S. hominis* were all identified as MDR pathogens, in children, *K. pneumoniae* was the only detected MDR pathogen.

Moreover, in adults, ampicillin and oxacillin have been recognized as ineffective drugs and trimethoprim, cefazolin, doripenem, oxacillin, benzylpenicillin, and erythromycin as highly resisted ones. In children, the detected bacteria were found to be highly resistant to ampicillin, nafcillin, cefoxitin, and benzylpenicillin. Moreover, nitrofurantoin was recognized as the most effective antibacterial drug against GNB and GPB in children and adults alike. Finally, this study supports the idea of running AMR surveillance at regular time intervals and establishing national antibiotic prescription guidelines to manage and overcome this problem in Iraq.

Supplementary Data

The supplementary data can be found at the end of this document.

Acknowledgment

We would like to express our gratitude to the directors and heads of laboratories at Baghdad Hospital, Central Children Hospital, and Al-Buraq Lab (Baghdad); Al-Ramadi Hospital and Al-Ramadi Children Hospital (Al-Anbar); Al-Karama Hospital (Wasit); Babylon Hospital (Babil); Al-Sadr General Hospital (Maysan); Al-Hakeem Hospital, Al-Sadar Hospital, and Al-Amal Lab (Al-Najaf); and Al-Hussain Hospital (Dhi-Qar) for their assistance during the data collection process.

References

Abou Fayad, A., Rizk, A., El Sayed, S., Kaddoura, M., Jawad, N.K., Al-Attar, A., Dewachi, O., Nguyen, V.K., and Sater, Z.A., 2023. Antimicrobial resistance and the Iraq wars: Armed conflict as an underinvestigated pathway with growing significance. *BMJ Global Health*, 7, p.e010863.

Al-Hasani, H., Al-Rubaye, D., and Abdelhameed, A., 2023. The emergence of multidrug-resistant (MDR), extensively drug-resistant (XDR), and Pandrug-resistant (PDR) In Iraqi clinical isolates of *Escherichia coli*. *Journal of Population Therapeutics and Clinical Pharmacology*, 30, pp.469-482.

Alhumaid, S., Al Mutair, A., Al Alawi, Z., Alzahrani, A.J., Tobaiqy, M., Alresasi, A.M., Bu-Shehab, I., Al-Hadary, I., Alhmeed, N., Alismail, M., Aldera, A.H., Alhbabi, F., Al-Shammari, H., Rabaan, A.A., and Al-Omari, A., 2021. Antimicrobial susceptibility of gram-positive and gram-negative bacteria: A 5-year retrospective analysis at a multi-hospital healthcare system in Saudi Arabia. *Annals of Clinical Microbiology and Antimicrobials*, 20, p.43.

Al-Jebouri, M.M., and Mdish, S.A., 2019. Tracing of antibiotic-resistant bacteria isolated from semen of Iraqi males with primary infertility. *Open Journal of Urology*, 9, pp.19-29.

Al-Jumaily, E.F.A., and Zgaer, S.H., 2016. Multidrug resistant *Proteus mirabilis* isolated from urinary tract infection from different hospitals in Baghdad City. *International Journal of Current Microbiology and Applied Sciences*, 5, pp.390-399.

Allami, M., Mohammed, E.J., Alazzawi, F., and Bahreini, M., 2021. Prevalence and antibiotic resistance pattern of pathogenic bacteria isolated from urinary tract infections in Qal'at Saleh Hospital, Iraq. *Avicenna Journal of Clinical Microbiology and Infection*, 8, pp.117-122.

Allel, K., Day, L., Hamilton, A., Lin, L., Furuya-Kanamori, L., Moore, C.E., Van Boeckel, T., Laxminarayan, R., and Yakob, L., 2023. Global antimicrobial-resistance drivers: An ecological country-level study at the human-animal interface. *The Lancet Planetary Health*, 7, pp.e291-e303.

Al-Naqshbandi, A.A., Chawsheen, M.A., and Abdulqader, H.H., 2019. Prevalence and antimicrobial susceptibility of bacterial pathogens isolated from urine specimens received in Rizgary hospital-Erbil. *Journal of Infection and Public Health,* 12, pp.330-336.

Al-Naqshbandi, A.A., Hassan, H.A., Chawsheen, M.A., and Abdul Qader, H.H., 2021. Categorization of Bacterial Pathogens Present in Infected Wounds and their Antibiotic Resistance Profile Recovered from Patients Attending Rizgary Hospital-Erbil. *Aro-the Scientific Journal of Koya University*, 9, pp.64-70.

Badry, A., Jameel, A., and Mero, W., 2014. Pathogenic microorganisms associated with diarrhea in infants and children in Duhok Province, Kurdistan Region/Iraq. *Science Journal of University of Zakho*, 2, pp.266-275.

Bhatia, R., and Ichhpujani, R.L., 2008. *Essentials of Medical Microbiology*. Jaypee Brothers Medical Publishers, New Delhi, p.47.

Borgio, J.F., Rasdan, A.S., Sonbol, B., Alhamid, G., Almandil, N.B., and Abdulazeez, S., 2021. Emerging status of multidrug-resistant bacteria and fungi in the Arabian Peninsula. *Biology* (*Basel*), 10, p.1144.

Chawsheen, M.A., Al-Naqshbandi, A.A., and Abdulqader, H.H., 2020. Bacterial profile and antimicrobial susceptibility of isolates recovered from lower respiratory tract infection for patients in Rizgary Hospital, Erbil. *Aro-the Scientific Journal of Koya University*, 8, pp.64-70.

Coque, T., Graham, D., Pruden, A., So, A., Topp, E., Echeverria, A., Vaughn Grooters, S., Halpaap, A., Hanna, N., and Salazar, M., 2023. *Bracing for Superbugs: Strengthening Environmental Action in the One Health Response to Antimicrobial Resistance*. UNEP-UN Environment Programme. Available from: https://www.unep.org/resources/superbugs/environmental-action [Last accessed on 2023 Sep 30].

Derakhshan, S., Navidinia, M., and Haghi, F., 2021. Antibiotic susceptibility of human-associated *Staphylococcus aureus* and its relation to agr typing, virulence genes, and biofilm formation. *BMC Infectious Diseases*, 21, p.627.

Dharmapalan, D., Shet, A., Yewale, V., and Sharland, M., 2017. High reported rates of antimicrobial resistance in Indian neonatal and pediatric blood stream infections. *Journal of the Pediatric Infectious Diseases Society*, 6, pp.e62-e68.

Hamza, O.A., and Omran, R., 2022. Prevalence of multi-antibiotic resistant bacteria isolated from children with urinary tract infection from Baghdad, Iraq. *Journal of Biosciences and Medicines*, 10, pp.240-252.

Häsler, R., Kautz, C., Rehman, A., Podschun, R., Gassling, V., Brzoska, P., Sherlock, J., Gräsner, J.T., Hoppenstedt, G., Schubert, S., Ferlinz, A., Lieb, W., Laudes, M., Heinsen, F.-A., Scholz, J., Harmsen, D., Franke, A., Eisend, S., Kunze, T., Fickenscher, H., Ott, S., Rosenstiel, P., and Schreiber, S., 2018. The antibiotic resistome and microbiota landscape of refugees from Syria, Iraq and Afghanistan in Germany. *Microbiome*, 6, p.37.

Hassan, S.K., Dahmash, E.Z., Madi, T., Tarawneh, O., Jomhawi, T., Alkhob, W., Ghanem, R., and Halasa, Z., 2023. Four years after the implementation of antimicrobial stewardship program in Jordan: Evaluation of program's core elements. *Frontiers in Public Health*, 11, p.1078596.

Ibrahim, M.E., 2018. High antimicrobial resistant rates among Gram-negative pathogens in intensive care units. *Saudi Medical Journal*, 39, pp.1035-1043.

Labib, J.R., Ibrahim, S.K., Salem, M.R., Youssef, M.R.L., and Meligy, B., 2018. Infection with gram-negative bacteria among children in a tertiary pediatric hospital in Egypt. *American Journal of Infection Control,* 46, pp.798-801.

Lambers, H., Piessens, S., Bloem, A., Pronk, H., and Finkel, P., 2006. Natural skin surface pH is on average below 5, which is beneficial for its resident flora. *International Journal of Cosmetic Science,* 28, pp.359-370.

Le Doare, K., Bielicki, J., Heath, P.T., and Sharland, M., 2015. Systematic review of antibiotic resistance rates among gram-negative bacteria in children with sepsis in resource-limited countries. *Journal of the Pediatric Infectious Diseases Society*, 4, pp.11-20.

Li, D., Zhang, X., Wang, Y., Xue, J., Ji, X., Shao, X., and Li, Y., 2021. Epidemiology and drug resistance of pathogens isolated from cerebrospinal fluids

at a children's medical center in Eastern China during 2006-2020. *Infection and Drug Resistance*, 14, pp.5417-5428.

Martínez, J.L., Coque, T.M., and Baquero, F., 2014. What is a resistance gene? Ranking risk in resistomes. *Nature Reviews Microbiology*, 13, pp.116-123.

Mazloumi, M.J., Akbari, R., and Yousefi, S., 2021. Detection of inducible clindamycin resistance genes (ermA, ermB, and ermC) in *Staphylococcus aureus* and *Staphylococcus epidermidis*. *Microbiology and Biotechnology Letters*, 49, pp.449-457.

Murray, C.J.L., Ikuta, K.S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E., Johnson, S.C., Browne, A.J., Chipeta, M.G., Fell, F.,… and., Naghavi, M., 2022. Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *The Lancet*, 399, pp.629-655.

Nji, E., Kazibwe, J., Hambridge, T., Joko, C.A., Larbi, A.A., Damptey, L.A.O., Nkansa-Gyamfi, N.A., Stålsby Lundborg, C., and Lien, L.T.Q., 2021. High prevalence of antibiotic resistance in commensal *Escherichia coli* from healthy human sources in community settings. *Scientific Reports*, 11, p.3372.

Ogundipe, F.O., Ojo, O.E., Feßler, A.T., Hanke, D., Awoyomi, O.J., Ojo, D.A., Akintokun, A.K., Schwarz, S., and Maurischat, S., 2020. Antimicrobial resistance and virulence of methicillin-resistant *Staphylococcus aureus* from human, chicken and environmental samples within live bird markets in three Nigerian Cities. *Antibiotics*, 9, p.588.

Poirel, L., Madec, J.Y., Lupo, A., Schink, A.K., Kieffer, N., Nordmann, P., Schwarz, S., Aarestrup, F.M., Schwarz, S., Shen, J., and Cavaco, L., 2018. Antimicrobial resistance in *Escherichia coli*. *Microbiology Spectrum*, 6.

Raoofi, R., Namavari, N., Rahmanian, V., and Dousthaghi, M.H., 2023. Evaluation of antibiotics resistance in Southern Iran in light of COVID□19 pandemic: A retrospective observational study. *Health Science Reports*, 6, p.e1153.

Raouf, F.E.A., Benyagoub, E., Alkhudhairy, M.K., Akrami, S., and Saki, M., 2022. Extended-spectrum beta-lactamases among Klebsiella pneumoniae from Iraqi patients with community-acquired pneumonia. *Revista da Associação Médica Brasileira*, 68, pp.833-837.

Rehman, S., 2023. A parallel and silent emerging pandemic: Antimicrobial resistance (AMR) amid COVID-19 pandemic. *Journal of Infection and Public Health*, 16, pp.611-617.

Ruan, Z., Bizri, A.R., El-Fattah, A.A., Bazaraa, H.M., Al Ramahi, J.W., Matar, M., Ali, R.A.N., El Masry, R., Moussa, J., Abbas, A.J.A., and Aziz, M.A., 2023. Antimicrobial resistance landscape and COVID-19 impact in Egypt, Iraq, Jordan, and Lebanon: A survey-based study and expert opinion. *PLoS One*, 18, p.e0288550.

Salman, H.A., Alhameedawi, A.K., Muhamad, S.M.S.G., and Taha, Z., 2022. Prevalence of multi-antibiotic resistant bacteria isolated from children with urinary tract infection from Baghdad, Iraq. *Microbiology and Biotechnology Letters*, 50, pp.147-156.

Santiago, G.S., Gonçalves, D., Da Silva Coelho, I., De Mattos De Oliveira Coelho, S., and Neto Ferreira, H., 2020. Conjugative plasmidic AmpC detected in Escherichia coli, Proteus mirabilis and *Klebsiella pneumoniae* human clinical isolates from Portugal. *Brazilian Journal of Microbiology*, 51, pp.1807-1812.

Sivasankar, S., Goldman, J.L., and Hoffman, M.A., 2023. Variation in antibiotic resistance patterns for children and adults treated at 166 non-affiliated US facilities using EHR data. *JAC-Antimicrobial Resistance*, 5, p.dlac128.

Sriram, A., Kalanxhi, E., Kapoor, G., Craig, J., Balasubramanian, R., Brar, S., Criscuolo, N., Hamilton, A., Klein, E., and Tseng, K., 2021. State of the world's antibiotics 2021: A global analysis of antimicrobial resistance and its drivers. Center for Disease Dynamics, Economics and Policy, Washington, DC, USA, pp.1-115.

Torumkuney, D., Behbehani, N., Van Hasselt, J., Hamouda, M., and Keles, N., 2022a. Country data on AMR in Kuwait in the context of community-acquired respiratory tract infections: Links between antibiotic susceptibility, local and international antibiotic prescribing guidelines, access to medicine and clinical outcome. *Journal of Antimicrobial Chemotherapy,* 77, pp.i77-i83.

Torumkuney, D., Dolgum, S., Van Hasselt, J., Abdullah, W., and Keles, N., 2022b. Country data on AMR in Saudi Arabia in the context of community-acquired respiratory tract infections: Links between antibiotic susceptibility, local and international antibiotic prescribing guidelines, access to medicine and clinical outcome. *Journal of Antimicrobial Chemotherapy*, 77, pp.i70-i76.

Vallée, M., Harding, C., Hall, J., Aldridge, P.D., and Tan, A., 2023. Exploring the *in situ* evolution of nitrofurantoin resistance in clinically derived uropathogenic *Escherichia col*i isolates. *Journal of Antimicrobial Chemotherapy*, 78, pp.373-379.

World Bank (WB), 2017. *Drug-Resistant Infections: A Threat to Our Economic Future. International Bank for Reconstruction and Development*. The World Bank, United States.

World Health Organization (WHO), 2021. *Antimicrobial Resistance*. World Health Organization. Available from: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance [Last accessed on 2023 Jan 01].

Xu, Z., Cave, R., Chen, L., Yangkyi, T., Liu, Y., Li, K., Meng, G., Niu, K., Zhang, W., Tang, N., Shen, J., and Mkrtchyan, H.V., 2020. Antibiotic resistance and molecular characteristics of methicillin-resistant *Staphylococcus epidermidis* recovered from hospital personnel in China. *Journal of Global Antimicrobial Resistance*, 22, pp.195-201.

Yıldız, S.S., Hekimoğlu, C.H., Sucaklı, M.B., Bakkaloğlu, Z., Çevik, Y.N., Ünaldı, Ö., Arslantürk, H., Zikusooka, M., Keçik, M., Nellums, L., and Elci, O.C., 2023. Community-acquired antimicrobial resistance among Syrian refugees and the local population in Türkiye. *European Journal of Public Health*, 33, pp.809-814.

ARO p-ISSN: 2410-9355, e-ISSN: 2307-549X

http://dx.doi.org/10.14500/aro.11689

Supplementary Data

TABLE S1
Responses Of Isolated Gnb To Different Antimicrobial Drugs In Iraqi Health-care Facilities

Antibiotics VS GNB	*Achromobacter denitrificans* No. (14) (%)	*Acinetobacter baumannii* No. (307) (%)	*Acinetobacter haemolyticus* No. (12) (%)	*Acinetobacter lwoffii* No. (26) (%)	*Citrobacter freundii* No. (24) (%)	*Enterobacter aerogenes* No. (34) (%)	*Enterobacter cloacae* No. (166) (%)	*Escherichia coli* No. (14) (%)	*Klebsiella oxytoca* No. (65) (%)	*Klebsiella pneumoniae* No. (921) (%)
AM-Ampicillin	NT	NT	NT	NT	NT	NT	NT	R9 (90), S1 (10)	R30 (76.92), S9 (23.08)	R454 (95.18), S23 (4.82)
AMC-Amoxicillin/Clavulanic Acid	NT	NT	NT	NT	NT	NT	R7 (63.64), S4 (36.36	NT	NT	R22 (36.07S39) (63.93)
AN-Amikacin	R5 (45.45S6) (54.55)	NT	R1 (10) S9 (90)	R1 (4.35), S22 (95.65	R0 (0) S17 (100)	R2 (8.33), S22 (91.67)	R20 (15.38), S110 (84.62)	R4 (28.57), S10 (71.43)	R4 (7.14), S52 (92.86)	R138 (23.83), S441 (76.17)
ATM-Aztreonam	NT	NT	NT	NT	NT	R3 (25), S9 (75)	R14 (21.21), S52 (78.79)	NT	R0 (0), S17 (100)	R126 (38.77), S199 (61.23)
CAZ-Ceftazidime	R1 (9.09), S10 (90.91)	R145 (60.42), S95 (39.58)	R2 (20), S8 (80)	R6 (27.27), S16 (72.73)	R5 (29.41), S12 (70.59)	R10 (40), S15 (60)	R34 (25) , S102 (75)	NT	R7 (12.5), S49 (87.5)	R295 (37.53), S491 (62.47)
CIP-Ciprofloxacin	R4 (36.36), S7 (63.64)	R153 (63.49), S88 (36.51)	R3 (30), S7 (70)	R1 (4.55), S21 (95.45)	R3 (17.65), S14 (82.35)	R11 (42.31), S15 (57.69)	R18 (12.95), S121 (87.05)	R7 (50), S7 (50)	R7 (12.5), S49 (87.5)	R269 (33.75), S528 (66.25)
CRO-Ceftriaxone	NT	R75 (66.37), S38 (33.63)	NT	NT	NT	R15 (83.33), S3 (16.67)	R44 (51.76), S41 (48.24)	R9 (90), S1 (10)	R12 (25), S36 (75)	R340 (61.15), S216 (38.85)
CS-Colistin	NT	R6 (4.69), S122 (95.31)	NT	R0 (0), S13 (100)	NT	NT	R78 (89.66), S9 (10.34)	NT	NT	R7 (14.58), S41 (85.42)
CZ-Cefazolin	NT	R101 (90.18), S11 (9.82)	NT	NT	NT	R17 (94.44), S1 (5.56)	R78 (89.66), S9 (10.34)	R9 (90), S1 (10)	R25 (52.08), S23 (47.92)	R411 (73.79), S146 (26.21)
ETP-Ertapenem	NT	NT	NT	NT	NT	R2 (11.11), S16 (88.89)	R21 (22.83), S71 (77.17)	NT	R3 (6.25), S45 (93.75)	R129 (23.04), S431 (76.96)
FEP-Cefepime	R5 (45.45), S6 (54.55)	R123 (52.56), S111 (47.44)	R0 (0), S10 (100)	R1 (4.35), S22 (95.65)	R3 (17.65), S14 (82.35)	R8 (32), S17 (68)	R30 (22.22), S105 (77.78)	R12 (85.71), S2 (14.29)	R3 (5.36), S53 (94.64)	R259 (32.74), S532 (67.26)
FOX-Cefoxitin	NT	NT	NT	NT	NT	R8 (57.14), S6 (42.86)	R48 (80), S12 (20)	R8 (80), S2 (20)	R9 (23.08), S30 (76.92)	R152 (36.28), S267 (63.72)
FT-Nitrofurantoin	NT	NT	NT	NT	NT	R0 (0), S15 (100)	R2 (2.9), S67 (97.1)	R3 (30), S7 (70)	R0 (0), S39 (100)	R17 (3.7), S443 (96.3)
GM-Gentamicin	R4 (36.36), S7 (63.64)	R129 (52.87), S115 (47.13)	R2 (20), S8 (80)	R0 (0), S21 (100)	R3 (17.65), S14 (82.35)	R10 (38.46), S16 (61.54)	R40 (28.78), S99 (71.22)	R7 (50), S7 (50)	R7 (12.5), S49 (87.5)	R293 (36.67), S506 (63.33)

Antibiotics VS GNB	*Achromobacter denitrificans* No. (14) (%)	*Acinetobacter baumannii* No. (307) (%)	*Acinetobacter haemolyticus* No. (12) (%)	*Acinetobacter lwoffii* No. (26) (%)	*Citrobacter freundii* No. (24) (%)	*Enterobacter aerogenes* No. (34) (%)	*Enterobacter cloacae* No. (166) (%)	*Escherichia coli* No. (14) (%)	*Klebsiella oxytoca* No. (65) (%)	*Klebsiella pneumoniae* No. (921) (%)
IPM-Imipenem	R0 (0), S11 (100)	R130 (54.39), S109 (45.61)	R0 (0), S10 (100)	R0 (0), S19 (100)	R0 (0), S17 (100)	R2 (8), S23 (92)	R26 (18.98), S111 (81.02)	R6 (42.86), S8 (57.14)	R3 (5.36), S53 (94.64)	R152 (19.24), S638 (80.76)
LEV-Levofloxacin	NT	R63 (52.94), S56 (47.06)	NT	NT	NT	R11 (57.89), S8 (42.11)	R10 (11.11), S80 (88.89)	R5 (50), S5 (50)	R6 (12.5), S42 (87.5)	R182 (32.21), S383 (67.79)
MEM-Meropenem	NT	R88 (55.7), S70 (44.3)	NT	R0 (0), S15 (100)	R0 (0), S11 (100)	R1 (9.09), S10 (90.91)	R10 (13.89), S62 (86.11)	NT	R0 (0), S17 (100)	R66 (20.31), S259 (79.69)
MNO-Minocycline	NT	R29 (22.31), S101 (77.69)	NT	R0 (0), S15 (100)	NT	NT	R5 (11.63), S38 (88.37)	NT	NT	R62 (27.56), S163 (72.44)
PEF-Pefloxacin	NT	NT	NT	NT	NT	NT	NT	NT	NT	R9 (18.75), S39 (81.25)
PIP-Piperacillin	NT	R87 (66.92), S43 (33.08)	NT	R5 (38.46), S8 (61.54)	NT	NT	R16 (34.04), S31 (65.96)	NT	NT	R188 (79.32), S49 (20.68)

(Contd...)

TABLE S1
(Continued)

Antibiotics VS GNB	*Achromobacter denitrificans* No. (14) (%)	*Acinetobacter baumannii* No. (307) (%)	*Acinetobacter haemolyticus* No. (12) (%)	*Acinetobacter lwoffii* No. (26) (%)	*Citrobacter freundii* No. (24) (%)	*Enterobacter aerogenes* No. (34) (%)	*Enterobacter cloacae* No. (166) (%)	*Escherichia coli* No. (14) (%)	*Klebsiella oxytoca* No. (65) (%)	*Klebsiella pneumoniae* No. (921) (%)
SAM-Ampicillin/Sulfactam	NT	R22 (53.66), S19 (46.34)	NT	NT	NT	NT	NT	NT	NT	R84 (59.15), S58 (40.85)
SXT-Trimethoprim/Sulfamethoxazole	R2 (18.18), S9 (81.82)	R119 (51.97), S110 (48.03)	NT	R1 (6.25), S15 (93.75)	R7 (43.75), S9 (56.25)	R16 (61.54), S10 (38.46)	R42 (30.88), S94 (69.12)	R9 (69.23), S4 (30.77)	R15 (26.79), S41 (73.21)	R436 (55.4), S351 (44.6)
TCC-Ticarcillin/Clavulanic Acid	NT	R79 (66.39), S40 (33.61)	NT	R1 (7.69), S12 (92.31)	NT	NT	R4 (11.76), S30 (88.24)	NT	NT	R60 (46.15), S70 (53.85)
TGC-Tigecycline	NT	R4 (3.7), S104 (96.3)	NT	NT	NT	R0 (0), S18 (100)	R2 (2.38), S82 (97.62)	R0 (0), S10 (100)	R0 (0), S48 (100)	R32 (6.26), S479 (93.74)
TIC-Ticarcillin	NT	R85 (69.11), S38 (30.89)	NT	R3 (25), S9 (75)	NT	NT	R14 (32.56 , S29 (67.44)	NT	NT	R206 (93.21), S15 (6.79)
TM-Tobramycin	NT	R83 (48.54), S88 (51.46)	NT	R0 (0), S18 (100)	NT	R3 (23.08), S10 (76.92)	R14 (19.18), S59 (80.82)	NT	R3 (17.65), S14 (82.35)	R149 (39.01), S233 (60.99)
TZP-Piperacillin/Tazobactam	R2 (18.18), S9 (81.82)	R154 (63.37), S89 (36.63)	R2 (20), S8 (80)	R3 (23.08), S10 (76.92)	R3 (18.75), S13 (81.25)	R9 (34.62), S17 (65.38)	R30 (22.56), S103 (77.44)	R9 (64.29), S5 (35.71)	R5 (8.93), S51 (91.07)	R245 (31.33), S537 (68.67)

Antibiotics VS GNB	*Morganella morganii* No. (37) (%)	*Proteus mirabilis* No. (270) (%)	*Pseudomonas aeruginosa* No. (862) (%)	*Pseudomonas fluorescens* No. (19) (%)	*Pseudomonas luteola* No. (19) (%)	*Salmonella typhi* No. (88) (%)	*Serratia fonticola* No. (21) (%)	*Serratia marcescens* No. (82) (%)	*Shigella dysenteriae* No. (16) (%)	*Sphingomonas paucimobilis* No. (58) (%)
AM-Ampicillin	R12 (100), S0 (0)	R58 (82.86), S12 (17.14)	R35 (79.55), S9 (20.45)	NT	NT	R30 (81.08), S7 (18.92)	NT	NT	NT	NT
AMC-Amoxicillin/Clavulanic Acid	NT	R4 (25), S12 (75)	R23 (62.16), S14 (37.84)	NT	NT	NT	NT	NT	NT	NT
AN-Amikacin	R2 (6.06), S31 (93.94)	R7 (5.07), S131 (94.93)	R195 (33.39), S389 (66.61)	R4 (30.77), S9 (69.23)	R2 (20), S8 (80)	R1 (1.82), S54 (98.18)	R1 (7.14), S13 (92.86)	R3 (6.12), S46 (93.88)	NT	R2 (5.88), S32 (94.12)
ATM-Aztreonam	R5 (21.74), S18 (78.26)	R15 (11.63), S114 (88.37)	NT	NT	NT	R22 (50), S22 (50)	NT	R6 (23.08), S20 (76.92)	NT	R10 (55.56), S8 (44.44)
C-Chloramphenicol	NT	R5 (50), S5 (50)	NT	NT	NT	NT	NT	NT	NT	NT
CAZ-Ceftazidime	R6 (17.14), S29 (82.86)	R69 (37.3), S116 (62.7)	R213 (32.08), S451 (67.92)	R0 (0), S13 (100)	R0 (0), S10 (100)	R49 (68.06), S23 (31.94)	R4 (30.77), S9 (69.23)	R6 (10.91), S49 (89.09)	R0 (0), S15 (100)	R5 (13.16), S33 (86.84)
CFM-Cefixime	NT	R6 (54.55), S5 (45.45)	NT	NT	NT	R2 (20), S8 (80)	NT	NT	NT	NT
CIP-Ciprofloxacin	R15 (42.86), S20 (57.14)	R78 (41.27) , S111 (58.73)	R309 (46.05), S362 (53.95)	R3 (25), S9 (75)	R2 (20), S8 (80)	R1 (1.37), S72 (98.63)	R10 (71.43), S4 (28.57)	R7 (12.73), S48 (87.27)	R0 (0), S13 (100)	R9 (23.68), S29 (76.32)
CRO-Ceftriaxone	R2 (11.11), S16 (88.89)	R55 (55.56), S44 (44.44)	R26 (55.32), S21 (44.68)	NT	NT	R32 (65.31), S17 (34.69)	R8 (80), S2 (20)	R14 (41.18), S20 (58.82)	NT	R3 (11.54), S23 (88.46)
CS-Colistin	NT	R22 (100), S0 (0)	R138 (27.06), S372 (72.94)	NT	NT	R0 (0), S14 (100)	NT	NT	NT	R6 (54.55), S5 (45.45)
CT-Ceftolozane/Tazobactam	NT	NT	R32 (64), S18 (36)	NT	NT	NT	NT	NT	NT	NT
CXM-Cefuroxime	NT	R7 (63.64), S4 (36.36)	NT	NT	NT	R2 (18.18), S9 (81.82)	NT	NT	NT	NT
CXMA-Cefuroxime axetil	NT	R7 (63.64), S4 (36.36)	NT	NT	NT	R2 (18.18), S9 (81.82)	NT	NT	NT	NT

(Contd...)

ARO p-ISSN: 2410-9355, e-ISSN: 2307-549X

http://dx.doi.org/10.14500/aro.11689

TABLE S1
(Continued)

Antibiotics VS GNB	*Achromobacter denitrificans* No. (14) (%)	*Acinetobacter baumannii* No. (307) (%)	*Acinetobacter haemolyticus* No. (12) (%)	*Acinetobacter lwoffii* No. (26) (%)	*Citrobacter freundii* No. (24) (%)	*Enterobacter aerogenes* No. (34) (%)	*Enterobacter cloacae* No. (166) (%)	*Escherichia coli* No. (14) (%)	*Klebsiella oxytoca* No. (65) (%)	*Klebsiella pneumoniae* No. (921) (%)
CZ-Cefazolin	R17 (94.44), S1 (5.56)	R60 (68.18), S28 (31.82)	R156 (89.66), S18 (10.34)	NT	NT	R29 (72.5), S11 (27.5)	R9 (90), S1 (10)	R34 (100), S0 (0)	NT	R4 (16), S21 (84)
CZA-Ceftazidime/Avibactam	NT	NT	R33 (66), S17 (34)	NT	NT	NT	NT	NT	NT	NT
DOR-Doripenem	NT	NT	R36 (72), S14 (28)	NT	NT	NT	NT	NT	NT	NT
ETP-Ertapenem	R2 (11.11), S16 (88.89)	R6 (6.67), S84 (93.33)	NT	NT	NT	R0 (0), S43 (100)	R1 (9.09), S10 (90.91)	R3 (8.33), S33 (91.67)	NT	NT
FEP-Cefepime	R3 (8.33), S33 (91.67)	R39 (19.7), S159 (80.3)	R180 (26.99), S487 (73.01)	R2 (16.67), S10 (83.33)	R0 (0), S10 (100)	R43 (55.13), S35 (44.87)	R3 (21.43), S11 (78.57)	R7 (12.73), S48 (87.27)	R0 (0), S14 (100)	R2 (6.06), S31 (93.94)
FOX-Cefoxitin	R0 (0), S11 (100)	R5 (8.93), S51 (91.07)	NT	NT	NT	R0 (0), S35 (100)	NT	R3 (13.64), S19 (86.36)	NT	NT

Antibiotics VS GNB	*Morganella morganii* No. (37) (%)	*Proteus mirabilis* No. (270) (%)	*Pseudomonas aeruginosa* No. (862) (%)	*Pseudomonas fluorescens* No. (19) (%)	*Pseudomonas luteola* No. (19) (%)	*Salmonella typhi* No. (88) (%)	*Serratia fonticola* No. (21) (%)	*Serratia marcescens* No. (82) (%)	*Shigella dysenteriae* No. (16) (%)	*Sphingomonas paucimobilis* No. (58) (%)
FT-Nitrofurantoin	R0 (0), S12 (100)	R0 (0), S69 (100)	R23 (52.27), S21 (47.73)	NT	NT	R0 (0), S36 (100)	NT	R0 (0), S27 (100)	NT	NT
GM-Gentamicin	R19 (54.29), S16 (45.71)	R55 (29.89), S129 (70.11)	R278 (41.55), S391 (58.45)	R2 (16.67), S10 (83.33)	R2 (20), S8 (80)	R2 (2.7), S72 (97.3)	R5 (33.33), S10 (66.67)	R14 (25.45), S41 (74.55)	R0 (0), S16 (100)	R7 (17.95), S32 (82.05)
IPM-Imipenem	R1 (2.86), S34 (97.14)	R18 (9.89), S164 (90.11)	R234 (35.45), S426 (64.55)	R4 (36.36), S7 (63.64)	R0 (0), S10 (100)	R0 (0), S69 (100)	R1 (7.69), S12 (92.31)	NT	R0 (0), S15 (100)	R2 (5.26), S36 (94.74)
LEV-Levofloxacin	R3 (15), S17 (85)	R31 (31), S69 (69)	R107 (46.93), S121 (53.07)	NT	NT	R2 (4), S48 (96)	R8 (80), S2 (20)	R2 (5.71), S33 (94.29)	NT	R5 (19.23), S21 (80.77)
MEM-Meropenem	R1 (4.35), S22 (95.65)	R3 (2.33), S126 (97.67)	R167 (31.45), S364 (68.55)	NT	NT	R0 (0), S46 (100)	R1 (20), S4 (80)	R1 (3.57), S27 (96.43)	R0 (0), S13 (100)	R2 (10.53), S17 (89.47)
MNO-Minocycline	R9 (56.25), S7 (43.75)	R66 (61.68), S41 (38.32)	R20 (45.45), S24 (54.55)	R1 (10), S9 (90)	NT	R0 (0), S36 (100)	NT	R4 (22.22), S14 (77.78)	R0 (0), S11 (100)	R2 (15.38), S11 (84.62)
MXF-Moxifloxacin	NT	R3 (27.27), S8 (72.73)	NT	NT	NT	NT	NT	NT	NT	NT
PEF-Pefloxacin	NT	R6 (50), S6 (50)	R3 (21.43), S11 (78.57)	NT	NT	NT	NT	NT	NT	NT
PIP-Piperacillin	R6 (35.29), S11 (64.71)	R48 (44.44), S60 (55.56)	R214 (43.76), S275 (56.24)	NT	NT	R24 (60), S16 (40)	NT	R10 (52.63), S9 (47.37)	NT	R2 (16.67), S10 (83.33)
SAM-Ampicillin/Sulbactam	NT	R13 (29.55), S31 (70.45)	R27 (65.85), S14 (34.15)	NT	NT	R2 (12.5 , S14 (87.5)	NT	NT	NT	NT
SPI-Piperacillin/Sulbactam	NT	NT	R34 (68), S16 (32)	NT	NT	NT	NT	NT	NT	NT
SXT-Trimethoprim/Sulfamethoxazole	R29 (82.86), S6 (17.14)	R157 (83.96), S30 (16.04)	R52 (55.32), S42 (44.68)	R4 (36.36), S7 (63.64)	NT	R3 (4.17), S69 (95.83)	R6 (46.15), S7 (53.85)	R7 (13.21), S46 (86.79)	NT	R9 (25), S27 (75)
TCC-Ticarcillin/Clavulanic Acid	R0 (0), S14 (100)	R3 (4.17), S69 (95.83)	R217 (44.93), S266 (55.07)	NT	NT	R2 (10), S18 (90)	NT	R5 (41.67), S7 (58.33)	NT	R1 (9.09), S10 (90.91)
TE-Tetracycline	NT	R10 (83.33), S2 (16.67)	NT	NT	NT	R1 (10), S9 (90)	NT	NT	NT	NT

(Contd...)

TABLE S1
(Continued)

Antibiotics VS GNB	*Achromobacter denitrificans* No. (14) (%)	*Acinetobacter baumannii* No. (307) (%)	*Acinetobacter haemolyticus* No. (12) (%)	*Acinetobacter lwoffii* No. (26) (%)	*Citrobacter freundii* No. (24) (%)	*Enterobacter aerogenes* No. (34) (%)	*Enterobacter cloacae* No. (166) (%)	*Escherichia coli* No. (14) (%)	*Klebsiella oxytoca* No. (65) (%)	*Klebsiella pneumoniae* No. (921) (%)
TGC-Tigecycline	R0 (0), S20 (100)	R9 (10.47), S77 (89.53)	R97 (68.31), S45 (31.69)	NT	NT	R0 (0), S49 (100)	R0 (0), S10 (100)	R3 (10), S27 (90)	NT	R1 (4.76), S20 (95.24)
TIC-Ticarcillin	R7 (46.67), S8 (53.33)	R47 (48.96), S49 (51.04)	R263 (54.91), S216 (45.09)	NT	NT	R18 (64.29), S10 (35.71)	NT	R6 (33.33), S12 (66.67)	NT	R2 (16.67), S10 (83.33)
TM-Tobramycin	R7 (30.43), S16 (69.57)	R55 (41.04), S79 (58.96)	R277 (45.04), S338 (54.96)	R1 (10), S9 (90)	NT	R0 (0), S39 (100)	NT	R7 (22.58), S24 (77.42)	R0 (0), S13 (100)	R3 (12.5), S21 (87.5)
TMP-Trimethoprim	NT	R8 (80), S2 (20)	NT	NT	NT	NT	NT	NT	NT	NT
TZP-Piperacillin/Tazobactam	R1 (2.86), S34 (97.14)	R7 (3.8), S177 (96.2)	R247 (38.65), S392 (61.35)	R3 (30), S7 (70)	NT	R1 (1.43), S69 (98.57)	R2 (14.29), S12 (85.71)	NT	R0 (0), S15 (100)	R6 (18.18), S27 (81.82)

NT, not tested; R, Resistance; S, Sensitive; No., number of samples; Percentages of R or S = (number of tests with R or S response/total number of tests)*100

TABLE S2
Responses of isolated GPB to different antimicrobial drugs in Iraqi health-care facilities

Antibiotics VS GPB	*Enterococcus faecalis* No. (443) (%)	*Enterococcus faecium* No. (78) (%)	*Staphylococcus aureus* No. (1304) (%)	*Staphylococcus epidermidis* No. (417) (%)	*Staphylococcus haemolyticus* No. (411) (%)	*Staphylococcus hominis* No. (191) (%)	*Staphylococcus saprophyticus* No. (18) (%)	*Streptococcus agalactiae* No. (213) (%)	*Streptococcus alactolyticus* No. (19) (%)	*Streptococcus pneumoniae* No. (99) (%)
AM-Ampicillin	R3 (6.67), S42 (93.33)	NT	NT	NT	NT	NT	NT	R15 (15.79), S80 (84.21)	R3 (30), S7 (70)	NT
C-Chloramphenicol	NT	NT	NT	NT	NT	NT	NT	R8 (10.13), S71 (89.87)	NT	R5 (17.86), S23 (82.14)
CIP-Ciprofloxacin	R14 (28), S36 (72)	NT	R10 (9.26), S98 (90.74)	R10 (14.08), S61 (85.92)	R75 (59.52), S51 (40.48)	R8 (25.81), S23 (74.19)	NT	NT	NT	NT
CM-Clindamycin	NT	NT	R330 (29.86), S775 (70.14)	R50 (16.18), S259 (83.82)	R84 (27.36), S223 (72.64)	R33 (24.63 , S101 (75.37)	R5 (35.71), S9 (64.29)	R48 (32.21), S101 (67.79)	NT	R36 (65.45), S19 (34.55)
CRO-Ceftriaxone	NT	NT	NT	NT	NT	NT	NT	R16 (18.39), S71 (81.61)	NT	R20 (36.36), S35 (63.64)
CTX-Cefotaxime	NT	NT	NT	NT	NT	NT	NT	R19 (22.09), S67 (77.91)	R5 (50), S5 (50)	R27 (50), S27 (50)
DAP-Daptomycin	R0 (0), S16 (100)	NT	R2 (4.08), S47 (95.92)	R0 (0), S30 (100)	R3 (4.62), S62 (95.38)	R2 (14.29), S12 (85.71)	NT	NT	NT	NT
E-Erythromycin	R185 (72.83) S69 (27.17)	R22 (88), S3 (12)	R763 (70.26), S323 (29.74)	R219 (73.49), S79 (26.51)	R250 (93.98), S16 (6.02)	R115 (87.79), S16 (12.21)	R12 (85.71), S2 (14.29)	R48 (57.14), S36 (42.86)	R7 (70), S3 (30)	R43 (79.63), S11 (20.37)
FA-Fusidic Acid	NT	NT	R171 (16.51), S865 (83.49)	R94 (29.19), S228 (70.81)	R79 (23.8), S253 (76.2)	R47 (32.87), S96 (67.13)	R4 (25), S12 (75)	NT	NT	NT

(Contd...)

ARO p-ISSN: 2410-9355, e-ISSN: 2307-549X

http://dx.doi.org/10.14500/aro.11689

TABLE S2
(Continued)

Antibiotics VS GPB	*Enterococcus faecalis* No. (443) (%)	*Enterococcus faecium* No. (78) (%)	*Staphylococcus aureus* No. (1304) (%)	*Staphylococcus epidermidis* No. (417) (%)	*Staphylococcus haemolyticus* No. (411) (%)	*Staphylococcus hominis* No. (191) (%)	*Staphylococcus saprophyticus* No. (18) (%)	*Streptococcus agalactiae* No. (213) (%)	*Streptococcus alactolyticus* No. (19) (%)	*Streptococcus pneumoniae* No. (99) (%)
FOS-Fosfomycin	NT	NT	R259 (69.44), S114 (30.56)	R17 (58.62), S12 (41.38)	R13 (59.09), S9 (40.91)	NT	NT	NT	NT	NT
FT-Nitrofurantoin	R1 (0.41), S240 (99.59)	R0 (0), S27 (100)	R3 (0.28), S1071 (99.72)	R0 (0), S271 (100)	R0 (0), S227 (100)	R0 (0), S125 (100)	R0 (0), S14 (100)	R0 (0), S70 (100)	NT	NT
GM-Gentamicin	NT	NT	R224 (19.68) S914 (80.32)	R41 (12.46), S288 (87.54)	R123 (37.16), S208 (62.84)	R9 (6.21), S136 (93.79)	R3 (20), S12 (80)	NT	NT	NT
LEV-Levofloxacin	R87 (39.91), S131 (60.09)	R17 (77.27), S5 (22.73)	R223 (21.78) S801 (78.22)	R31 (12.2), S223 (87.8)	R80 (40), S120 (60)	R18 (15.79), S96 (84.21)	R3 (23.08), S10 (76.92)	R32 (20.92), S121 (79.08)	R2 (20), S8 (80)	R13 (23.64), S42 (76.36)
LNZ-Linezolid	R40 (13.70), S252 (86.30)	R3 (8.11), S34 (91.89)	R69 (5.84), S1113 (94.16)	R16 (4.66), S327 (95.34)	R19 (5.35), S336 (94.65)	R23 (14.94), S131 (85.06)	R3 (18.75), S13 (81.25)	R3 (1.76 , S167 (98.24)	R0 (0) , S10 (100)	R2 (3.64), S53 (96.36)
MUP-Mupirocin	NT	NT	R119 (31.48, S259 (68.52)	NT	NT	NT	NT	NT	NT	NT
MXF-Moxifloxacin	NT	NT	R62 (5.47), S1072 (94.53)	R2 (0.64), S310 (99.36)	R4 (1.38), S285 (98.62)	R4 (2.82), S138 (97.18)	R0 (0), S15 (100)	R22 (14.29), S132 (85.71)	R2 (25), S6 (75)	R8 (27.59), S21 (72.41)
OX1-Oxacillin	NT	NT	R937 (83.96) S179 (16.04)	R294 (90.74), S30 (9.26)	R306 (93.58), S21 (6.42)	R107 (75.35), S35 (24.65)	R10 (71.43), S4 (28.57)	NT	NT	NT
P-Benzylpenicillin	R0 (0), S16 (100)	NT	R776 (90.87), S78 (9.13)	R107 (90.68), S11 (9.32)	R156 (95.71), S7 (4.29)	R49 (83.05), S10 (16.95)	NT	R20 (22.99), S67 (77.01)	NT	R25 (46.3), S29 (53.7)

Antibiotics VS GPB	*Enterococcus faecalis* No. (443) (%)	*Enterococcus faecium* No. (78) (%)	*Staphylococcus aureus* No. (1304) (%)	*Staphylococcus epidermidis* No. (417)	*Staphylococcus haemolyticus* No. (411) (%)	*Staphylococcus hominis* No. (191) (%)	*Staphylococcus saprophyticus* No. (18) (%)	*Streptococcus agalactiae* No. (213) (%)	*Streptococcus alactolyticus* No. (19) (%)	*Streptococcus pneumoniae* No. (99) (%)
RA-Rifampicin	NT	NT	R212 (18.73), S920 (81.27)	R44 (14.1), S268 (85.9)	R78 (26.99), S211 (73.01)	R26 (18.44), S115 (81.56)	R2 (14.29), S12 (85.71)	NT	NT	R2 (6.9), S27 (93.1)
SXT-Trimethoprim/ Sulfamethoxazole	R11 (23.40), S36 (76.60)	NT	R169 (15.36), S931 (84.64)	R30 (12.1), S218 (87.9)	R134 (42.95), S178 (57.05)	R19 (17.76), S88 (82.24)	R4 (33.33), S8 (66.67)	R2 (2.17), S90 (97.83)	NT	R1 (2.63), S37 (97.37)
TE-Tetracycline	R217 (81.27), S50 (18.73)	R23 (85.19), S4 (14.81)	R667 (58.87), S466 (41.13)	R157 (48.16), S169 (51.84)	R165 (50.3), S163 (49.7)	R57 (39.86), S86 (60.14)	R8 (57.14), S6 (42.86)	R145 (87.88), S20 (12.12)	R7 (70), S3 (30)	R48 (87.27), S7 (12.73)
TEC-Teicoplanin	R33 (11.42), S256 (88.58)	R14 (37.84), S23 (62.16)	R72 (6.09), S1110 (93.91)	R26 (7.65), S314 (92.35)	R28 (7.91), S326 (92.09)	R28 (18.06), S127 (81.94)	R3 (18.75), S13 (81.25)	NT	NT	NT
TGC-Tigecycline	R10 (3.50) , S276 (96.50)	R1 (2.7), S36 (97.3)	R13 (1.11), S1155 (98.89)	R3 (0.88), S339 (99.12)	R4 (1.13), S351 (98.87)	R4 (2.58), S151 (97.42)	R1 (6.25), S15 (93.75)	R1 (0.63), S158 (99.37)	NT	R0 (0), S29 (100)
TM-Tobramycin	NT	NT	R210 (20.47), S816 (79.53)	R28 (10.89), S229 (89.11)	R47 (22.93), S158 (77.07	R8 (7.02), S106 (92.98)	R2 (15.38), S11 (84.62)	NT	NT	NT
VA-Vancomycin	R26 (10.61), S219 (89.39)	R8 (38.1), S13 (61.9)	R122 (11.47), S942 (88.53)	R22 (7.46), S273 (92.54)	R21 (7.02), S278 (92.98)	R20 (16), S105 (84)	R4 (26.67), S11 (73.33)	R12 (7.59), S146 (92.41)	R1 (10), S9 (90)	R6 (10.91), S49 (89.09)

NT, not tested; R, Resistance; S, Sensitive; No., number of samples; Percentages of R or S = (number of tests with R or S response/total number of tests)*100

TABLE S3
RESPONSES OF GNB AND GPB THAT WERE ISOLATED IN IRAQI CHILDREN PATIENTS TO VARIOUS ANTIMICROBIAL AGENTS

Antibiotics	GNB Isolates				
	Acinetobacter baumannii No. (37) (%)	*Enterobacter cloacae* No. (23) (%)	*Klebsiella pneumoniae* No. (83) (%)	*Proteus mirabilis* No. (25) (%)	*Pseudomonas aeruginosa* No. (51) (%)
AM-Ampicillin	NT	NT	R63 (96.92), S2 (3.08)	NT	NT
ATM-Aztreonam	NT	R3 (13.64), S19 (86.36)	R18 (21.95), S64 (78.05)	R0 (0), S25 (100)	R15 (31.91), S32 (68.09)
C-Chloramphenicol	NT	NT	R12 (70.59), S5 (29.41)	R4 (16.67), S20 (83.33)	NT
CRO-Ceftriaxone	R24 (68.57), S11 (31.43)	R8 (36.36), S14 (63.64)	R41 (50), S41 (50)	R11 (44) , S14 (56)	R15 (31.25), S33 (68.75)
DO-Doxycycline	R19 (54.29), S16 (45.71)	R4 (18.18), S18 (81.82)	R12 (14.63), S70 (85.37)	R11 (44), S14 (56)	R18 (37.5), S30 (62.5)
FOX-Cefoxitin	R9 (75), S3 (25)	R10 (76.92), S3 (23.08)	R51 (78.46), S14 (21.54)	NT	NT
FT-Nitrofurantoin	R2 (8.7), S21 (91.3)	NT	NT	NT	R4 (10.81), S33 (89.19)
Nafcillin	R9 (75), S3 (25)	R12 (100), S0 (0)	R55 (85.94), S9 (14.06)	NT	R10 (100), S0 (0)
RA-Rifampicin	NT	R1 (7.69), S12 (92.31)	R14 (21.54), S51 (78.46)	NT	NT
SXT-Trimethoprim/ Sulfamethoxazole	R16 (45.71), S19 (54.29)	R7 (33.33), S14 (66.67)	R39 (48.15), S42 (51.85)	R5 (20.83), S19 (79.17)	R11 (23.4), S36 (76.6)
TIC-Ticarcillin	NT	R9 (69.23), S4 (30.77)	R18 (27.69), S47 (72.31)	NT	NT
TM-Tobramycin	NT	R0 (0), S13 (100)	R0 (0), S65 (100)	NT	NT

Antibiotics	GPB Isolates		
	Staphylococcus aureus No. (52)	*Staphylococcus epidermidis* No. (30)	*Staphylococcus haemolyticus* No. (59)
DO-Doxycycline	R3 (6.25), S45 (93.75)	R2 (8.33), S22 (91.67)	R28 (50), S28 (50)
DOR-Doripenem	R7 (14.58), S41 (85.42)	R7 (30.43), S16 (69.57)	R13 (23.21), S43 (76.79)
OFL-Ofloxacin	R0 (0), S21 (100)	NT	R0 (0), S23 (100)
P-Benzylpenicillin	R14 (51.85), S13 (48.15)	R15 (100), S0 (0)	R33 (97.06), S1 (2.94)
SAM-Ampicillin/Sulbactam	R2 (4.17), S46 (95.83)	R13 (54.17), S11 (45.83)	R13 (23.21), S43 (76.79)
SXT-Trimethoprim/ Sulfamethoxazole	R2 (4.08), S47 (95.92)	R10 (40), S15 (60)	R26 (46.43), S30 (53.57)

NT, not tested; R, Resistance; S, Sensitive; No., number of samples; Percentages of R or S = (number of tests with R or S response/total number of tests)*100