ORIGINAL ARTICLE

Initiation of Infectious Disease Clinical Pharmacist's Role in an Antimicrobial Stewardship Program - An Experience from Saudi Arabia

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Abstract

Background: Pharmacists are leading antimicrobial stewardship all over the world. In the Middle Eastern hospitals, the concepts of infectious disease clinical pharmacists and antimicrobial stewardship programs are not yet implemented. **Aim:** The aim of this study is to set a base for antimicrobial use in a tertiary care hospital in Saudi Arabia through determination of the patterns of antimicrobial resistance and sensitivity and to use these data as a base to initiate the clinical pharmacist's role in an antimicrobial stewardship program. **Methods:** A total of 1487 cultures and sensitivity reports were collected from all departments of the hospital during a 1-year period, reports were analyzed to detect the percentages of different microorganisms, their resistance/sensitivity patterns and to outline recommendations about antimicrobial use within the hospital. The roles of infectious disease pharmacist in an antimicrobial stewardship program were initiated through three phases. **Results:** Approximately 30% of the detected microorganisms were Gram-positive. *Staphylococcus* accounted for 84% of the Gram-positive bacteria. The remaining bacteria (70%) were Gram-negative, consisting of *Pseudomonous aeruginosa* (27%), *Klebsiella* (19%), *Acinetobacter* (17%), and *Escherichia coli* (15%). 81% of the Gram-negative organisms were sensitive to piperacillin/tazobactam, 76% to imipenem/cilastatin, 73% to amikacin, 62% to gentamycin, 54% to ciprofloxacin, and 51% to cephalosporins. Sensitivity to linezolid and vancomycin was approximately 99% among Gram-positive organisms. **Conclusions:** To minimize the emergence of microbial resistance, infectious disease pharmacists should assist physicians in optimizing antimicrobials use. Implementation of an antimicrobial stewardship program in this hospital had a great impact in terms of optimizing antimicrobials use.

Key words: Antimicrobial resistance, antimicrobial sensitivity, antimicrobial stewardship, infection pharmacist

INTRODUCTION

Resistance to antimicrobial agents is a global concern in both human and veterinary medicine.[1] The misuse of antimicrobial agents is counted as a major factor contributing toward the development and spread of antimicrobial drug resistance. [2,3] Pharmacists have a major role in reducing this antimicrobial drug resistance. Pharmacists can participate in: Identifying antibiotic misuse; promoting changes in prescribing; and promoting patient care.[4] In the United Kingdom hospitals, the introduction of specialist antibiotic pharmacists was initiated as a result of the inappropriate antimicrobial prescribing.[5] Major responsibilities of these pharmacists include monitoring antimicrobial use, providing recommendations, educating health-care team members, and implementing strategies to prevent resistance. Infections disease pharmacists have been shown to be important in many clinical situations and their role can be expanded to include direct intervention in a patient's treatment regimen.[6] The responsibility of infectious disease pharmacists in antimicrobial stewardship and infection prevention and control programs in health systems

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Received: 03-09-2018
Revised: 08-12-2018
Accepted: 21-12-2018

was defined by the American Society of Health-System Pharmacists. Pharmacist involvement reports inappropriate antimicrobial use and their participation in multidisciplinary health-care committees can significantly reduce antimicrobial resistance within the health system.[7] The main objective of the antimicrobial stewardship programs is to optimize individual patient outcomes while reducing unexpected consequences such as antimicrobial resistance and adverse effects in the individual patient.[8] These programs mainly include evidence-based guidelines and educational sessions, and regular feedback of antimicrobial usage to prescribers, and to, in turn, enhance appropriate and evidence-based prescribing.[9] Pharmacists have a vital role within hospitals to promote evidence-based medicine in addition to cost-effective prescribing.[10] In England hospitals, clinical pharmacy services typically involve ward visits on a daily basis and medication chart review, provision of individualized interventions on medication use, and pharmacist's attendance on multidisciplinary ward rounds to provide specialist input on medication management processes. Increasing antimicrobial resistance worldwide necessitates initiation of clinical pharmacist roles in the field of anti-infectives. This may help in optimizing antimicrobial use, enhance patient outcomes, promote appropriate prescribing, and potentially reduce the emergence and spread of antimicrobial resistance.[11,12] Pharmacists are leading antimicrobial stewardship all over the world, with multidisciplinary working models described in many countries such as the United States of America,[13] Australia,[14,15] France,[16] and Ireland.[17] In Middle Eastern hospitals, the concept of infectious disease pharmacists and antimicrobial stewardship programs is not yet implemented. Antimicrobials are prescribed empirically in many situations without obtaining culture and sensitivity (C/S) reports, so the emergence of antimicrobial resistance is very high. The objectives of this study are two-fold: To set a base for antimicrobial use in a tertiary care hospital in Saudi Arabia through determination of the patterns of antimicrobial resistance and sensitivity, and to use these data as a base to initiate the role of the clinical pharmacist in an antimicrobial stewardship program.

METHODS

Setting

The study was conducted in King Fahad Specialist Hospital, Buraydah, Saudi Arabia.

The investigators roles in initiating the service

The clinical pharmacy services were initiated in this hospital in 2009 by the pharmacy director (one of the investigators). The other investigator was working as a clinical pharmacy

Table 1: Actions taken as a result of the first phase of the study

Recommendations
Antimicrobial guidelines were developed based on the results of Phase I
Antimicrobials that showed a high incidence of microbial sensitivity (Piperacillin/tazobactam, Tienam, linezolid, and vancomycin) were kept a second line treatment and supplied only based on C/S reports to avoid resistance
Antimicrobials that showed a moderate incidence of microbial sensitivity such as amikacin, gentamicin, ciprofloxacin, and cefepime for susceptible Gram-negative infections and nitrofurantoin, clindamycin, tetracycline, and trimethoprim/sulfamethoxazole for susceptible Gram-positive infections were used as a first line and in case of treatment failure, second-line treatment (Tazocin and imipenem for Gram-negative and linezolid and vancomycin for Gram-positive) should be used
Many new antimicrobials were included in the drugs formulary, such as - Piperacillin to avoid rapid development of resistance to piperacillin/tazobactam which is more effective, telithromycin which can be used as an alternative to erythromycin and other macrolides in resistant strains especially for patients with atypical pneumonia, other 2nd generation IV cephalosporins such as cefoxitin or cefotetan and 3rd generation IV cephalosporins such as cefotaxime or ceftizoxime or ceftobiprole to counteract the resistance to ceftazidime, ceftriaxone, and cefuroxime
Respiratory quinolones (Levofloxacin, moxifloxacin, and gatifloxacin) were added to the hospital's drug formulary, and they should be used in cases of respiratory infection (hospital-acquired infections) instead of ciprofloxacin, due to the high rates of resistance to ciprofloxacin Linezolid should be added to the hospital's drug formulary and used instead of vancomycin in renal-impaired patients Tigecycline should be added to the hospital's drug formulary as the resistance to tetracycline was not very high, and this antibiotic can treat many skins and soft tissue infections
To minimize the emergence of antimicrobial resistance, infectious disease pharmacist roles were initiated in the hospital as they can help physicians to optimize antimicrobial use by avoiding overuse, underuse, inadequate dosing, and poor adherence to antimicrobials
A clinical pharmacokinetics laboratory service was implemented with clinical pharmacist consultations, to monitor the serum levels of Aminoglycosides and Vancomycin. Un-adjusted (over and under) doses of these antimicrobials can make drug-resistant bacteria evolve more quickly

C/S: Culture and sensitivity

consultant and participated in the implementation of clinical pharmacy services in this hospital. The investigators tried to expand the roles of clinical pharmacists in the hospital through exploring the danger of antimicrobial resistance within the hospital setting and using a systematic approach to initiate all the tasks of infectious disease pharmacist in the antimicrobial stewardship program.

Study design and methodology

This study involved retrospective evaluation and descriptive analysis, conducted on a total of 1487 C/S report in a tertiary care hospital. C/S reports were collected from all clinical departments of the hospital and analyzed to identify the percentages of Gram-positive and Gram-negative microorganisms and their resistance and sensitivity patterns. A data collection form was designed, on which the following variables were recorded: The C/S reports site of collection, the C/S reports sampling type (blood, urine, wound….etc.), Gram-positive or Gram-negative microorganism, name of the detected microorganism (s), the most sensitive antibiotic (s) in the C/S report, and the most resistant antibiotic (s) in the C/S report.

Inclusion and exclusion criteria

This study included patients who received any antimicrobial agent during hospitalization, regardless of their medical condition, age, sex, clinical department, or other variables.

Study phases

The study was carried out in three phases

Phase-I

During this phase, all C/S reports were analyzed prospectively to detect patterns of microorganism sensitivity/resistance to various antimicrobial agents. Cultures and sensitivity reports were collected over a 1-year period from all hospital departments and units. The collected data were analyzed, and all necessary information such as specimen collection sites, microorganisms detected, and their sensitivity/resistance patterns were recorded. The collected data were analyzed to determine the most common organisms along with their sensitivity/resistance patterns.

Phase-II

In this phase, the results of phase-I were communicated with the medical team through educational sessions and newsletters. Communicated information included the most common microorganisms detected in the hospital and their pattern of antimicrobial agent resistance and sensitivity. Guidelines for the appropriate use of antibiotics were developed based on the results of Phase I and the last updated evidence-based therapeutic guidelines. Pharmacists and physicians participated in developing these guidelines, which were approved by the pharmacy and therapeutics committee.

Phase-III

In this phase, the infectious disease pharmacist highlighted certain recommendations [Table 1] to the pharmacy and therapeutics committee. These recommendations concerned the initiation of antibiotic restriction policies for particular antibiotics (to decrease the chance of developing resistance), exchanging some antibiotics with others and inclusion of new antibiotics in the hospital's drug formulary.

RESULTS

A total of 1487 C/S reports were analyzed during the first phase of the study to detect the most common microorganisms from all hospitals' clinical departments. The sensitivity and resistance patters to antimicrobials for all the detected microorganisms are shown in the supplementary material section [Supplementary material 1]. Figures 1 and 2 outlines, the most prevalent Gram-positive and Gram-negative microorganisms detected. Approximately 30% of detected

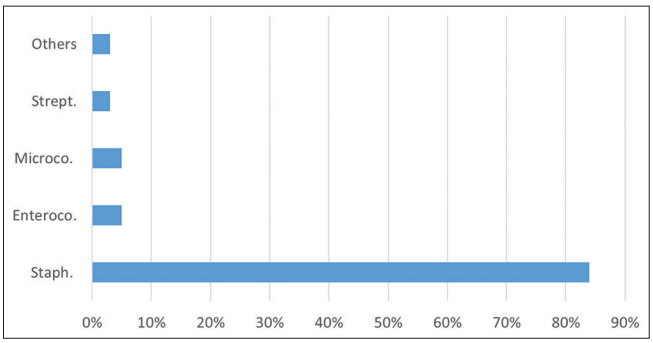

Figure 1: Percentages of Gram-positive microorganisms detected during the study period. *Staph.: Staphylococcus* species, *Enteroco.: Enterobacter cloacae*, *Microco.: Micrococcus* species, *Strept.: Streptococcus* species

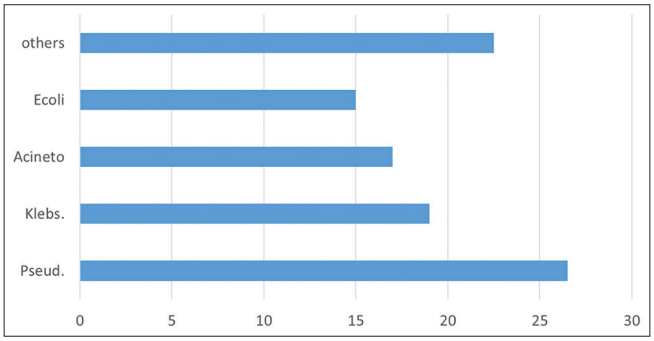

Figure 2: Percentages of Gram-negative microorganisms detected during the study period. *Acineto.: Acinetobacter, Pseudo.: Pseudomonas aeruginosa, Klebs.: Klebsiella pneumoniae, E coli.: Escherichia coli*

microorganisms were Gram-positive. *Staphylococcus* species recorded the highest percentage (84%) among detected Gram-positive microorganisms. The patterns of antimicrobial agent sensitivity were determined for Gram-positive and Gram-negative microorganisms (Figures 3 and 4). More than 75% of the detected Gram-negative microorganisms were sensitive to Piperacillin/tazobactam and imipenem/cilastatin. Amikacin also recorded high sensitivity (approximately 70%). Sensitivity to ciprofloxacin, cefepime, and ceftazidime was approximately 50% in all C/S reports; ceftriaxone recorded the lowest sensitivity pattern among the studied samples, where approximately 60% of the detected microorganisms were resistant to ceftriaxone. Among antimicrobials that cover Gram- positive infections, Linezolid recorded the highest sensitivity (95%) followed by vancomycin (90%). Resistance to ampicillin/clavulanic acid (Augmentin) was very high (approximately70%).

Table 2 outlines the different hospital sites for sample collection and the different types of collected samples.

During the second phase, the previously collected information was communicated to the medical team through bed rounds, education sessions, and published in the pharmacy newsletter. The patterns of antimicrobial agent resistance and sensitivity detected in Phase I were also considered during empiric antibiotic selection, especially for patients in critical care units. During the third phase, certain recommendations were highlighted to the Pharmacy and Therapeutics committee regarding using the data obtained from Phase I to change the hospital antibiotic use policy. Table 1 summarizes the clinical pharmacist recommendations.

DISCUSSION

One of the major challenges to the effective management of infections in hospitalized patients is antimicrobial resistance. Clinical pharmacy services are present in hospitals worldwide and they are effectively limit antimicrobial resistance. In Saudi Arabia, especially in Al-Qassim region, clinical pharmacy services were initiated in 2009. This current study attempted to convince the medical team about the impact of infectious disease pharmacists in the health care systems, by exploring the danger of antimicrobial resistance within the hospital setting and using a systematic approach to initiate all

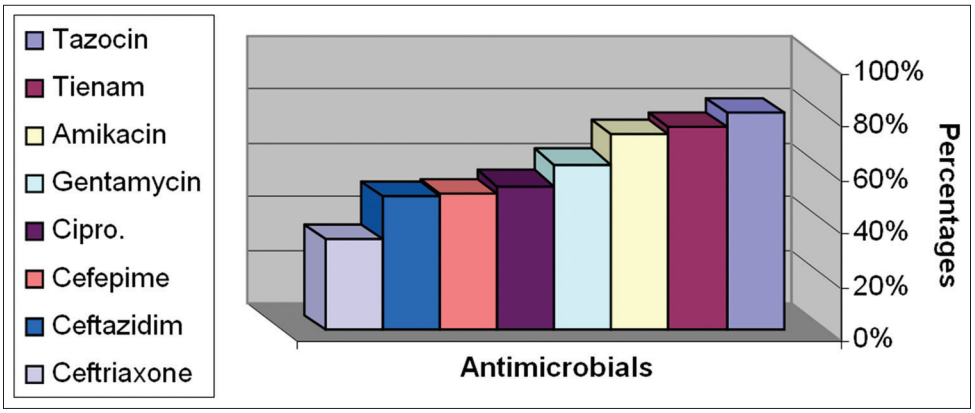

Figure 3: Patterns of microbial sensitivity to antimicrobials covering Gram-negative microorganisms
Cipro. : Ciprofloxacin

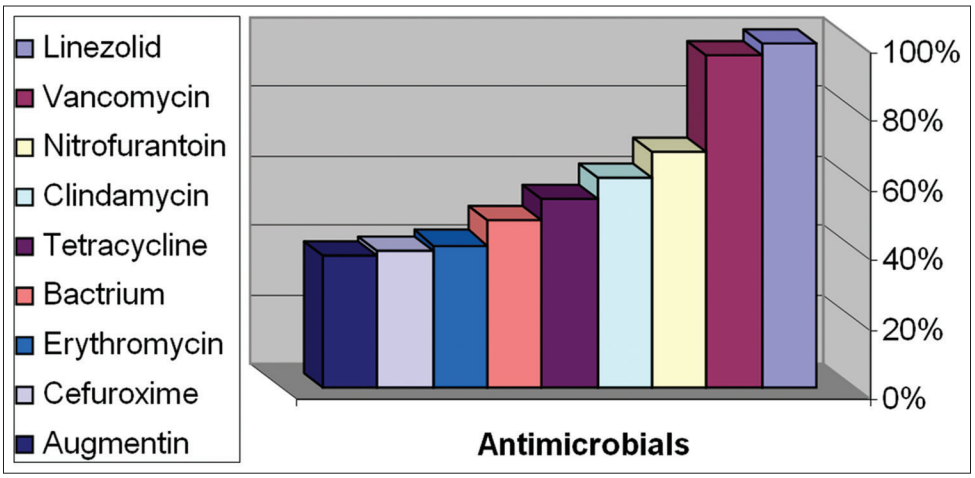

Figure 4: Patterns of microbial sensitivity to antimicrobials covering Gram-positive microorganisms

Table 2: Hospital sites and types of collected samples

Sample's source	Medical wards	ICU/SDU	Surgical wards	Clinics	BU	CW and CCU	Ortho wards	Others
n (%)	300 (20)	494 (34)	187 (12.5)	125 (8.5)	68 (4.5)	96 (6.5)	47 (3)	170 (11.5)
Sample's type	Wound discharge	Tracheal aspiration	Blood	Urine	Sputum	Catheter's tip	Ear discharge	Others
n (%)	409 (27)	365 (24)	218 (15)	189 (13)	79 (5.5)	68 (4.5)	57 (4)	102 (7)

ICU: Intensive care unit, MICU: Medical intensive care unit, BU: Burn unit, CCU: Cardiac care unit, Ortho: Orthopedic ward, CW: Cardiology ward

the tasks of infectious disease pharmacist in the antimicrobial stewardship program. Based on our knowledge, this is the first study in Saudi Arabia that documented the role of infectious disease pharmacist in an antimicrobial stewardship program in a practical way. Another study was conducted in King Abdullah Medical City aimed to detect the importance of the infectious disease pharmacist recommendations on only caspofungin, imipenem, and meropenem use.[18] During the study phases, the investigators initiated all the responsibilities of infectious disease pharmacists in the antimicrobial stewardship programs. The investigators used the data collected during phase one of the study as a base for antimicrobial agent prescribing. The infectious disease pharmacists also worked in collaboration with the medical team to ensure appropriate antimicrobial use, appropriate dosing, rapid initiation, proper monitoring, and de-escalation of antimicrobial therapies. In addition to the development of restricted antimicrobial-use procedures, therapeutic interchange, treatment guidelines, and clinical care plans. By the end of the second study phase, many of the tasks of the antimicrobial stewardship program were achieved. These tasks included: (i) Producing and exploring quantitative data on antimicrobial use to conduct clinical and economical outcome analyses; (ii) collaborating with other health-care teams (the microbiology laboratory team) to enhance the reporting process of the microbial susceptibility tests and ensure results are produced in a timely manner; (iii) working with the laboratory, infectious disease specialists, and infectious disease team in organizing susceptibility reports for distribution to prescribers within the health system to guide empirical therapy; and (iv) enhancing antimicrobial stewardship through surveillance, utilization and outcome reporting, and the development of clinical decision-support tools. No studies have utilized the stepwise approach that was implemented in the current study. Patterns of antimicrobial resistance have been studied in the published literature. In this current study, a total of 1487 C/S reports were analyzed to detect the most common microorganisms from all hospital departments. Approximately 30% of the detected microorganisms were Gram-positive. *Staphylococcus* species recorded the highest percentage (84%) in the detected Gram-positive microorganisms [Figure1]. *Staphylococcus aureus* accounted for approximately 62% of all detected *Staphylococcus* species and *Staphylococcus epidermidis* for approximately 24.5%. *S. aureus* presents a major challenge due to their ability to develop quick resistance to new antibiotics.[19] A total of 796 C/S reports were analyzed by Bijoy *et al*.[4] They conducted a retrospective study to assess antimicrobial patterns of sensitivity over a 6-month period in a private hospital of South India. *Escherichia coli* was the major microorganism identified in 36.4% of isolated specimens, followed by *Klebsiella*, *Streptococcus pneumoniae*, *S. aureus,* and *Pseudomonas*. Over the past 20 years, in Gulf countries, the most commonly detected Gram-negative microorganisms were *E. coli* and *Klebsiella pneumonia*.[20] In the current study, the rate of Gram-negative microorganisms was 70% [Figure 2], *Pseudomonas aeruginosa* was the highest detected Gram-negative microorganism in this study, followed by the *Klebsiella* Species (19%), *Acinetobacter* species (17%), and *E. coli* (15%). *P. aeruginosa* resistance to different antimicrobials was very high; it was studied by Sharma and Srivastava and used as a guide for empirical treatments in one Indian hospital.[21] In the results of another study, presented by Bijoy *et al*., *E. coli* was highly sensitive to Amikacin, followed by *Klebsiella*, then *Pseudomonas* to Meropenem.[4] In their study, pneumonia was found to be the most common disease in 51 patients. Cephalosporins (73%), and in particular Ceftriaxone (63.5%), was highly prescribed. Our study shows different results as shown in Figure 3, where >75% of the detected Gram-negative microorganisms were sensitive to Piperacillin/tazobactam and imipenem/cilastatin. Amikacin also recorded a high sensitivity pattern of about 70%. The sensitivity to ciprofloxacin, cefepime, and ceftazidime was about 50% in all C/S reports, while ceftriaxone recorded the lowest sensitivity pattern among the studied samples (approximately 60% of the detected microorganisms were resistant to ceftriaxone). Similar results were obtained by Goel *et al*.,[22] who concluded that a very high rate of resistance (80–100%) was observed among predominant Gram-negative bacilli to ciprofloxacin, ceftazidime, co-trimoxazole, and amoxicillin/clavulanic acid combination. On the contrary, the results of Gayathri *et al*., regarding antibiotic susceptibility patterns of rapidly growing mycobacteria, showed higher sensitivity patterns to ciprofloxacin.[23] Their study was conducted on 148 rapidly growing mycobacteria isolates, 146 (98%) were susceptible to amikacin, 138 (91%) to gatifloxacin, 132 (87%) to moxifloxacin, 122 (76%) to ciprofloxacin, and 116 (74%) to norfloxacin. In the current study, *S. aureus* was responsible for 84% of all Gram-positive infections. Among Gram-positive covering antibiotics, Linezolid recorded the highest

sensitivity pattern (95%) followed by vancomycin 90%. Sensitivities to clindamycin, co-trimoxazole, and cefuroxime were 58%, 45%, and 35%, respectively. Resistance to ampicillin/clavulanic acid was very high (approximately 70%, Figure 4). Bijoy *et al*. [4] recorded different Gram-positive sensitivity patterns during their study as the sensitivity of *S. aureus* to clindamycin, co-trimoxazole, and cefuroxime was 18%, 2%, and 13%, respectively. During the second phase of this study, the investigators succeeded in initiation of other pharmacists' responsibilities in antimicrobial stewardship and infection prevention and control. These responsibilities included: (i) Facilitating safe antimicrobial agent management by utilizing efficient and effective systems to reduce potential errors and adverse drug events; (ii) communicating with the medical team through conducting education sessions and producing newsletters regarding the most common microorganisms detected in the hospital and their patterns of antimicrobial agent resistance and sensitivity, and (iii) collaborating in the development of guidelines for the appropriate use of antibiotics, based on the results of Phase I and the last updated evidence-based therapeutic guidelines. Pharmacists and physicians participated in developing these guidelines. In the third phase of the study, the investigators worked within the Pharmacy and Therapeutics Committee, and the antibiotics guidelines were approved by the committee. The investigators highlighted certain recommendations [Table 1] to the pharmacy and therapeutics committee regarding restriction of some antibiotics (Imipenem, piperacillin/tazobactam, linezolid, and vancomycin) as these antibiotics showed high sensitivity patterns and they should only be dispensed on the basis of culture or by infectious disease consultants. Other recommendations included the necessity to change some items in the hospital formulary, inclusion of new oral cephalosporins, and changing some third-generation cephalosporins to others from the same group. For example, omitting ceftriaxone and ceftazidime because they showed high percentages of resistance among microorganisms; about 60% of microorganisms developed resistance to both of them and adding other third generation cephalosporins like cefotaxime, ceftizoxime or ceftobiprole. Other recommendations included ordering certain antibiotics such as respiratory quinolones (levofloxacin and moxifloxacin), linezolid, and tigecycline. Therapeutic drug monitoring for aminoglycosides and vancomycin was also recommended due to its contribution toward infection control and decreasing the incidence of antimicrobial resistance. By the end of the third study phase, the investigators succeeded in initiating other infectious disease pharmacist roles in antimicrobial stewardship and infection prevention and control. These roles included: (i) Working within the pharmacy and therapeutics committee to ensure that the number and types of antimicrobial agents available are appropriate for the patient population served and (ii) developing antimicrobial-use policies to optimize the therapeutic outcomes and minimize the risk of resistant strains of microorganisms emerging.

CONCLUSIONS

To minimize the emergence of microbial resistance, infectious disease pharmacists should help physicians to optimize antimicrobials use. Implementation of an antimicrobial stewardship program in hospitals had a great impact toward optimizing antimicrobial use.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

ACKNOWLEDGMENT

The authors would like to thank Mr. Abdullah Alharbi for his valuable help during data collection.

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Source of Support: Nil. **Conflict of Interest:** None declared.

Supplementary Material

The most commonly detected Gram-positive and Gram-negative microorganisms and their sensitivity and resistance patterns to different antibiotics.

Supplementary material 1: Sensitivity and resistance patters to antimicrobials for all the detected microorganisms

The most common detected MOs*	***Staphylococcus* species No.# (377)**			***Acinetobacter baumannii/ haemolyticus* No. (184)**			***Pseudomonas aeruginosa* No. (275)**			***Klebsiella pneumoniae* No. (196)**			***Escherichia coli* No. (151)**		
Antibiotics tested	**I**	**R**	**S**	**I**	**R**	**S**	**I**	**R**	**S**	**I**	**R**	**S**	**I**	**R**	**S**
Amikacin	14	45	158	2	135	47	13	46	214	10	16	170	5	2	144
Amoxicillin/K Clavulanate	24	124	98	-	-	-	-	-	-	77	43	76	38	26	87
Ampicillin/ Sulbactam	28	98	69	54	85	43	-	-	-	9	139	48	23	78	48
Ampicillin	4	86	22	-	-	-	-	-	-	8	184	4	1	112	38
Azithromycin	1	42	35	-	-	-	-	-	-	-	-	-	-	-	-
Aztreonam	8	55	90	-	-	-	16	80	145	2	129	49	5	38	94
Cefazolin	4	134	89	-	-	-	-	-	-	1	142	53	6	62	84
Cefepime	9	88	119	11	155	18	17	80	175	4	125	64	-	42	109
Cefotaxime	42	106	69	5	146	15	126	129	18	7	133	56	3	40	112
Cefoxitin	8	13	69	-	-	-	-	-	-	15	17	148	9	8	114
Ceftazidime	6	99	111	2	160	21	13	84	177	3	138	59	6	33	112
Ceftriaxone	30	191	124	15	154	16	85	159	29	4	136	56	3	41	107
Cefuroxime	7	92	81	-	-	-	-	-	-	1	139	56	7	48	104
Cephalothin	1	4	4	-	-	-	-	-	-	-	-	-	4	7	6
Chloramphenicol	1	19	54	-	-	-	2	4	3	5	39	92	6	10	52
Ciprofloxacin	19	145	192	2	162	20	7	56	210	33	83	80	1	50	100
Clindamycin	4	47	76	-	-	-	-	-	-	-	-	-	-	-	-
Colistin	-	1	26	-	-	-	-	-	13	-	3	41	-	2	63
Ertapenem	1	2	88	-	-	-	-	-	-	2	15	163	-	1	130
Erythromycin	1	73	58	-	-	-	-	-	-	-	-	-	-	-	-
Gatifloxacin	9	4	35	-	-	-	-	-	-	-	-	-	-	-	-
Gentamicin	17	113	215	11	133	60	34	55	176	2	55	139	-	28	123
Imipenem	17	38	162	40	98	45	20	65	189	4	10	186	-	-	151
Levofloxacin	2	23	44	2	8	4	2	8	26	1	2	12	1	6	13
Linezolid	-	-	135	-	-	-	-	-	-	-	-	-	-	-	-
Meropenem	9	46	109	22	116	21	10	57	161	4	10	132	-	1	96
Moxifloxacin	5	32	42	-	-	-	-	-	-	-	-	-	-	-	-
Mupirocin	-	7	65	-	-	-	-	-	-	-	-	-	-	-	-
Netilmicin	20	50	130	18	76	75	43	38	157	22	34	123	9	18	104
Nitrofurantoin	11	2	20	-	-	-	-	-	-	13	7	26	1	4	68
Norfloxacin	3	10	24	-	-	-	2	1	12	8	10	29	1	26	46
Oxacillin	-	77	51	-	-	-	-	-	-	-	-	-	-	-	-
Penicillin	-	2	11	-	-	-	-	-	-	-	-	-	-	-	-
Piperacillin/ Tazobactam	5	22	148	-	-	-	-	60	214	22	34	139	13	7	131

(Contd...)

Supplementary material 1: *(Continued)*

The most common detected MOs*	***Staphylococcus* species No.# (377)**			***Acinetobacter baumannii/ haemolyticus* No. (184)**			***Pseudomonas aeruginosa* No. (275)**			***Klebsiella pneumoniae* No. (196)**			***Escherichia coli* No. (151)**		
Piperacillin	1	8	7	-	-	-	-	8	25	1	11	4	-	12	6
Rifampin	3	17	118	-	-	-	-	-	-	-	-	-	-	-	-
Tetracycline	2	109	179	13	90	80	1	2	7	6	35	155	1	98	49
Quinupristin/ dalfopristin	41	3	122	-	-	-	-	-	-	-	-	-	-	-	-
Ticarcillin/K Clavulanate	1	5	11	2	11	1	-	11	22	6	1	9	2	3	16
Tobramycin	-	4	12	1	5	11	-	6	29	-	9	3	-	5	14
Trimethoprim/Sulfa	-	102	98	-	108	76	-	3	7	-	133	63	-	87	62
Vancomycin	-	6	132	-	-	-	-	-	-	-	-	-	-	-	-

*MOs: Microorganisms, #No.: The number detected during the study period, I: Intermediate sensitivity, R: Resistant, S: Sensitive