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AWARENESS OF BACTERIAL RESISTANCE AMONG PHYSICIANS, PHARMACISTS AND NURSES

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Abstract
Objective: To assess the level of medical staff awareness of bacterial resistance and characterize the most common resistant bacterial species, the factors contributing to the development of such resistance, and the possible measures to limit the increasing rate of resistance to current antibacterial therapies. **Method:** A questionnaire was administered to 352 health care professionals including physicians, pharmacists and nurses at four central university hospitals in Jordan. **Results:** Our results indicate that most of the responding physicians and pharmacists considered *Pseudomonas aeruginosa* and methicilin-resistant *Staphylococcus aureus* the most frequently encountered resistant bacterial species. However, nurses recognized both methicilin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococci* (VRE) as the most prevalent resistant species. Physicians and nurses (50.0% and 61.6%, respectively) reported prolonged hospitalization as a factor likely to contribute to the increased incidence of bacterial resistance. About 58% of pharmacists indicated the use of antibiotics without prescription as a significant reason for the development of bacterial resistance. Most of physicians (61.2%) reported that appropriate infection control is the most important measure to reduce bacterial resistance. Pharmacists (58.1%) recognized better adherence to the infection control guidelines as the most important factor that could reduce the risk of bacterial resistance. **Conclusion:** The findings of this study indicate a varying level of awareness of bacterial resistance among the health care professionals. Thus, serious efforts are still needed to develop and implement strategies to decrease the future risk of bacterial resistance to antibiotics.

Key words:
Bacterial resistance, MRSA, *P. aeruginosa*, Awareness, Antibiotics, VRE

INTRODUCTION

Antibiotics are among the most successful therapeutic agents used for combating bacterial infections. Unfortunately, a serious disadvantage is the development of resistance against these agents [1]. Until the end of the 20th century, pharmaceutical companies were consistently able to develop new antibiotics that were active against most of the resistant bacterial strains. However, the number of organisms that developed antibiotic resistance has been steadily increasing over the last 10–15 years, which is a real threat to disease management [see 2 for review]. Infections due to resistant microorganisms considerably increase the mortality rate, costs of treatment, disease spread, and duration of illness [3]. Initially, multiple-drug resistant organisms were encountered mostly in hospitals, where antimicrobials are used most extensively. However, at present, bacterial resistance is found almost as frequently in the community [4]. Several groups of researchers have shown increased drug resistance in the developing countries [reviewed in 3]. For example, the studies from the southeastern Mediterranean region, including Jordan, indicate a high rate of antibiotic resistance, compared with the Western countries [5], along with a predominant

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consumption of broad-spectrum antibiotics in hospital settings. This was postulated as a possible factor behind the documented high rate of bacterial resistance to antibiotics in hospitals in these countries [6].

The organisms exhibiting antibiotic resistance include MRSA, VRE, and *Pneumococci* resistant to penicillin and macrolides, and multiple-drug resistant gram-negative species [2]. The potential factors contributing to bacterial resistance as well as the possible strategies to manage this growing problem have been described in literature [see 7]. In this study, we assessed the medical staff awareness of the most common resistant bacterial species, the factors contributing to the development of bacterial resistance, and the possible measures to limit the increasing rate of this resistance.

METHOD

The study was performed during the period from October 2006 to December 2007. The study population included a total of 198 physicians, 113 nurses, and 42 pharmacists. About 95% of the medical professionals approached agreed to take part in the study and complete the questionnaire. The population sample was selected from among the central university hospitals in Jordan, including King Abdullah University Hospital, Princess Basma Hospital, Princess Rahma Hospital, and Princess Badeaa Hospital. A snowball sampling technique was used in data collection. The investigators asked every participant to nominate another two health care professionals until the desired sample size was obtained (n = 352).

To establish the test-retest reliability, 30 subjects (20 physicians, 5 nurses, and 5 pharmacists) were selected randomly and answered the questionnaire twice with a one-week interval. The test-retest data on each item were analyzed using interclass correlation. For each item, the correlation coefficients ranged from 0.78–0.88, indicating that the questionnaire is a reliable tool. No validation procedures were conducted.

Each participant was asked to complete a four-part questionnaire. In the first part, the demographic data such as age, gender, occupation and level of education were reported. In the second part, each individual was asked to answer a number of questions on his/her awareness regarding the frequently encountered bacterial species that are resistant to antibiotics. The respondents were to choose from a list of five microorganisms known for their increasing resistance to antibacterials, these including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococci* (VRE), extended-spectrum β-lactamase producing Gram-negative bacilli (ESBL), *Pseudomonas aeruginosa* (*P. aeruginosa*), and *acinetobacter baumannii* (*A. baumannii*). They were asked to rate their response on a four-point scale (1 — very likely, 2 — somewhat likely, 3 — somewhat unlikely, 4 — very unlikely). The same rating method was used in the other sections of the questionnaire. The third part of the questions concerned the factors contributing to the increasing prevalence of bacterial resistance; ten different factors were listed here. The participants were also asked about the possible measures that can be applied to decrease the risk of bacterial resistance. They were to assess 10 different methods currently available to manage bacterial resistance, including among others the reduction of hospital stay, appropriate infection control practices, limiting unnecessary use of medical instruments, applying better strategies for antibiotic management, etc. In the last section of the questionnaire, the participants were to answer the following question: "In the future, do you think the problem of bacterial resistance can be controlled, or will it become much worse?" The investigator was present to answer any question on the part of the respondents at the time of completing the questionnaire. The investigator informed the participants that there was no financial reward for their participation. The study protocol was designed in accordance with the principles described in the Helsinki Declaration of 1975, with all amendments and revisions. Only the investigators had access to the data collected.

The data were analyzed using the SPSS (Statistical Package for the Social Sciences, version 15.0, SPSS Inc., Chicago, IL, USA). Frequency analysis for different groups of health care professionals was tabulated and the data

were compared using the chi-square goodness-of-fit test. For all statistical analyses, the level of significance was set at $P < 0.05$.

RESULTS

The proportion of male to female respondents was 53.6% vs. 46.4%, respectively. The participants reported different educational levels and/or different medical specialties. Table 1 shows the detailed demographic characteristics of the study population.

With regard to the most frequently encountered antibiotic-resistant bacterial species, the physicians pointed both to MRSA (31.6%) and *P. aeruginosa* (25.8%) as the species very likely to be associated with resistance to antibacterials. A similar response was obtained from the pharmacists who ranked MRSA (29.3%) and *P. aeruginosa* (28.2%) as the bacterial species meeting this crtiterion. The nurses indicated MRSA (33.6%) and ESBL (19.2%) as very likely to be resistant. A two-way contingency table analysis revealed a significant association between the medical profession and the responses indicating MRSA, *P. aerugenosa* and *A. baumannii* χ^2 (6,N = 336) = 30.7, 14.6 and 15.3, respectively (Table 2).

In the part of the questionnaire investigating the level of awareness of the important factors contributing to the increasing incidence of bacterial resistance, the physicians assessed that prolonged hospitalization (50.0%), improper use of antibiotics (without medical prescription) (46.9%) and inappropriate antibiotic prescription (45.9%) are the very likely causes of bacterial resistance. The responses given by the pharmacists were consistent with those of the physicians; they indicated the use of antibiotics without prescription,(58.1%), inappropriate use of antibiotics (53.5%), and prolonged hospitalization (48.8%) as the factors very likely to contribute to bacterial resistance. The majority of nurses (61.6%) pointed to prolonged hospitalization as such a factor. A much lower percentage of nurses (17.7%) responded that the high rate of patients transferred between units and hospitals is very likely to contribute to the development of bacterial resistance. Significant relations were detected between the medical profession and the responses reporting inadequate infection control practices, extensive use of newer generations of antibiotics, and the use of antibiotics without prescription (Table 3).

The results regarding the medical staff awareness of the methods used to control current bacterial resistance are presented in Table 4. A high percentage of physicians (61.2%) shared an opinion that applying better infection control practices will very likely decrease the current prevalence of bacterial resistance. On the other hand, 58.1% of pharmacists believed that better adherence to the infection control guidelines will very likely reduce bacterial

Table 1. Demographic data of the study participants

Demographics	Physicians	Pharmacists	Nurses
Age (years)			
Mean	34.4	31.0	28.7
Range	24–59	23–48	21–44
Gender			
Male N (%)	151 (77)	13 (30.2)	25 (22.1)
Female N (%)	45 (23)	30 (69.8)	88 (77.9)
Education			
Consultants N (%)	43 (21.9)	—	—
Residents N (%)	153 (78.1)	—	—
Bachelor's degree N (%)	—	31 (72.1)	86 (76.1)
Master's degree N (%)	—	5 (11.6)	11 (9.7)
PhD (%)	—	7 (16.3)	16 (14.2)

Table 2. Medical staff awareness of the most frequently encountered resistant bacterial species in medical practice*

Bacterial species		Physicians		Pharmacists		Nurses		Chi	P
		N	%	N	%	N	%		
MRSA	A1	62	31.6	12	29.3	37	33.6	30.7	0.00
	A2	96	49.0	22	53.7	40	36.3		
	A3	25	12.8	7	17.1	7	6.4		
	A4	13	6.6	0	0.0	26	23.6		
VRE	A1	28	14.4	4	10.3	19	17.8	13.2	0.11
	A2	53	27.2	12	30.8	45	42.1		
	A3	67	34.4	15	38.5	31	29.0		
	A4	46	23.6	8	20.5	12	11.2		
ESBL	A1	28	14.4	7	18.4	20	19.2	9.5	0.15
	A2	85	43.8	12	31.6	31	29.8		
	A3	52	26.8	16	42.1	37	35.6		
	A4	29	14.9	3	7.9	16	15.4		
P. aerugenosa	A1	50	25.8	11	28.2	18	16.4	14.6	0.02
	A2	86	44.3	19	48.7	40	36.4		
	A3	35	18.0	8	20.5	31	28.2		
	A4	23	11.9	1	2.6	21	19.1		
A. baumannii	A1	22	11.3	2	5.1	7	6.5	15.3	0.02
	A2	34	17.4	12	30.8	36	33.3		
	A3	68	34.9	8	20.5	35	32.4		
	A4	71	36.4	17	43.6	30	27.8		

* Total N of physicians = 196, of pharmacists = 43, of nurses = 113.
MRSA — Methicillin-resistant *Staphylococcus aureus*
VRE — Vancomycin-resistant *Enterococci*.
ESBL — extended spectrum β-lactamase producing Gram-negative bacilli.
Response: A1 — very likely, A2 — somewhat likely, A3 — somewhat unlikely, A4 — very unlikely.

resistance. The nurses (58.4%) thought that implementation of better hygiene practices is the solution that is very likely to reduce bacterial resistance. Two-way contingency table analysis indicated significant associations between the medical profession and most of the strategies proposed for controlling bacterial resistance (Table 4).

With regard to the opinions on the future developments concerning the problem , a majority of health care professionals expected that the status of bacterial resistance will very likely become worse if the current practices in antimicrobial handling do not change. Only a small percentage of physicians (6.1%), pharmacists (7.0%), and nurses (11.6%) thought that this global problem may be solved in the following few years (Table 5).

DISCUSSION

Antimicrobial resistance is a major problem for the global health and economy [8]. In the developing countries, a high rate of infections usually coincides with a rapid development and spread of microbial resistance [9]. The findings of this study revealed that most of the physicians and nurses in Jordan regard both MRSA and *P. aeruginosa* as highly resistant bacteria. However, the nurses' opinion was somewhat different;

Table 3. Awareness of the most common factors contributing to bacterial resistance

Contributing factor		Physicians		Pharmacists		Nurses		Chi	P
		N	%	N	%	N	%		
Prolonged hospitalization	A1	98	50.0	21	48.8	69	61.6	11.2	0.08
	A2	68	34.7	13	30.2	28	24.8		
	A3	24	12.2	8	18.6	8	7.1		
	A4	6	3.1	1	2.3	8	7.1		
Increased use of medical instrumentation	A1	79	40.3	13	30.2	46	41.1	10.6	0.10
	A2	79	40.3	19	44.2	31	27.7		
	A3	28	14.3	7	16.3	28	25.0		
	A4	10	5.1	4	9.3	7	6.3		
Inappropriate infection control practices	A1	82	41.8	12	27.9	47	42.0	18.8	0.01
	A2	74	37.8	16	37.2	25	22.3		
	A3	24	12.2	13	30.2	26	23.2		
	A4	16	8.2	2	4.7	14	12.5		
Improper antibiotic prescription	A1	90	45.9	19	44.2	38	33.6	9.6	0.14
	A2	69	35.2	17	39.5	39	34.5		
	A3	31	15.8	6	14.0	32	28.3		
	A4	6	3.1	1	2.3	4	3.5		
Inappropriate antibiotic use	A1	92	46.9	23	53.5	39	34.5	9.0	0.17
	A2	62	31.6	13	30.2	37	32.7		
	A3	32	16.3	6	14.0	29	25.7		
	A4	10	5.1	1	2.3	8	7.1		
Extensive use of newer generations of antibiotics	A1	75	38.3	20	46.5	24	21.8	17.7	0.01
	A2	71	36.2	17	39.5	53	48.2		
	A3	39	19.9	5	11.6	31	28.2		
	A4	11	5.6	1	2.3	2	1.8		
High rate of patients' transfer between hospital units	A1	35	18.1	2	4.7	20	17.7	10.6	0.10
	A2	70	36.3	17	39.5	39	34.5		
	A3	53	27.5	19	44.2	41	36.3		
	A4	35	18.1	5	11.6	13	11.5		
Patients' noncompliance	A1	53	27.0	11	25.6	33	29.5	6.8	0.34
	A2	81	41.3	14	32.6	32	28.6		
	A3	43	21.9	13	30.2	30	26.8		
	A4	19	9.7	5	11.6	17	15.2		
The use of antibiotics without medical prescription	A1	96	49.0	25	58.1	51	45.9	17.83	0.00
	A2	63	32.1	8	18.6	20	18.0		
	A3	19	9.7	8	18.6	28	25.2		
	A4	18	9.2	2	4.7	12	10.8		
Prescribing antibiotics when no blood culture is performed	A1	52	26.5	18	41.9	48	42.5	12.1	0.06
	A2	75	38.3	16	37.2	33	29.2		
	A3	42	21.4	6	14.0	23	20.4		
	A4	27	13.8	3	7.0	9	8.0		

Response: A1 — very likely, A2 — somewhat likely, A3 — somewhat unlikely, A4 — very unlikely.

Table 4. Awareness of the strategies to control emergence of bacterial resistance

Contributing factor		Physicians		Pharmacists		Nurses		Chi	P
		N	%	N	%	N	%		
Better hygiene practices	A1	95	48.7	9	20.9	66	58.4	34.5	0.00
	A2	77	39.5	20	46.5	21	18.6		
	A3	15	7.7	12	27.9	18	15.9		
	A4	8	4.1	2	4.7	8	7.1		
Appropriate infection control practices	A1	120	61.2	16	38.1	65	58.0	29.0	0.00
	A2	62	31.6	11	26.2	28	25.0		
	A3	10	5.1	10	23.8	9	8.0		
	A4	4	2.0	5	11.9	10	8.9		
Reducing hospital stay	A1	112	57.4	10	23.3	49	43.4	23.1	0.00
	A2	61	31.3	20	46.5	38	33.6		
	A3	18	9.2	9	20.9	20	17.7		
	A4	4	2.1	4	9.3	6	5.3		
Limiting the use of medical instrumentation	A1	91	47.2	9	20.9	40	35.7	20.3	0.00
	A2	72	37.3	16	37.2	40	35.7		
	A3	21	10.9	14	32.6	25	22.3		
	A4	9	4.7	4	9.3	7	6.3		
Better adherence to infection control guidelines	A1	109	55.6	25	58.1	45	40.2	14.9	0.02
	A2	64	32.7	8	18.6	40	35.7		
	A3	20	10.2	8	18.6	24	21.4		
	A4	3	1.5	2	4.7	3	2.7		
Hospital internal restrictions	A1	93	47.4	18	41.9	30	27.5	21.2	0.00
	A2	74	37.8	13	30.2	43	39.4		
	A3	25	12.8	10	23.3	26	23.9		
	A4	4	2.0	2	4.7	10	9.2		
Better antibiotic handling strategies	A1	89	45.4	20	46.5	41	36.3	16.1	0.01
	A2	84	42.9	13	30.2	40	35.4		
	A3	15	7.7	7	16.3	25	22.1		
	A4	8	4.1	3	7.0	7	6.2		
Antibiotic cycling	A1	48	24.5	7	16.3	19	16.8	8.5	0.02
	A2	84	42.9	17	39.5	45	39.8		
	A3	45	23.0	14	32.6	28	24.8		
	A4	19	9.7	5	11.6	21	18.6		
Education programs for the general public	A1	89	45.4	15	34.9	47	41.6	8.1	0.23
	A2	69	35.2	14	32.6	36	31.9		
	A3	36	18.4	12	27.9	24	21.2		
	A4	2	1.0	2	4.7	6	5.3		
Accurate diagnosis	A1	104	53.1	24	55.8	62	54.9	22.2	0.00
	A2	60	30.6	12	27.9	13	11.5		
	A3	23	11.7	4	9.3	27	23.9		
	A4	9	4.6	3	7.0	11	9.7		

Response: A1 — very likely, A2 — somewhat likely, A3 — somewhat unlikely, A4 — very unlikely.

Table 5. Medical staff opinions on the future risk of bacterial resistance

Contributing factor		Physicians		Pharmacists		Nurses		Chi	P
		N	%	N	%	N	%		
Bacterial resistance will become worse if current practices do not change	A1	110	56.1	33	76.7	63	56.3	10.0	0.13
	A2	68	34.7	9	20.9	36	32.1		
	A3	12	6.1	0	0.0	11	9.8		
	A4	6	3.1	1	2.3	2	1.8		
Bacterial resistance will be controlled	A1	12	6.1	3	7.0	13	11.6	6.35	0.39
	A2	76	38.8	11	25.6	35	31.3		
	A3	61	31.1	17	39.5	34	30.4		
	A4	47	24.0	12	27.9	30	26.8		

Response: A1 — very likely, A2 — somewhat likely, A3 — somewhat unlikely, A4 — very unlikely.

they ranked not only MRSA but also VRE as belonging to the most resistant microorganisms. There is no doubt that the association between the bacterial species listed in our questionnaire and antibiotic resistance varies considerably. The difference in the assessment between representatives of different medical professions can be attributed to individual knowledge and personal experience with such infectious agents. The Gram-positive bacteria resistant to antibiotics are a common cause of nosocomial (hospital-acquired) blood stream infections in the United States [10]. MRSA isolates are resistant to available β-lactam antibiotics, including penicillins and cephalosporins [11,12]. Since the late 1970s, MRSA isolates have been the reported cause of many hospital outbreaks worldwide. They can be encountered in small community hospitals, chronic care facilities, and even within the community [13–15]. In addition, resistance to vancomycin has been acquired by the strains of *Enterococcus faecium*, thus accounting for treatment failures. At present, five types of vancomycin resistance have been reported for *Enterococci* [reviewed in 16]. On the other hand, multidrug resistant *P. aeruginosa* strains are one of the most common Gram-negative bacilli which are the cause of nosocomial infections with a high incidence of morbidity and mortality [17,18]. *Acinetobacter* is another important causal agent of nosocomial infections that has been associated with many illnesses in hospitalized patients, especially in the intensive care units (ICUs) [19]. *Acinetobacter* is frequently resistant to aminoglycosides, flouroqiunolones, ureidopenicilliuns, and third-generation cephalosporins as well as carbapenems [20,21].

Many factors have been associated with the emergence and spread of antimicrobial resistance. In fact, the use of antimicrobial agent, by itself, is considered to exert a selective pressure on resistance [9]. In addition, the use of antibiotics for the treatment of non-bacterial, mostly viral, infections, and the overuse of broad-spectrum antibiotics in the management of bacterial infections promotes antibiotic resistance [22], and increases the costs of health care [23]. Inappropriate prescription of more expensive or second-line antibiotics in daily clinical practice is considered even more problematic [9]. A recent report discusses the underlying reasons for the differences in antibiotic prescription practice as applied by health care professionals. A major reason for the large-scale prescription of antibiotics is inadequate knowledge about the consequences of bacterial resistance as a worldwide problem. Secondly, it is believed that the rate of this practice increases due to the growing demand for antibiotics on the part of the patients. This results in the physicians' softening their attitude and responding to these expectations. Thirdly, the educational aspect, which is related mainly to the professional or cultural background of the physicians, is thought to play a role [24]. Finally, it was shown that the physicians who take care of a large number of patients are more likely to prescribe antibiotics when these are not appropriate [25,26].

Nosocomial infections are the most common complications affecting hospitalized patients. About 25% of nosocomial infections apply to patients in the ICU, and almost 70% of these infections are caused by microorganisms that are

resistant to one or more antibiotics [27]. Accordingly, it was not surprising that about half of the physicians and nurses in the study population were aware that prolonged hospital stay is a major contributor to greater bacterial resistance. Moreover, about half of the responding physicians thought that the other factors that are likely to contribute to bacterial resistance include the use of antibiotics without prescription and inappropriate antibiotic use, while the nurses pointed to the use of antibiotics without prescription and prescribing antibiotics when no blood culture is performed. In the pharmacists' responses, the focus was on the handling of antibiotics. A high percentage of pharmacists shared an opinion that such factors as the use of antibiotics without prescription, inappropriate antibiotic use, together with improper prescription of antibiotics are the leading causal factors of the emergence of bacterial resistance. The discrepancies in the level of awareness of bacterial resistance that were noted between the physicians, pharmacists and nurses can be explained taking into account the medical background of each profession and the field of clinical practice. While the physicians tend to focus more on the diseases and pathogenesis, the pharmacists pay more attention to medications and an improper handling of pharmaceuticals. Moreover, the physicians and nurses are in a closer contact with patients during hospitalization than are the pharmacists. These differences in practice may also add to the different views expressed by representatives of particular medical professions.

It is alarming that neither the high rate of patients transferred between different hospital units, nor the patients' non-compliance with infection control guidelines, have been considered the factors leading to bacterial resistance. Actually, many studies have shown that the latter two are the major contributors to the emergence of bacterial resistance [28–30].

When the risk factors for bacterial resistance are identified, effective measures should be undertaken to reduce the risk of future resistant infections. The strategies for limiting bacterial resistance are consistently discussed in literature. The adoption of certain guidelines, practice parameters, clinical pathways, or protocols, is associated with more appropriate antibiotic use, improved patient outcomes, fewer adverse events and errors, and more importantly, minimized resistance emergence [reviewed in 9,31]. Since nosocomial infections highly contribute to poor outcomes and increased rates of bacterial resistance, hospitals should play a major role in limiting bacterial resistance. Better infection control strategies in hospitals and regular efficiency checks on these strategies must be put to practice. Such strategies should include reducing unnecessary hospital stay, avoiding or shortening the use of invasive devices, adhering to hand hygiene guidelines, and applying antimicrobial cycling and combination strategies [9,31,32]. The participants of our study showed a significant awareness of the above approaches. The physicians concentrated on the necessity to apply appropriate infection control practices, while the nurses focused on hygiene practices and the pharmacists were concerned with a better adherence to the infection control guidelines.

To sum up, the study has revealed a number of discrepancies in the level of awareness between the physicians, pharmacists, and nurses with respect to the frequently encountered resistant bacterial strains, the factors contributing to antimicrobial resistance and the strategies to limit this adverse phenomenon. Therefore, continuous medical education programs would be desirable to keep the health care professionals updated and diminish the future risk of excessive bacterial resistance.

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