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Original Article | Artículo Original

Bacterial contamination of mobile phones of medical laboratory workers at Sana'a city, Yemen and their antimicrobial susceptibility

[Contaminación bacteriana de teléfonos móviles de trabajadores de laboratorios médicos en la ciudad de Saná, Yemen y su susceptibilidad a los antimicrobianos]

Wadhah Hassan Edrees[1,2*], Mohammed Sadeq Al-Awar[1]

[1]Medical Laboratory Department, Faculty of Medical Sciences, Al-Razi University, Yemen.
[2]Medical Microbiology, Faculty of Applied Sciences, Hajjah University, Yemen.
*E-mail: wadah.edrees@alraziuni.edu.ye; edress2020@gmail.com

Abstract

Context: Mobile phones of laboratory workers could harbor a variety of potentially pathogenic bacteria that cause nosocomial infection for the patients, self, and family members.

Aims: To determine the bacterial contamination on mobile phones belonging to the medical laboratory workers and assessment the antimicrobial susceptibility patterns of isolated bacteria at Sana'a city, Yemen.

Methods: A cross-sectional study was conducted from January to February 2020 on 100 laboratory workers' mobile phones, which were randomly selected by moistened sterile swabs. The data were collected by using a designed questionnaire. The collected samples were transported to the microbiology laboratory at Al-Razi University for bacteria isolation and identification by standard bacteriological procedures. Antibiotic susceptibility testing was performed by the disc diffusion methods.

Results: The results revealed that the overall rate of bacterial contamination on the mobile phone was 70% with one type of pathogenic bacteria (88.6%). *Staphylococcus aureus* (34.6%) was the most frequently isolated bacteria followed by *Staphylococcus epidermidis* (23.1%), *Pseudomonas* sp. (20.5%), *Staphylococcus saprophyticus* (15.4%), *Enterobacter aergene* (2.5%), *Escherichia coli* (1.3%), *Citrobacter intermedites* (1.3%), and *Citrobacter freundiii* (1.3%). The antibiotics susceptibility tests revealed that the highest sensitivity were *S. aureus*, *S. epidermides,* and *S. saprophyticus* against gentamycin, *Pseudomonas* sp. against kanamycin, *E. aergenes* against all tested antibiotics, and *C. intermedites* against gentamycin, vancomycin, and kanamycin. Also, *Pseudomonas* sp. was highly resistant to cefepime and vancomycin and *S. saprophyticus* to cefepime.

Conclusions: Mobile phones might play a role in the transmission of potentially pathogenic bacteria. It is required to promote personal hygiene and regularly disinfect the mobile phones and hands by alcohol before leaving the lab to minimize the cross-infection to the community and environment.

Keywords: antimicrobial; bacterial contamination; mobile phone; Yemen.

Resumen

Contexto: Los teléfonos móviles de los trabajadores de laboratorio podrían albergar bacterias potencialmente patógenas que causan infecciones nosocomiales a los pacientes, a sí mismos y a sus familiares.

Objetivos: Determinar la contaminación bacteriana en teléfonos móviles de los trabajadores del laboratorio médico y evaluar los patrones de susceptibilidad a los antimicrobianos de bacterias aisladas en la ciudad de Saná, Yemen.

Métodos: Se realizó un estudio transversal de enero a febrero de 2020 en los teléfonos móviles de 100 trabajadores de laboratorio, que fueron seleccionados al azar mediante hisopos estériles humedecidos. Los datos se recopilaron mediante un cuestionario diseñado. Las muestras recolectadas se transportaron al laboratorio de microbiología de la Universidad Al-Razi para el aislamiento e identificación de bacterias mediante procedimientos bacteriológicos estándar. La prueba de susceptibilidad a los antibióticos se realizó mediante métodos de difusión en disco.

Resultados: La tasa general de contaminación bacteriana en el teléfono móvil fue del 70% con un tipo de bacteria patógena (88,6%). *Staphylococcus aureus* (34,6%) fue la bacteria más frecuentemente aislada, seguida de *Staphylococcus epidermidis* (23,1%), *Pseudomonas* sp. (20,5%), *Staphylococcus saprophyticus* (15,4%), *Enterobacter aergene* (2,5%), *Escherichia coli* (1,3%), *Citrobacter intermedites* (1,3%) y *Citrobacter freundiii* (1,3%). Las pruebas de susceptibilidad a los antibióticos revelaron que las más sensibles fueron *S. aureus*, *S. epidermides* y *S. saprophyticus* frente a gentamicina, *Pseudomonas* sp. contra kanamicina, *E. aergenes* contra todos los antibióticos probados y *C. intermedites* contra gentamicina, vancomicina y kanamicina. Además, *Pseudomonas* sp. fue altamente resistente a cefepima y vancomicina y *S. saprophyticus* a cefepima.

Conclusiones: Los teléfonos móviles pueden desempeñar un papel en la transmisión de bacterias potencialmente patógenas. Se requiere promover la higiene personal y desinfectar regularmente los teléfonos móviles y las manos con alcohol antes de salir del laboratorio para minimizar la infección cruzada a la comunidad y al medio ambiente.

Palabras Clave: antimicrobiano; contaminación bacteriana; teléfono móvil; Yemen.

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INTRODUCTION

Mobile phones, like other inanimate items, can harbor microorganisms related to human infections. Human hands are appropriate for harbor microorganisms as part of normal flora, as well as temporary microbes acquired from the environment (Famurewa and David, 2009). It is imaginable that the transfer of pathogenic microorganisms might occur between human hands and mobile phones (Mark et al., 2014).

Mobile phones act as a reservoir for microorganisms grow and proliferation, particularly in warm and humid environments; for medical workers, it may serve as a spread of hospital-acquired infections. Also, the use of the same mobile phones between healthcare workers in a hospital may directly facilitate the spread of potentially pathogenic and nosocomial bacteria to the community (Foong et al., 2015).

In spite of the high opportunity of being contaminated, cellular phones are rarely cleaned and are frequently touched throughout or after the patient's examination and handling of specimens without hygienic practices. Therefore, these phones consider to be the appropriate habitat for different pathogenic bacteria and become exogenous sources of infection for the patients and are also a potential health hazard for healthcare workers and their family members (Arora et al., 2009; Kilic et al., 2009).

Many reports have been documented the bacteria contamination on mobile phones belonged to the medical laboratory workers. A study conducted in Nigeria by Amala and Ejikema (2015) isolated the coagulase-negative *Staphylococci*, *S. aureus*, *Streptococcus* sp., *Escherichia coli*, and *Pseudomonas* sp. from mobile phones from medical laboratory workers.

Moreover, the study by Pal et al. (2015) revealed that the most commonly isolated bacteria from mobile phones of the medical laboratory in Bengal were *S. epidermidis* followed by *Micrococcus* sp., *S. aureus*, *Diphtheroids* sp., *Bacillus subtilis*, and *Acinetobacter* sp.

Recently, in Egypt, EL-Kady (2017) revealed that the majority (90%) of the examined mobile phones of the medical laboratory were contaminated with the coagulase-negative *Staphylococci*, *S. aureus*, *Micrococci* sp., *E. coli*, *Streptococci viridans*, *Diphtheroids*, *K. pneumonia*, and *Enterobacter aerogenes* bacteria.

In the developing countries are lake awareness about the potentially pathogenic bacteria and hospital-acquired microorganisms that can be transmitted by mobile phones between healthcare workers. Hitherto, no study that determined the microbial contamination of mobile phones healthcare in Yemen. So, the current study aimed to determine the bacterial contamination on the mobile phones used by medical laboratory workers and assessment the antimicrobial susceptibility patterns of isolated bacteria at Sana'a city, Yemen.

MATERIAL AND METHODS

Reagents and chemicals

The chemicals used in this study were of high-purity grade (99%). The following materials were used: Nutrients agar, MacConkey agar, chocolate agar, blood agar, and Mueller-Hinton agar obtained all from HiMedia (HiMedia Laboratories, India). Also, the reagents and solution for the glucose and mannitol fermentation. Other tests including citrate utilization, urease test, oxidase test, DNase test, catalase activity, indole production, methyl red test, and Vogues Proskauer test were obtained from HiMedia (HiMedia Laboratories, India).

Study design and area

A current investigation was carried out at the medical laboratory at Al-Razi University in Sana'a city, Yemen, during the period from January to February 2020. Four public medical laboratories were subjected to this study namely Al-Gmohori hospital, Kuwait hospital, Al-Sabeen hospital, and National Central laboratory.

Data collection

A structured questionnaire was approved by the Faculty of Medical Sciences of Al-Razi University and applied for each participant such as age, gender, level of education, department of job, experience years, job time, hand cleaning, type of phone, mobile phone storing place, duration, and frequency of mobile phone usage, mobile phone cleaning habit, and hand-washing frequency were asked.

Samples collection

A total of 100 swabs were collected from mobile phones belong to medical laboratory workers working in public hospitals. Samples were collected by using sterile swabs moistened with normal saline by rotating and swabbing over the screen, sides, external cover surface of the mobile phones. The examined mobile phones were randomly collected from the laboratory department: reception, hematology, parasitology, microbiology, biochemistry. All samples were immediately transported to the medical microbiology laboratory for processing.

Samples examination

Isolation of bacteria was made by inoculating swabs onto MacConkey agar (HiMedia, India), chocolate agar (HiMedia, India), and blood agar (HiMedia, India) surface plates and incubated at 37°C for 24 h. Identification of the isolated bacteria was subjected to standard microbiological identification tests based on morphological characteristics for the colony, and biochemical tests to confirm their identity/purity (Leboffe and Pierce, 2011).

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing of isolates was performed by the modified Kirby-Bauer disks diffusion method on Mueller-Hinton agar under the CLSI protocol (CLSI, 2016). The using 5 antibiotic discs were used that included gentamycin (10 µg), cefepime (30 µg), kanamycin (30 µg), piperacillin/tazobactam (100/10 µg), and vancomycin (30 µg) discs (Hi Media Labs, India). The plates of Muller Hinton Agar were incubated overnight, and the zone of inhibition of bacterial growth was measured and interpreted according to the Clinical and Laboratory Standards Institute (CLSI, 2016).

Statistical analysis

The obtained data were performed for statistical purposes using the IBM SPSS Statistics software (version 20.0, 2011). The significance level of $p<0.01$ was used to indicate statistical significance.

RESULTS AND DISCUSSION

Mobile phones are widely used by healthcare workers in the community. They are gradually becoming a significant means of communication in the community and the healthcare facility for epidemiological data collection and chronic disease control (Waruingi and Underdahl, 2009).

A total of 100 swab specimens were collected from mobile phones from medical laboratory workers from four laboratories. The distribution of collected samples according to gender was shown in Fig. 1. The high rate of females participated in this study because they are more on number than males in healthcare in Yemen.

Table 1 shows the bacterial growth results in culture media surface among collected specimens from male and male significant that revealed that the positive growth was more than the negative growth. The contamination rate was almost equal found in the mobile phones used by males and females and also there was not significantly difference between gender and bacterial contamination. This result is constant with a study by Elmanama et al. (2015) found that 71.6% of samples were positive growth for bacteria contamination.

Little studies were found the higher contamination on mobile phones in medical laboratory workers than in our study. A study by Amala and Ejikema (2015) in Nigeria observed that 87.50% of collected samples of the medical laboratory were contaminated by bacteria. Pal et al. (2015) in Bengal reported that 100% of samples were contaminated. In Egypt, EL-Kady (2017) found that 90% of samples were contaminated by bacteria species.

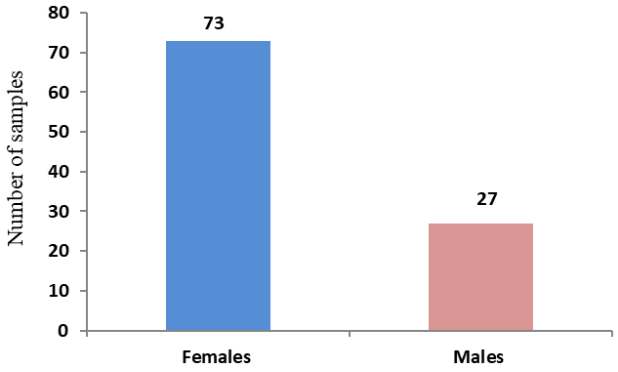

Figure 1. Number of collected samples according to genders.

Table 1. The sample positive and negative bacteria growth in media

Gender type	No. examined	Type of growth		P value
		Positive No. (%)	Negative No. (%)	
Male	27	20 (74.1)	7 (25.9)	>0.01
Female	73	50 (68.5)	23 (31.5)	
Total	**100**	**70 (70)**	**30 (30)**	

Characteristics of participants and

The present work revealed that the high frequency of bacterial contamination was among age group between 22-26 year that did not marry with educational levels of diploma degree worked in hematology section (33%) with part-time and cleaned them hand before and after work through 1-10 times/day (Table 2). These results have been supported by EL-Kady (2017) and Bodena et al. (2019).

A similar study by Elmanama et al. (2015) recorded that a high rate of bacterial contamination was among participants washing them a hand of 1-10 (times/day) (41%).

Mobile phone characterization

These results show that the high rates of bacterial contamination were among participants who had a touchscreen phone with a cover were sharing their mobile phones with their family members and 94% of them used mobile phones at work between ≤6-50 times/day. Also, the high frequency of bacterial contamination was between mobile phones cleaned daily and only 63% of them cleaned their phones by alcohol method as listed in Table 3. These results are consistent with studies by Bodena et al. (2019) who documented that the prevalence of bacterial contamination was between mobile phones without cover (96.6%) and didn't regularly clean (96.9%).

However, in a similar study by Elmanama et al. (2015) recorded that high rate of bacterial contamination was between a mobile phone with cover use (48.9%), use daily between 16-30 times (39.3%), hand washing of 1-10 (times/day) (41%), mobile cleaning daily (77.5%), and method of cleaning by alcohol (90.9%) found that 71.6% of samples were positive growth for bacteria.

In contrast, Pal et al. (2015) showed that the keypad phone had the highest bacterial contamination with 94.44% when compared to the touch phone (67.86%). Nowadays, the keypad type of mobile phone is becoming the old technology and most people don't prefer to use it and they use the Screen touch type which explains that the low rate of keypad type of collected mobile phone in this study.

Table 2. Characteristics of a participated lab. personal to a questionnaire and bacterial contamination.

Variable	Description	Frequency	Positive (%)	P value
Age (year)	22-26	55	17 (30.90)	<0.01
	27-34	20	8 (40.00)	
	≥35	25	5 (20.00)	
Marital state	Single	56	48 (85.71)	<0.01
	Married	44	22 (50.00)	
Level of education	Diploma	39	30 (76.92)	>0.01
	Bachelor	57	38 (66.60)	
	Master	4	2 (50.00)	
Department name	Microbiology	33	22 (66.60)	>0.01
	Hematology	22	20 (90.90)	
	Parasitology	20	17 (85.00)	
	Biochemistry	11	9 (81.18)	
	Serology	8	5 (62.50)	
	Reception	6	5 (83.30)	
Job time	Part time	73	52 (71.23)	>0.01
	Full time	27	18 (66.60)	
Hand cleaning	Before or after work	84	58 (69.05)	<0.01
	Before and after	16	12 (75.00)	
Hand washing (times/day)	1-10	100	70 (70.00)	NA
	11-20	0	0	

Table 3. Characteristics of the use of mobile phone and positive contamination.

Variable	Description	Frequency	Positive (%)	P value
Type of phone	Screen touch	98	69 (70.40)	>0.01
	Keypad type	2	1 (50.00)	
Phone with cover	Yes	32	26 (81.25)	<0.01
	No	68	44 (64.70)	
Do children/ wife use your mobile at home	Yes	43	24 (55.81)	>0.01
	No	57	36 (63.15)	
Frequency of use of mobile at work area	≤ 5 times/day	6	4 (66.60)	>0.01
	≤ 6-50 times/day	94	66 (70.20)	
Cleaning of mobile	Daily	32	24 (75.00)	>0.01
	Not daily	68	46 (67.65)	
Method of cleaning	Alcohol	24	18 (75.00)	>0.01
	Water	13	6 (46.15)	
	Wipe	63	46 (73.00)	

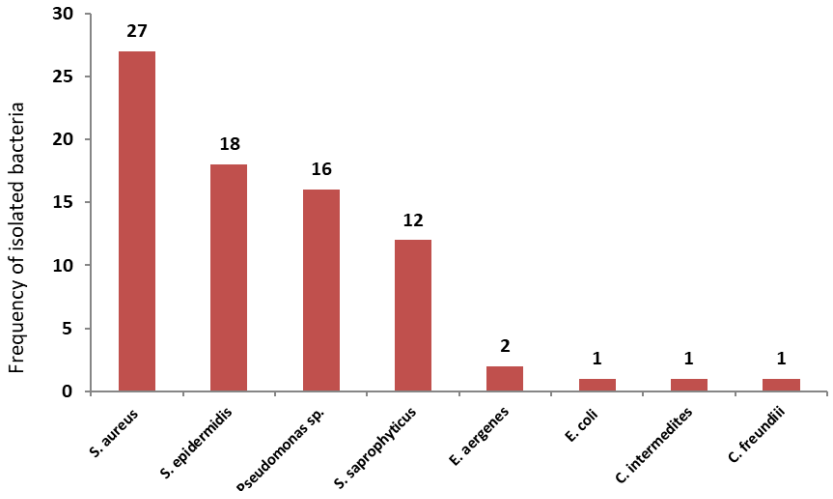

Figure 2. Type and frequency of bacteria isolated from mobile phones.

Identification of isolated bacteria

In the present study, eight species of bacteria were isolated and identified from collected samples of mobile phones as showed in Fig. 2. The high frequency of bacteria isolates was *S. aureus* was detected in 34.6% of the samples, followed by *S. epidermidis* (23.1%), *Pseudomonas* sp. (20.5%), *S. saprophyticus* (15.4%), *E. aergene* (2.5%), and *E. coli*, *C. intermedites*, and *C. freundiii* (1.3% each). In a similar study was done by Amala and Ejikema (2015) where *S. epidermidis* was isolated from 42.85% of mobile phones owned medical laboratory workers, followed by *S. aureus* (24.28%), *Streptococcus* sp. (14.28%), *E. coli* (11.42%), and *Pseudomonas* sp. (7.14%).

Moreover, the study by Pal et al. (2015) the isolated bacteria included *S. epidermidis* (33.33%), *Micrococcus* sp. (27.27%), *S. aureus* (18.18%), *Diphtheroids* sp. (9.09%), *B. subtilis* (6.06%), *Acinetobacter* sp. (6.06%). EL-Kady (2017) found that *S. epidermidis* was detected in 33% of specimens followed by *S. aureus* (24%), *Micrococci* sp. (17%), *E. coli* (15%), *Streptococci viridans* (11%), *Diphtheroids* (9%), *K. pneumoniae* (5%), and *E. aerogenes* (2%).

S. epidermidis and *S. aureus* are normal inhabitants of humans that present on hands, mouth, nose, skin, clothes, bed linen. Also, the *Staphylococci* species transmission onto mobile phones was observed by direct contact by hand palms (Melnick and Edward, 2004).

S. aureus is a common nosocomial pathogen that causes toxic shock syndrome, food poisoning, scalded skin syndrome, and abscesses virtually anywhere in the body while the *S. epidermidis* has become an important opportunistic nosocomial pathogen. Also, *Pseudomonas* is an opportunistic pathogen ubiquitous in the environment and very recalcitrant to manage in infections (Murray, 2018). The occurrence of these bacteria on mobile phones of medical laboratory workers calls for serious public health attention.

However, *E. aergene*, *E. coli*, *C. intermedites*, and *C. freundiii* belong to *Enterobacteriaceae* that are natural habitat in the intestinal tract of humans (Murray, 2018). The presence of these bacteria on mobile phones is a direct indicator that contamination is due to poor personal hygiene or fecal contamination also noted (Amala and Ejikema, 2015; EL-Kady, 2017).

The present results revealed that 88.6% of samples were contaminated with one type of bacteria while 11.4% with two types of bacteria as listed in Table 4. A nearly similar result was reported by EL-Kady (2017) where 64% of tested mobile phones were contaminated by single isolated bacteria and 26% by two types of isolated bacteria. Also, Elmanama et al. (2015) observed that 71.9% of samples were contaminated by one type of bacteria species.

Table 4. Number of isolated bacterial species per specimen.

Number of type bacteria	Number	Percent	P value
Single	62	88.6%	<0.01
Two	8	11.4%	
Total	**70**	**100%**	

Table 5. Distribution of the bacterial isolates according to the sample sources.

Department	Bacteria isolated N (%)							
	S. aureus	*S. epidermidis*	*Pseudomonas sp.*	*S. saprophyticus*	*E. aergenes*	*E. coli*	*C. intermedites*	*C. freundiii*
Microbiology	7 (25.9)	7 (25.9)	3 (18.7)	2 (16.7)	1 (50)	0	0	0
Hematology	6 (22.2)	3 (16.6)	5 (31.2)	3 (25.0)	0	0	0	0
Parasitology	6 (22.2)	2 (11.1)	3 (18.7)	2 (16.7)	1 (50)	1 (100)	0	1 (100)
Biochemistry	1 (3.7)	2 (11.1)	2 (12.5)	2 (16.7)	0	0	0	0
Serology	3 (11.1)	2 (11.1)	2 (12.5)	1 (8.3)	0	0	0	0
Reception	4 (14.8)	2 (11.1)	1 (6.2)	2 (16.7)	0	0	1(100)	0
Total (%)	**27 (34.6)**	**18 (23.1)**	**16 (20.5)**	**12 (15.4)**	**2 (2.5)**	**1 (1.3)**	**1 (1.3)**	**1 (1.3)**

Distribution of the bacterial isolates according to the sample sources

The highest frequency of isolated bacteria of laboratory departments was *S. aureus*, followed by *S. epidermidis*, *Pseudomonas* sp., *S. saprophyticus*, *E. aergenes*, *C. freundiii*, and *C. intermedites* that was listed in Table 5.

Antibiotic susceptibility pattern of bacterial isolates

The isolated bacteria were showed variable susceptibility patterns for different antibiotics tested (Table 6). It was found that 90% of *S. aureus*, 100% each of *S. epidermides,* and *S. saprophyticus* isolates had the highest sensitivity to gentamycin. Different results were reported with various levels of sensitivity rates to gentamycin. Bodena *et al*. (2019) recorder that *S. aureus* (64.5%) and *S. epidermides* (80.3%) were sensitive to gentamycin. Also, a study by Nwankwo *et al.* (2014) showed that 71.4% of *S. aureus* and 54.1% of *S. epidermides* were sensitive to gentamycin. In contrast, Lavanya et al. (2016) showed that *S. aureus* was resistant to gentamycin.

However, it was found in this investigation that 60% and 63.6% of *S. aureus* and *S. epidermides*, respectively, were observed to be sensitive to vancomycin. Pimpalkar et al. (2018) showed 100% each of *S. aureus* and *S. epidermides* were sensitive to vancomycin. Also, 100% isolates of *Pseudomonas* sp. were sensitive to kanamycin, 66.7% intermediate-resistant to gentamycin, and 83.3% resistant to cefepime.

In contrast, Nwankwo et al. (2014) showed 54.5% of *Pseudomonas* sp. was sensitive to gentamycin. Pimpalkar *et al*. (2018) showed that 40% and 62.5% isolates of *Pseudomonas* were sensitive to cefepime and gentamycin, respectively. Bodena et al. (2019) *Pseudomonas* sp. with 87.5% was sensitive to gentamycin. Also, *E. aergenes* was 100% sensitive for all tested antibiotics. While *C. inter-*

medites was completely sensitive to gentamycin, vancomycin, and kanamycin.

Limitation of the study

Limitation of this study representing on the lack the effect of period variations and small size of samples makes it problematic to understand the actual practice of medical laboratory workers and to perform further multivariable analysis to identify the effect of specific factors on mobile phone contamination. Therefore, further studies should be conducted to find out a wider range of variables with greater sample sizes. Such investigations will better contribute towards knowledge of the behavioral or hygiene characteristics of healthcare workers that might increase the risk of contamination.

CONCLUSIONS

The high rate of bacterial contamination on mobile phones between medical laboratory workers indicated that mobile phones act as a reservoir for potentially pathogenic bacteria that causing severe health implications. Therefore, implementing guidelines is necessary to prevent and control the nosocomial transmission of antibiotics bacteria resistant through mobile phones are recommended.

Table 6. Antimicrobial susceptibility pattern of bacteria isolated from mobile phones of a laboratory workers.

Antibiotics		Bacteria isolates N (%)					
		S. aureus	*S. epidermidis*	*Pseudomonas* sp.	*S. saprophyticus*	*E. aergenes*	*C. intermedites*
Gentamycin	S	9 (90)	11 (100)	2 (33.3)	10 (100)	1 (100)	1 (100)
	I	0	0	4 (66.7)	0	0	0
	R	1 (10)	0	0	0	0	0
Cefepime	S	5 (50)	7 (63.6)	0	4 (40)	1 (100)	0
	I	2 (20)	2 (18.2)	1 (16.7)	1 (10)	0	1 (100)
	R	3 (30)	2 (18.2)	5 (83.3)	5 (50)	0	0
Kanamycin	S	8 (80)	9 (81.8)	6 (100)	6 (60)	1 (100)	1 (100)
	I	1 (10)	1 (9.1)	0	0	0	0
	R	1 (10)	1 (9.1)	0	4 (40)	0	0
Piperacillin/ tazobactam	S	8 (80)	9 (81.8)	5 (83.3)	9 (90)	1 (100)	0
	I	0	2 (18.2)	1 (16.7)	1 (10)	0	1 (100)
	R	2 (20)	0	0	0	0	0
Vancomycin	S	6 (60)	7 (63.6)	1 (16.7)	3 (30)	1 (100)	1 (100)
	I	2 (20)	3 (27.3)	0	5 (50)	0	0
	R	2 (20)	1 (9.1)	5 (83.3)	2 (20)	0	0

S: Sensitive; I: Intermediate; R: Resistance.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTION:

Contribution	Edress WH	Al-Awar MS
Concepts or ideas	x	x
Design	x	
Definition of intellectual content	x	
Literature search	x	x
Experimental studies	x	
Data acquisition		x
Data analysis	x	
Statistical analysis	x	x
Manuscript preparation	x	
Manuscript editing	x	x
Manuscript review	x	x

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