Research Article

Extended Spectrum β-Lactamase Producers in Mobile Phones and Nosocomial infections: Risk Factors for Infection Control Practices

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Abstract

Extended Spectrum β-Lactamase Producers (ESBLs) isolates contaminating the healthcare workers (HCWs) mobile phones may cause threat to not only the life of hospital staffs, patients and visitors but also to the people in the community. This study was conducted to determine whether mobile phones of HCWs harbor ESBLs with their antibiotic susceptibility pattern. Isolation, identification and antimicrobial susceptibility test of bacteria were done using standard microbiological procedures. Further screening and confirmation of ESBLs were done according to Clinical Laboratory Standard Institutes (CLSI) guidelines. Out of the 100 mobile swab samples cultured, 97 (97%) showed bacterial growth. Frequency distribution of the total 67 isolates showed that the most prevalent Gram negative bacteria identified was Klebsiella spp 29.85%, followed by Escherichia coli 22.38%, Acenetobacter spp 14.93%, Proteus spp 13.43%, Pseudomonas aeruginosa 8.96%, Enterobacter spp 7.46% and Citrobacter spp 2.99%. The prevalence of ESBLs among the Gram negative isolates in this study was 29.85%. The most effective drug of choice were Amikacin, Nitrofurantoin and Imipenem for many gram negative isolates. These results showed that HCWs' mobile phones were contaminated with various types of pathogenic multi drug resistant microorganisms. Mobile phones used by HCWs in daily practice may be a source of hospital acquired infections in hospitals. Indeed, HCWs mobile phones contaminated with ESBLs increase the risk for infection may be the key factor in epidemiology of ESBLs producing bacterial infection not only in a hospital setting but also in community. Therefore, regular surveillance, disinfection with suitable agent at regular interval would minimize the colonization and transmission of pathogens like ESBLs.

Key words: Extended Spectrum β-Lactamase Producers (ESBLs), hospital acquired infection, mobile phone

Introduction

Mobile phone of healthcare workers (HCWs) could be colonized by potential bacterial pathogens and could become vectors of hospital acquired infections in healthcare facilities (Brady et al., 2006). As mobile phone acts as good habitat for microorganisms to thrive, especially in humid and warm environment, HCWs' mobile phones may serve as reservoirs of microorganisms that could be easily transmitted from the mobile phones to the HCWs' hands and therefore facilitate the transmission of bacterial isolates from one patient to another in different hospital wards (Elkholy & Ewees, 2010). The constant handling of mobile phones by users in hospitals (by patients, visitors and HCWs, etc) makes it an open breeding place for transmission of microorganisms as well as health care associated infections (HAIs) (Tagoe et al., 2011). Mobile phones are potential threats in infection control practices and could exaggerate the rate of hospital acquired infections.

HAIs are a major challenge to the healthcare system and are associated with significant mortility, morbidity and high economic burden (WHO, 2011). Sources of HAI can be endogenous or exogenous. Exogenous sources which can serve as reservoir of infection are patients, HCWs, inanimate objects like computer keyboards, faucet handles, stethoscopes, wrist watches, mobile phones, and other items present in the immediate vicinity of the patient. Cell phones are more problematic compared to other stationary objects (fomites) in that they facilitate inter wards transmission and are very difficult to get rid of pathogens (Famurewa & David, 2009).

ESBL isolates contaminating the HCWs mobile phones may cause threat to not only the life of hospital staffs, patients and visitors but also to the people in the community. Indeed, the delay in detection and reporting such pathogens may lead to prolonged hospitalization of patients, increased morbidity and mortality as well as increased cost of health care (Lautenbach et al., 2001). Members of family Enterobacteriacea able to produce extended spectrum of beta-lactamase which is responsible to hydrolyze the third generation of cephalosporin group antibiotics resulting treatment failure (Reyes et al., 2013; Huddleston et al., 2014). The increasing use of broad spectrum cephalosporins has become one of the major factors responsible for the high rate of ESBL producing microorganisms (Mirza et al., 2006).

Therefore, monitoring and evaluation of mobile phone is vital procedure for infection control in hospital setting. Mobile phones are used in hospital without restriction and the majority of HCWs neither cleans their mobile phones regularly nor wash hands after using mobile phones (Jagadeesan et al., 2013). Besides, there are no guidelines for disinfection of mobile phones that meet hospital standards. Further sharing of mobile phones between HCWs and non HCWs may distinctly facilitate the spread of potentially pathogenic bacteria to the community (Trivedi, 2011).

These pathogenic organisms can be detrimental to the health of the patients especially those in critical care units and if the organisms transferred happen to be drug-resistant; the situation becomes even more grave as it becomes difficult to treat because of the limited drug options available (Angadi et al., 2014). This study, thus aims to determine whether the mobile phones of HCWs are contaminated with pathogens like ESBLs and whether mobile phones could play a role in the spread of bacterial pathogen and to offer possible control or preventive measures that could be instituted to avoid this likely vehicle of infection in a tertiary hospital of Pokhara, Nepal.

Data and Methods

Study Design, Sample Size and Study Setting

This cross sectional study was carried out from the beginning of April 2017 till the end of December 2017 after obtaining ethical clearance from Gandaki Medical College and Teaching Hospital's Institutional Ethical Committee. A total of 100 samples (mobile phone's swabs) were randomly collected from the mobile phones of Health care workers (which include doctors, nurses, laboratory technicians and helpers) working at various departments of Gandaki Medical College and Teaching Hospital, Prithivichowk, Pokhara, Nepal and these samples were processed in the microbiology laboratory of same institution. Verbal consent was taken from each participant and all samples were collected after he/she accepted and knew that they were participating in clinical study.

Collection and Processing of Samples

The health care worker's mobile phone swab samples were collected by means of sterile cotton swabs moistened in sterile saline water (0.85%). The swabs were wiped firmly on the entire surface of the the mobile phones. The sterilized cotton buds were rotated onto the overall surface area of the mobile phone by keeping the mobile phone in two fingers. The cotton bud swabs after swabbing the mobile phone were kept in the sterile small tube containing Brain Heart Infusion (BHI) broth separately, labeled and was immediately transported to the microbiology laboratory of Gandaki Medical College and Teaching Hospital (GMC) for further processing.

All the swabs were cultured directly on Blood agar, MacConkey agar and Mannitol salt agar (Himedia) after enrichment in BHI for 24 hrs at 37°C. All cultured plates were incubated aerobically at 37°C for 24 hours. The primary isolates were subcultured on nutrient agar (Himedia). Isolates were identified on the basis of colonial appearance, Gram stain, and conventional biochemical tests (Colle et al., 1996). Antibiotic disc susceptibility testing was done to compare isolates recovered from both mobile phones by using Clinical Laboratory Standards Institute guidelines (CLSI, 2000). Extended Spectrum Beta Lactamase (ESBL) production among Gram negative bacilli was performed by standard methods according to CLSI (CLSI, 2017).

Data Collection and Analysis

All the data were entered into a computer database using standard format, checked for errors and verified. Data maintained in the computer sheets were organized and analyzed by using GraphPad Prism software for Windows (Version 8). Data were presented in appropriate table, figures by calculating percentage, frequency etc.

Results

A total of 100 mobile swabs were collected from Health care workers of Gandaki Medical College and Teaching Hospital. Among 100 swab samples cultivated, 97 (97%) swabs yielded bacterial growth while rest, 3 (3%) swabs showed no bacterial growth. The bacterial isolates

obtained in this investigation were classified on the basis of their cultural characteristic, cell morphology, Gram staining reaction and their biochemical properties (Colle et al., 1996).

Identification of isolated Gram-positive and Gram- negative bacteria

Further analysis was conducted to identify the number of Gram positive and Gram negative bacteria among the total of 165 isolates found on the mobile swabs obtained from 97 culture positive samples. The Gram stain identified that (98/165) 59.39% of the bacteria found on the mobile swabs were Gram positive and (67/165) 40.60% of the isolates were Gram negative (Figure 1).

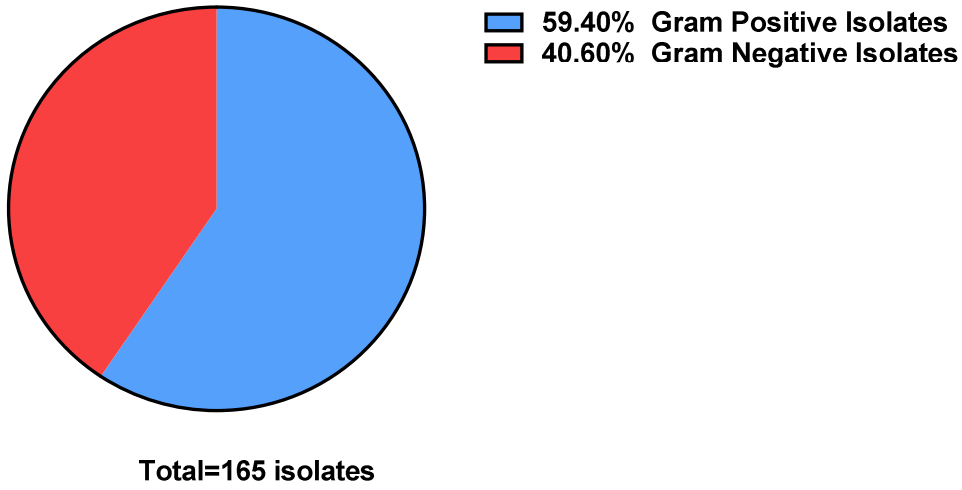

Figure 1. Percent number of Gram positive and Gram negative bacteria among the total isolates obtained from the mobile swabs.

Distribution Pattern of Gram-Negative Bacteria Isolated From Various Mobile Swabs Collected From HCWs.

The total numbers of Gram-negative bacteria isolated in this study was 67/165 (40.60%) isolates. The most common Gram-negative organism isolated in this study was *Klebsiella spp* 20 (29.85%), followed by, *Escherichia coli* 15 (22.38%), *Acenetobacter spp* 10 (14.93%), *Proteus*

spp 9 (13.43%), *Pseudomonas aeruginosa* 6 (8.96%), *Enterobacter aerogens* 5 (7.46%), and *Citrobacter spp* 2 (2.99%) (Table 1).

Table 1

Frequency, Percentage and Distribution Pattern of Gram-negative Bacteria Isolated from Various Mobile Swabs Collected from HCWs.

Organism Identified	**Number**	**Frequency**
Klebsiella spp	20	29.85%
Escherichia coli	15	22.38%
Acenetobacter spp	10	14.93%
Proteus spp	9	13.43%
Pseudomonas aeruginosa	6	8.96%
Enterobacter aerogens	5	7.46%
Citrobacter spp	2	2.99%
Total	**67**	**100%**

Antibiotic Susceptibility Test of the isolated Gram-negative bacteria

Various antibiotics were used for antibiotic susceptibility pattern determination using Kirby Bauer disc diffusion method. *Klebsiella* species showed 100% resistant to Amoxicillin+Clavulanate, Gentamycin, Cotrimoxazole and Ampicillin. The most effective drug of choice were Amikacin (95%) followed by 70% sensitive to Nitrofurantoin, Cefotaxime and Ceftazidime. Where as Imipenem (50%) and 45% sensitive to Tetracycline and Ceftriaxone (Table 2).

Comparatively antibiotic susceptibility pattern in *E.coli* showed different than that of *Klebsiella spp. E. coli* was found to be 100% resistant to Amoxicillin+Clavulanate, Gentamycin, Cotrimoxazole and Ampicillin. The most effective drug of choice were Amikacin and showing 86.66% sensitivity followed by 73.33% sensitive to Cefotaxime, Ceftazidime, Imipenem and

Nitrofurantoin. 53.33% sensitive to Tetracycline and Ceftriaxone and 40% sensitive to Ciprofloxacin (Table 2).

However, *Acenetobacter spp* showed 100% resistant to almost all antibiotics tested except sensitive to Cefotaxime (60%), Ceftazidime (60%), Amikacin (50%) and 20% sensitive to Imipenem and Nitrofurantoin.

Proteus species showed 100% resistant to Gentamycin, Ampicillin and Amoxicillin+ Clavulanate. The most effective antibiotic were Cefotaxime, Ceftazidime, Amikacin and Nitrofurantoin with 66.66% sensitivity followed by Ciprofloxacin (55.55%), Imipenem and Ceftriaxone with 44.44% (Table 2).

Similarly *Pseudomonas aeruginosa* also showed 100% resistant to most antibiotics tested and 66.66% sensitive to only Cefotaxime, Ceftazidime and Amikacin followed by 50% sensitive to Imipenem and 33.33% sensitive to Ciprofloxacin and 16.66% sensitive to Tetracycline (Table 2).

Enterobacter species showed 100% resistnt to Amoxicillin+Clavulanate, Gentamycin and Cotrimoxazole. The most effective drug of choice were Cefotaxime, Ceftazidime and Imipenem with 80% sensitivity followed by 60% sensitive to Nitrofurantoin, Ceftriaxone, Amikacin, Tetracycline and Cotrimoxazole. Where as 40% sensitive to ciprofloxacin (Table 2).

Citrobacter species showed 100% resistant to Amoxicillin+Clavulanate, Cotrimoxazole, and Ampicillin. The most effective antibiotics were Cefotaxime, Ceftazidime, Imipenem, Amikacin, and Nitrofurantoin with 100% sensitivity followed by Ceftriaxone, Tetracycline and Ciprofloxacin with 50% sensitivity and Gentamycin with 33.33% sensitivity.

Table 2

Antibiotic Susceptibility Pattern of the Isolated Gram-negative Bacteria

Pathogens	***Klebsiella spp***	***Escherichia coli***	***Acenetobacter spp***	***Proteus spp***	***Pseudomonas aeruginosa***	***Enterobacter aerogens***	***Citrobacter spp***
Total no. of isolates	**20**	**15**	**10**	**9**	**6**	**5**	**2**
No. (%) of isolates sensitive to							

CTX	14 (70)	11 (73.33)	6 (60)	6 (66.66)	4 (66.66)	4 (80)	2 (100)
CTZ	14 (70)	11 (73.33)	6 (60)	6 (66.66)	4 (66.66)	4 (80)	2 (100)
AMC	0	0	0	0	0	0	0
GEN	0	0	0	0	0	0	1 (50)
COT	0	0	0	6 (66.66)	0	3 (60)	0
CIP	8 (40)	6 (40)	0	5 (55.55)	2 (33.33)	2 (40)	1 (50)
TE	9 (45)	8 (53.33)	0	3 (33.33)	1 (16.66)	3 (60)	1 (50)
AMP	0	0	0	0	0	0	0
IPM	10 (50)	11 (73.33)	2 (20)	4 (44.44)	1 (16.66)	4 (80)	2 (100)
AK	19 (95)	13 (86.66)	5 (50)	6 (66.66)	4 (66.66)	3 (60)	2 (100)
NIT	14 (70)	11 (73.33)	3 (30)	6 (66.66)	0	3 (60)	2 (100)
CTZ	9 (45)	8 (53.33)	0	4 (44.44)	0	3 (60)	1 (50)

CTX, Cefotaxime; CTZ, Ceftazidime; AMC, Amoxicillin+Clavulanate ; GEN, Gentamycin; COT, Cotrimoxzole; CPL, Ciprofloxacin; TE, Tetracycline; NX, Norfloxacin; IPM, Imipenem; AK, Amikacin; NIT, Nitrofurantoin; CTZ, Ceftriaxone.

Prevalence of ESBLs among the isolated Gram negative bacteria

Out of total 67 Gram Negative isolates 20 were found to be ESBLs. The prevalence of ESBLs among the Gram Negative isolates in this study was (20/67) 29.85%. Total of 67 Gram negative bacilli were observed. Out of total 20 *Klebsiella spp* isolated, 6(30%); out of total 15 *Escherichia coli* 4(26.66%); out of total 10 *Acenetobacter spp* isolated 4(40%); out of 9 *Proteus spp* isolated

3(33.33%); out of total 6 *Pseudomonas spp* 2(33.33%), out of total 5 *Enterobacter spp* 1(20%) and No *Citrobacter spp* was found to be Extended B-Lactamase Producers (ESBLs).

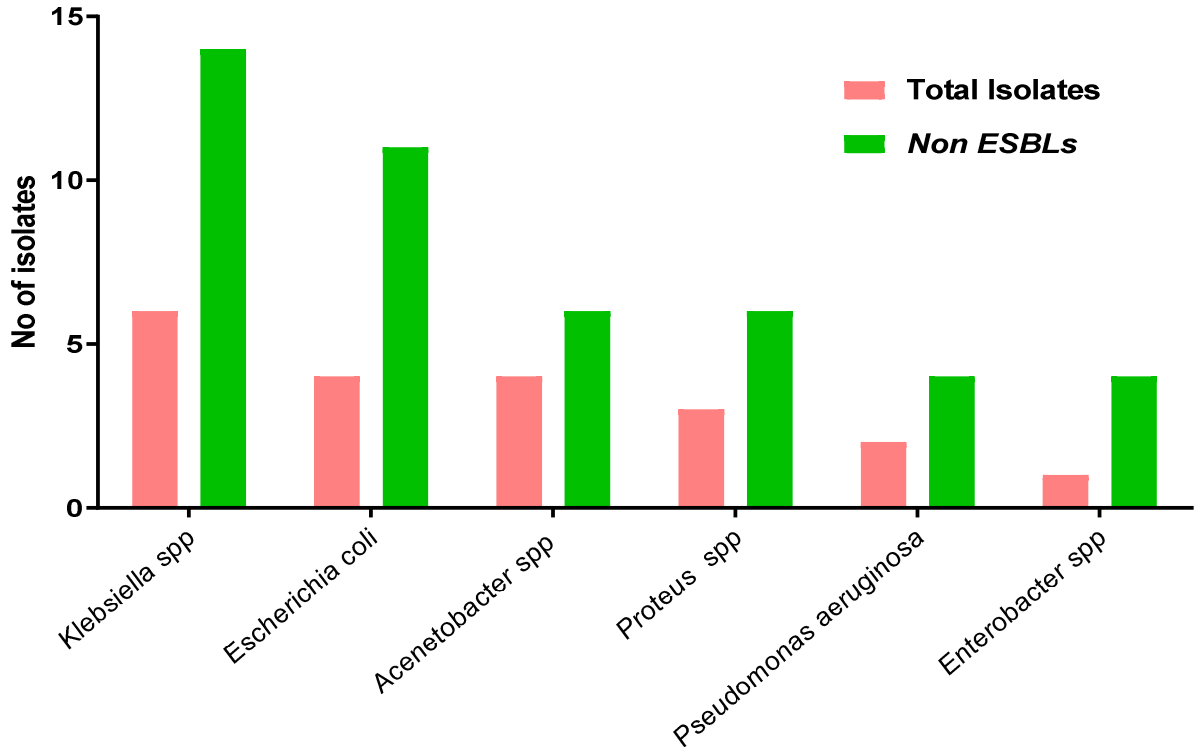

Figure 2. Distribution of ESBL Producing Gram Negative Isolates

Discussion

In the past few years, the mobile phone gradually became more and more involved in our daily life, including its private and work-related capacities. With high level of mobile phone penetration, a mobile culture has evolved, where the phone has become a key social tool. High technology applied in mobile phones has led to a better strategic life with good communication (Akinyemi et al., 2009).

In an attempt to provide better communication and health care facilities, nowadays nearly 100% of HCWs own and use mobile phones. In fact, uncontrolled use of mobile phones by HCWs increases the spread of nosocomial infections (Amer et al., 2016). Actually, not all HCWs clean their hands before or after using their phones which exposes both themselves as well as the others to the risk of transferring infections. HCW scan transfer microorganisms from the patient

himself or from one of the samples taken from him to their own hands, from their hands to their phones, and from their phones to their faces, mouths and ears. In reverse, HCWs can transfer microorganisms from their phones to patients or to other members of the community outside the health care facility (Bobat et al., 2016).

This study revealed high level of bacterial contaminants on Mobile phones which were contaminated with considerable number of Gram positive bacteria and Gram negative bacteria. However, Gram positive bacteria were found to occur more than Gram negative bacteria. Most skin flora bacteria are Gram positive, which would account for their predominance on mobile phones contamination.

Out of 100 samples (mobile swabs) processed, 97(97%) showed bacterial contamination. There is slightly higher than the reports of some researchers like Brady et al (2007) who showed that 89.7% of mobile phones were contaminated by bacteria. Ulger et al (2009) stated that 94.5% of phones showed evidence of bacterial contamination.

This study also highlighted the presence of potential pathogenic Gram-negative bacteria in mobile phones of HCWs. *Klebsiella* spp*, Escherichia coli, Acenetobacter* spp*, Proteus* spp*, Enterobacter* spp*, Pseudomonas* spp, and *Citrobacter* spp were the main Gram-negative bacteria isolated in this research work so far. The fact that bacteria of the enterobacteriaceae found on different mobile phones may indicate feacal contamination of the hands as the origin. This might be due to the fact that most people go to toilet and end up contaminating their hands with fecal and urinal material and fail to wash their hand because they take the issue of hygiene with levity, they also lack the concept of hand washing as a simple means of stopping this spread of infectious agents, this correspond with the work of Zhad et al (1998), who reported that the high rate of isolation of these organisms was only achieved during epidemics in which human hands serve as the vehicle of transmission. Gram negative sepsis, urinary tract infections are most commonly caused by *E. coli* and *Klebsiella* spp. The presence of these pathogenic bacteria on mobile phones poses a potential risk to vulnerable, immune-compromised individuals.

Similar to this study, in other studies, Gram negative bacteria like *E. coli, Klebsiella spp., Pseudomonas spp, Acinetobacter* which also can cause hospital acquired infections were also

isolated from the mobile phones (Patil & Pawar, 2012). Srikantha et al (2010) reported that commonly isolated pathogens from mobile phones were *S. aureus, Escherichia coli, Pseudomonas aeruginosa, Acinetobacter spp.* and *Klebsiella pneumoniae*. Borer et al (2005) observed that there were contaminations of hands and mobile phones only in 10% of their staff who were sampled for once. Tagoe et al (2011) observed that bacterial isolates from cell phones were *Bacillus cereus* being the highest followed by *Proteus mirabilis*, coagulase negative *Staphylococci* and the least organisms sampled were *Citrobacter spp.* and *Shigella* spp.

Klebsiella species showed 100% resistant to Amoxicillin+Clavulanate, Gentamycin, Cotrimoxazole and Ampicillin. The most effective drug of choice were Amikacin (95%) followed by 70% sensitive to Nitrofurantoin, Cefotaxime and Ceftazidime. Comparatively antibiotic susceptibility pattern in *E.coli* showed different than that of *Klebsiella spp. E. coli* was found to be 100% resistant to Amoxicillin+Clavulanate, Gentamycin, Cotrimoxazole and Ampicillin. However, *Acenetobacter spp* showed 100% resistant to almost all antibiotics tested except sensitive to Cefotaxime (60%), Ceftazidime (60%), Amikacin (50%) and 20% sensitive to Imipenem and Nitrofurantoin. *Proteus* species showed 100% resistant to Gentamycin, Ampicillin and Amoxicillin+ Clavulanate. Similarly *Pseudomonas aeruginosa* also showed 100% resistant to most antibiotics tested and 66.66% sensitive to only Cefotaxime, Ceftazidime and Amikacin. *Enterobacter* species showed 100% resistnt to Amoxicillin+Clavulanate, Gentamycin and Cotrimoxazole. *Citrobacter* species showed 100% resistant to Amoxicillin+Clavulanate, Cotrimoxazole, and Ampicillin.

In this study most of the Gram negative isolates were Multidrug resistance and resistant to Cefotaxime, Ceftazidime, Amoxicillin+clavulanate, Gentamycin, and Cotrimoxazole which is in agreement with other studies who also found 100 % resistant to Cefotaxime and Ceftazidime. For ESBL producing *E coli* or *Klebsiella* species, the Amikacin, Nitrofurantoin, and Imipenem were found to be effective drugs of choice likewise in the study done by Stoesser et al (2015) reported 96% isolates susceptible to Nitrofurantoin. The isolated organisms from mobile phones of HCWs in this study were resistant to most of the commonly used antibiotics. This may be due to indiscriminate use of multiple antibiotics, intravenous drug abuse, self-medication, and inappropriate use of antibiotics.

Indiscriminate use of antibiotics and delay in seeking medical treatment could be other reason for high rate of resistance to various antimicrobials in the this study. Isolation of ESBLs from mobile phones of the health care workers is worrisome. There is the possibility of transmission of pathogenic ESBLs from hospital units (OT, ICUs) mobile phones to patients, patients to health care professionals and vice versa during patient care, various diagnostic and therapeutic procedures. Therefore, regular surveillance, with suitable agent at regular interval would minimize the colonization and transmission of ESBLs.

Conclusion

The isolation of ESBLs on mobile phones of HCWs is a matter of concern. It proves the pathogenic potential of the organisms and highlights the risk of mobile phones as vehicles of transmission of serious multiple drug resistant pathogens. The benefits of a mobile phone to the HCW far outweigh the risk of cross-transmission of nosocomial pathogens. The findings of this study shall make aware on using mobile phones in health care settings especially during working hours to reduce the risk of transmission of detrimental nosocomial pathogens including multidrug-resistant pathogens as ESBLs. The prevention of the potential spread of infections through mobile phones needs strict adherence to infection control and precautions such as hand washing (hand-hygiene protocols must include directions for hand washing before and after mobile phone usage) and good hygienic practice among the users.

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