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ORIGINAL RESEARCH

High Rate of Bacterial Contamination on Healthcare Worker's Mobile Phone and Potential Role in Dissemination of Healthcare-Associated Infection at Debre Berhan Referral Hospital, North Shoa Zone, Ethiopia

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Background: Mobile Phone (MP) handling by healthcare workers (HCWs) in hospital is an open breeding place for the transmission of bacteria and healthcare-associated infection (HCAI). This HCAI is a huge problem to the healthcare system worldwide.

Methods: A laboratory-based cross-sectional study design was conducted from January 2020 to January 2021 in Debre Berhan Referral Hospital, North Shoa Zone, Ethiopia. A total of 65 swab samples were collected from HCWs mobiles phone. Other important data were collected using a self-administered questionnaire. The collected samples were processed for bacteriological identification and drug susceptibility testing. Data obtained were entered and cleaned into MS Excel spreadsheet and analyzed using SPSS version 21.

Results: From the total of 65 swab sample, 84 bacterial isolates were detected. Of these bacterial isolates, 46.4% were Gram-positive bacteria while 53.6% were Gram-negative bacteria. The overall MDR prevalence was found to be 42.9%. The proportion of MP contamination was higher in males (67.9%) and the age groups of 20–35 years (50%). All the MP carried by HCWs was contaminated with at least one bacterial pathogen. The high rate of MP contamination was observed in the intensive care unit (ICU) (22.6%) followed by surgical ward (17.8) and laboratory rooms (17.8%). The rate of bacterial contamination of MP was higher among HCWs working in ICU, who did not disinfect or clean their phone regularly and who did not wash their hands regularly.

Conclusion: Healthcare worker's MP was contaminated with pathogenic bacteria. Since MP could serve as a vehicle and a reservoir for pathogenic bacteria, HCWs should be aware of the public health risks of HCAI, and appropriate intervention mechanisms should be practiced to reduce the burden and cross-transmission.

Keywords: bacterial contamination, mobile phone, healthcare worker

Introduction

The mobile phone (MP) has become an important part of our lives, the use of which in different environments is rapidly growing. It is gradually becoming a significant means of communication globally. Mobile Phone is widely used in the health care setting and its role in the dissemination of HCAI is overlooked. Healthcare-associated infection is an increasing global concern for patient treatment outcome

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and safety. It affects more than 25% of the total healthcare admissions in developing countries.[1,2]

In the last decade, MP use has introduced the clinical practice, providing rapid access to medical information and allowing efficient communication with colleagues worldwide. However, the use of MP without regular disinfection, coupled with their portability, makes them a potential source of infection.[3] Indication of MP contamination in health care settings has been observed; these may be implicated in outbreaks of HCAI. Therefore, MP probably represent a constant infection risk for patients, and developing countries are likely at a greater risk.[4] The increased use of MP in hospital wards may have more serious hygiene consequences because, unlike fixed phone, MP could be close to the patients and these patients are more vulnerable to HCAI.[4,5]

Healthcare-associated infections and antimicrobial resistance are principal threats to the patients of ICU and are the major determining factors for patient outcome. Objects with frequent hand contact such as MP can serve as reservoirs from which infections can spread to the hands of healthcare providers and then to patients. These mobile devices are also carried out of the hospital and to the home of HCWs and hence to the community.[6]

Understanding the sources of these infections could help hospital authorities to improve services and information dissemination and to formulate full guidelines about restricting the use of MP in clinical environments, hand hygiene, and frequent decontamination of mobile devices.[7] Therefore this study aims to determine bacterial contamination of MP of HCWs and potential role in the dissemination of HCAI. Also, it aims to examine the prevalence of antibiotic-resistant bacteria on MP of HCWs.

Materials and Methods

Study Design, Period, and Setting

A laboratory-based cross-sectional study design was done at Debre Berhan referral hospital from January 2020 to January 2021. There are 3 obstetricians, 4 surgeons, 40 General Practitioners, 10 pharmacists, 25 druggists, 81 nurses, 20 laboratory technicians/technologist and other health professionals. This study included HCWs from intensive care unit (ICU), pediatric ward, surgical ward, gynecology ward, and laboratory rooms. We excluded HCWs who do not hold MP at the time of data collection and those who cleaned their phone once they heard about our study, and those their MP were contaminated by hands of sample collector at the time of sample collection.

Data and Sample Collection

Scio-demographic and MP-related data (hand hygiene practice, MP disinfection, and service year) were collected by pre-tested self-administered questionnaire (Supplementary Figure 3). Then, a total of 65 swab samples were collected aseptically by scrubbing over the entire surface of the MP by sterile swab moistened with sterile physiological saline. The swab sample is inoculated on Tryptic Soy Broth (TSB) medium for transportation.

Isolation and Identification of Bacteria

The TSB media was incubated aerobically at 35–37°C for 24 hours and then inoculated on blood agar (Himedia, Mumbai, India), MacConkey agar (SRL-sisco research laboratory), Salmonella-Shigella agar (Unichem, Mumbai, India), and Mannitol salt agar (Himedia, Mumbai, India) at 35–37°C for 18–24 hours. Further identification was done by Gram staining and biochemical tests like catalase test, coagulase test, oxidase test, carbohydrate fermentation, and H_2S production, citrate utilization test, motility, indole test, lysine decarboxylase test, lysine deaminase test, urea test, and hemolysis on blood agar were used for identification.

Antimicrobial Susceptibility Testing

A standard Kirby-Bauer disk diffusion method was used on Muller-Hinton agar (Oxoid, Basingstoke, UK) to determine the antimicrobial susceptibility profiles of the isolates. Bacterial isolates were tested for susceptibility to the commonly prescribed antibiotics in Ethiopia. Those antibiotics are erythromycin (15μg), gentamycin (10μg), amikacin (30μg), amoxicillin-clavulunic acid (30μg), ceftriaxone (30μg), ciprofloxacin (5μg), tetracycline (30μg), cotrimoxazole (25μg), ampicillin (10μg), penicillin (10μg), chloramphenicol (30μg), doxycycline (30μg) and cefoxitin (30μg). Clinical Laboratory Standard Institute (CLSI) guideline was used to interpret the results.[8]

Multiple Drug-Resistance Isolates

After performing antimicrobial susceptibility test, the MDR isolates (acquired non-susceptibility to at least one agent in three or more antimicrobial categories) were determined according to suggested definition of international experts.[9]

Data Quality Assurance

All laboratory test procedures were done according to standard. Quality control strains: E. coli (ATCC 25922), *S. aureus* (ATCC 25923), and *P. aeruginosa* (ATCC 28753) were used to check the performance of each test according to the CLSI guideline.[8]

Data Management and Analysis

The data was analyzed by SPSS statistical software package version 21. Descriptive statistics were employed to report numerical summary of findings. A pattern of quantitative values (frequency and proportion) was presented using statistical tables and figures. All explanatory variables associated with outcome variable with P <0.25 were entered into multivariable logistic regression analysis. The significant association was identified by AOR, (95% CI) and P-value < 0.05.

Ethical Consideration

Ethical approval was gained from Debre Berhan University ethical review and research committee (Ethical code: ERC128/2020). Permission will be obtained from Debre Berhan referral hospital administration. All participants were informed about the purpose of the study, and that it was conducted in accordance with the Declaration of Helsinki (Supplementary Figure 1). Consent was obtained from all study participants (Supplementary Figure 2).

Result

Rate of Bacterial Contamination on MPs of HCWs

From the total of 65 swab sample, 84 bacterial isolates were detected. Of these bacterial isolates, 46.4% were Gram-positive bacteria while 53.6% were Gram-negative bacteria. *Staphylococcus aureus*, CoNS, *Bacillus* spp, *P. aeruginosa, Klebsiella* spp, *E. coli, Citrobacter* spp, *Enterobacter* spp, and *Salmonella* spp were among the isolated bacteria. The most frequently isolated bacteria were CoNS (14 isolates; 16.7%), *S. aurous* (13 isolates; 15.5%), and *Bacillus* spp (12 isolates; 14.3%), respectively [Table 1].

Table 1 Frequency of Bacterial Isolates from MP of HCWs in Debre Berhan Referral Hospital, Ethiopia

Bacteria Isolates	Number	Percent
S. aureus	13	15.5
CoNS*	14	16.7
Bacillus spp	12	14.3
P. aeruginosa	9	10.7
Klebsiella spp	6	7.1
E. coli	11	13.1
Citrobacter spp	6	7.1
Enterobacter spp	4	4.8
Salmonella spp	3	3.6
Other isolates**	6	7.1
Total	**84**	**100%**

Notes: *Coagulase-negative *staphylococci*, **Serratia* spp (3), *Proteus* spp, and *Acinetobacter* spp (1).

Factors Associated with MP Contamination

The proportion of MP contamination was higher in males (67.9%) and the age groups of 20–35 years (50%). All of the MP carried by HCWs was contaminated with at least one bacterial pathogen. A high rate of MP contamination was observed in the ICU (22.6%) followed by the surgical ward (17.8) and laboratory rooms (17.8%). From profession, the highest rate of MP contamination was obtained among the nurses (35.7%). A high rate of contamination was obtained among study participants with no frequent hand washing habit 36 (42.9) and undergo no regular MP disinfection 77 (91.7). Study participants with short service experience (1–5 years) were handed MP with a high rate of bacterial contamination [Table 2].

The rate of bacterial contamination of MP of HCWs working in ICU was higher than others (AOR: 0.452; 95% CI: 0.252–0.806). The rate of bacterial contamination of MP owed by those HCWs who did clean their phone regularly was also higher than those who cleaned their phones (AOR: 1.52; 95% CI: 1.246–2.117). And also the rate of bacterial contamination of MP owed by those HCWs who did not wash their hands regularly was higher than those who washed their hands (AOR; 0.512 95% CI: 0.212–1.233) [Table 2].

Antibiotic Susceptibility Profile of Bacterial Isolates

Bacterial isolates showed a higher resistance rate against penicillin (84%) followed by ampicillin (81%) and tetracycline (42%). However, lower resistance rate against ciprofloxacin (24%), gentamycin (23%), and chloramphenicol (18%). [Figure 1]

Multi-Drug Resistance (MDR) Profile of Isolates

The overall MDR prevalence was found to be (42.9%). Among isolates, (23.8%) were resistant to two antibiotics,

Table 2 Rate of Bacterial Isolates with Socio-Demographic and Other Variables from MP of HCWs in Debre Berhan Referral Hospital, Ethiopia

Variable	Frequency N (%)	Number of Isolated Organism N (%)	COR (95% CI)	AOR (95% CI)
Sex				
Male	40 (61.5)	57 (67.9)	4.53 (3.431–7.445)	0.289 (0.408–2.536)
Female	25 (38.5)	27 (32.1)		
Age				
20–35	33 (50.8)	42 (50)	2.73 (1.37–5.443)	1.681 (1.104–2.558)
35–50	24 (36.9)	31 (36.9)		
>50	8 (12.3)	11 (16.9)		
Working Place				
ICUs	12 (18.5)	19 (22.6)	1.47 (0.901, 2.486)	0.452 (0.252–0.806)**
Pediatric ward	10 (15.4)	13 (15.5)		
Surgical ward	10 (15.4)	15 (17.8)		
Gynecology ward	10 (15.4)	11 (13.1)		
Emergency ward	10 (15.4)	12 (14.3)		
Laboratory rooms.	13 (20)	15 (17.8)		
Profession				
Medical Doctor	20 (30.8)	27 (32.1)	3.32 (1.761–6.173)	3.159 (1.811–5.508)
Nurse	23 (35.4)	30 (35.7)		
Medical Laboratory	10 (15.4)	14 (16.7)		
Others	12 (18.5)	13 (15.5)		
Frequent Hand Washing				
Yes	47 (72.3)	48 (57.1)	1.55 (0.368–1.805)	0.512 (0.212–1.233)*
No	22 (27.7)	36 (42.9)		
Regular MP Disinfection				
Yes	7 (10.8)	7 (8.3)	1.47 (0.901, 2.486)	1.521 (1.246–2.117)*
No	58 (89.2)	77 (91.7)		
Service Year				
1–5 years	21 (32.3)	35 (41.7)	2.21 (2.138, 3.854)	2.840 (1.561–5.183)
6–10 years	26 (40)	30 (35.7)		
>10 years	18 (27.7)	1. (22.6)		

Notes: *P-value < 0.05, **P-value < 0.001.

(20.2%) were resistant to six and more antibiotics, and (16.7%) were resistant to one antibiotic, while (11.9%) were not resistant to any of the antibiotics tested [Table 3].

The highest rate of resistance to many antibiotics (resistance for more than or equal to six antibiotics) was higher for CoNS (57.1%), *E. coli* and (27.3%), and *Citrobacter* spp (33.33%). In contrast, a lower rate of resistance to many antibiotics (resistance for more than or equal to four antibiotics) was observed among *Bacillus* spp isolates [Table 3].

Discussion

Mobile phones have become one of the important devices used for communication in daily life, and they are commonly used almost everywhere. HCWs use MP for communication within the hospital settings. And also many medical conditions like diabetes, asthma, and an increased rate of vaccination by travelers reminded by short message service (SMS) have been controlled by the aid of MP[10–12] However, one of the most common concerns regarding the use of mobile devices in the hospital setting and outside is; they can act as a vehicle for

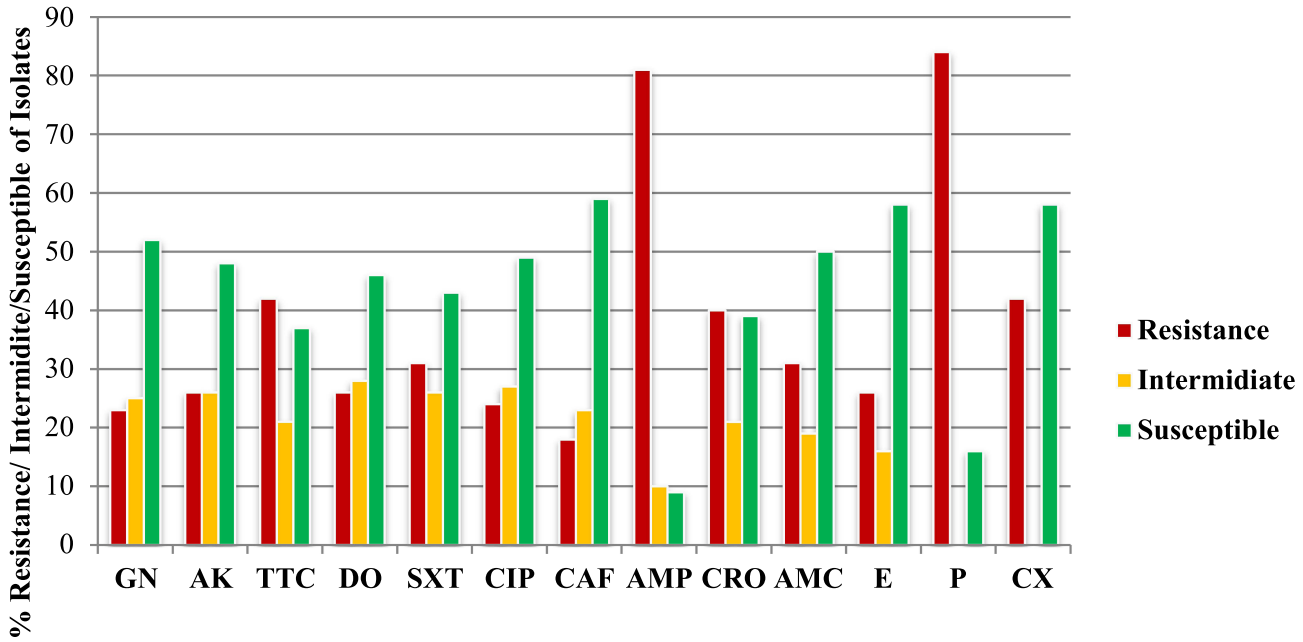

Figure 1 Antibiotic susceptibility and resistance profile of isolates against different antibiotics from MP of HCWs in Debre Berhan referral hospital, Ethiopia.
Abbreviations: GN, Gentmycin; AK, Amikacin; TTC, Tetracyclin; DO, Doxycyclin; SXT, Cotrimoxazole; CIP, Ciprofloxacin; CAF, Chloramphenicole; AMP, Ampicillin; CRO, Ceftriazone; AMC, Amoxacillin-Clavulunic Acid; E, Erytromyacin; P, Pencillin; CX, Cefoxitin.

transmitting pathogenic microorganisms particularly bacteria due to the adaptability of different environment.[4,13,14] However, there are no institutional or manufacturer protocols that advise on strategies to reduce bacterial contamination on MP in Ethiopia.

In this study, 84 bacterial isolates were detected from a total of 65 swab sample. All of the MP handled by HCWs was contaminated with at least one bacterial pathogen. This frequency is relatively high to those studies previously reported in Ethiopia and other countries.[15–21] The observed variations might be also due to the difference in adherence to infection prevention or frequency of cleaning MP, hand washing practice, the policy of MP uses in the hospital, and awareness about the role of MP in microbial transmission.

The most frequently isolated bacteria were CoNS (16.7%), *S. aureus* (15.5%), *Bacillus* spp (14.3%), *E. coli* (13.1%), and *P. aeruginosa* (10.7%) respectively. A lot of

Table 3 Multi-Drug Resistance Patterns of Bacterial Isolates from MP of HCWs in Debre Berhan Referral Hospital, Ethiopia

Bacteria isolates	Number of Isolates	R0	R1	R2	R3	R4	R5	≥ R6	MDR
S. aureus	13	0 (0)	3 (23.1)	4 (30.8)	3 (23.1)	0 (0)	1 (7.7)	2 (15.4)	7 (53.8)
*CoNS**	14	0 (0)	1 (7.1)	3 (21.4)	1 (7.1)	0 (0)	1 (7.1)	8 (57.1)	9 (64.3)
Bacillus Spp	12	5 (41.7)	2 (18.2)	3 (25)	2 (18.2)	0 (0)	0 (0)	0 (0)	0 (0)
Klebsiella Spp	6	0 (0)	0 (0)	3 (50)	1 (16.7)	1 (16.7)	0 (0)	1 (16.7)	3 (50)
E. coli	11	0 (0)	2 (18.2)	2 (18.2)	1 (9.1)	1 (9.1)	2 (18.2)	3 (27.3)	5 (45.4)
P. aeruginosa	9	4 (44.4)	1 (11.1)	2 (22.2)	2 (22.2)	NT	NT	NT	0 (0)
Citrobacter spp	6	0 (0)	2 (33.3)	0 (0)	0 (0)	0 (0)	2 (33.3)	2 (33.3)	4 (66.7)
Entrobacter spp	4	0 (0)	2 (50.0)	1 (25)	0 (0)	1 (25)	0 (0)	0 (0)	3 (75)
Salmonella spp	3	1 (33.3)	1 (33.3)	0 (0)	0 (0)	0 (0)	0 (0)	1 (33.3)	1 (33.3)
Other isolates**	6	0 (0)	0 (0)	2 (33.3)	1 (16.7)	2 (66.7)	1 (016.7)	0 (0)	4 (66.7)
Total	84	**10 (11.9)**	**14 (16.7)**	**20 (23.8)**	**11 (13.1)**	**5 (5.9)**	**7 (8.3)**	**17 (20.2)**	**36 (42.9)**

Notes: *Coagulase-negative *staphylococci*, **Serratia* spp (3), *Proteus* spp (2) and *Acinetobacter* spp (1).
Abbreviations: R0, Not resistant for any antibiotics tested; R1, Resistant to one antibiotic; R2, Resistant to two antibiotics; R3, Resistant to three antibiotics; R4, Resistant to four antibiotics; R5, Resistant to five antibiotics; ≥R6, Resistant to six or more antibiotics; NT, Not tested.

studies conducted in Ethiopia,[15,16,22,23] and outside Ethiopia[21,24,25] reported similar bacterial isolates with different isolation rates. Some other organisms like *Salmonella* spp, *Citrobacter* spp, *Enterobacter* spp, *Serratia* spp, *Proteus* spp, and *Acinetobacter* spp were also detected in this study were not usually reported by other studies. This might be due to the type and the numbers of culture media and biochemical tests used.

In the present study, CoNS isolates were detected predominantly in line with other study.[15,18,23,25,26] CoNS have comparatively low virulence and appears to be normal flora of the skin; however, it has become increasingly accepted as the most common cause of nosocomial bacteremia associated with indwelling devices. The *S. aureus* (15.5%) isolation rate was similar to the study done in Ethiopia[23] and India.[19,27] In this study, *Bacillus* spp (14.3%) was the third predominant isolates. It was also reported from a similar study in Ethiopia[12] and Egypt.[28] The isolation rate of *Bacillus* spp in this study confirms its ubiquitous nature as well as the abilities of its spores to resist environmental changes, and tolerate dry heat and chemical disinfectant for a certain time. The presence of *P. aeruginosa, K. pneumonia, E. coli, Citrobacter* spp, *Enterobacter* spp, *Proteus* spp, and *Acinetobacter* spp showed the high role of MP in transmission HCAI. The presence of *E. coli, Salmonella* spp, and *Serratia* spp indicates a low level of hand and MP hygienic practice as those organisms are part of the intestinal flora (first two) and Environment flora (last) and the leading cause of HCAI.

Different factors were associated with contamination of MP. In this study, sex difference is not associated with MP contamination. This is similar to the finding of Pal et al[19] and Shooriabi et al.[29] However, this was in contrast to a study conducted in Ethiopia,[23] India,[30] and Iran.[31] The rate of bacterial contamination of MP of HCWs, working in ICU was higher than others. This is opposite to other similar studies done in Zambia.[32] This difference might be the reflection of poor adherence to the infection prevention practice in ICU of the present study area. The rate of bacterial contamination of MP owed by those HCWs who did not disinfect or clean their phone was also higher than those who cleaned their phone. This was supported by other studies.[3,16,23,33,34] Past studies indicate a significant decline of MP contamination after treating with disinfectant.[35,36] The rate of bacterial contamination of MP owed by those HCWs who did not wash their hands was higher than those who washed their hands regularly. This might be because hand washing is the most important prevention method of communicable disease.

Antibiotic-resistant bacteria are the most serious health risk for patients.[32] Most of the isolates (88.1%) in this study were resistant to at least one antibiotic tested. Bacterial isolates showed a higher resistance rate against penicillin (84%) followed by ampicillin (81%) and tetracycline (42%), Also, MRSA and methicillin-resistant CoNS were isolated. These findings were similar to other studies conducted in different regions.[3,15,19] These may indicate that MP of HCWs are a habitat for antibiotic-resistant pathogens. And also many Gram-negative bacteria (eg, *Klebsiella* spp, *E. coli, Citrobacter* spp, and *Enterobacter* spp) isolates were found to be resistant to many antibiotics tested with similar antibiotic resistance profiles. This could suggest that they could have had a common source of contamination from patients, from the contaminated hospital environment, or any unknown source. In this study, relatively lower resistance was observed among bacterial isolates to Chloramphenicol, gentamycin, and ciprofloxacin whereas higher against tetracycline and ampicillin. This result was in line with other studies conducted elsewhere.[16,17,19,37–39]

MDR bacterial strains could be a result of unreasonable and excessive use of antibiotics.[23] In the current study, high rate of MDR (42.9%) was reported. This is in contrast to other study.[16,23,37] This difference might be due to the difference in the hospital environment, empirical treatment practice, use of antibiotics as prophylactic, easy availability of antibiotics without prescriptions, the dose of the antibiotics, and indiscriminate or prolonged use of antibiotics. The highest rate of MDR on MP proves the MP increase the burden of HCAI unless strict guidelines and measures are taken regarding the use and cleaning of MP in health care settings.

Among isolates, (23.8%) were resistant to two antibiotics, (20.2%) were resistant to six and more antibiotics, and (16.7%) were resistant to one antibiotic, while (11.9%) were not resistant to any of the antibiotics tested. The highest rate of resistance to many antibiotics (resistance for more than or equal to six antibiotics) was higher for CoNS (57.1%), *E. coli* and (27.3%), and *Citrobacter* spp (33.33%). In contrast, a lower rate of resistance to many antibiotics (resistance for more than or equal to four antibiotics) was observed among *Bacillus* spp isolates. The rate of contamination with MDR bacteria of MP of HCWs showed that Coagulase-negative *staphylococci* were the most frequently isolated species among potential pathogenic bacteria identified. This might be due to the ability to survive for long periods in aerosolized states and harsh conditions like drying as compared to others.[40]

Limitation of the Study

This study did not address the effect of period variations since it is a cross-sectional study design. Due to lack of budget, time and laboratory facility, this study did not include other important bacterial pathogens responsible for HCAI like anaerobes. The small sample size makes it difficult to understand the actual practice of health professionals and to perform further multivariable analysis to identify the effect of specific factors on MP contamination with MDR bacteria.

Conclusion

In this study, the result showed that MP of HCWs was contaminated with a variety of pathogenic bacteria that have been implicated in HCAI. Most bacterial isolates were resistant to at least one antibiotic and the majority of isolates were MDR. Working in ICU, the lack of regular hand washing and deficiency in disinfection of MP were the significantly associated factors of bacterial contamination of MP of HCWs in the current study. Based on these findings, HCWs should clean their MP after use and wash their hands before and after handling patients in the health care settings. It is better to develop and implement the mobile use guideline in health care settings.

Data Sharing Statement

All raw data are available upon request from the primary author.

Disclosure

The authors report no conflicts of interest in this work.

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