



Original Article

Open Access

Mobile phones of hospital workers: a potential reservoir for the transmission of pathogenic bacteria

*¹ Bissong, M. E. A., and ²Moukou, M.¹Department of Biomedical Sciences, University of Bamenda, P. O. Box 39, Bambili, Cameroon²Department of Medical Laboratory Science, University of Bamenda, P. O. Box 39, Bambili, Cameroon*Correspondence to: mabissong@yahoo.com; +237675301641

Abstract:

Background: Mobile phones are increasingly associated with the transmission of pathogenic microbial agents. In the clinical setting where there is usually high exposure to pathogens, these devices may serve as vehicles for the transmission/spread of pathogens. This study determined the prevalence of bacterial contamination of mobile phones of health workers and the predisposing factors, in order to ascertain the risk of transmission of pathogenic bacteria through mobile phones.

Methodology: This study was carried out in a private medical center at Mbouda, Cameroon, involving 78 health workers including health professionals (nurses, physicians, laboratory scientists) and hospital support workers (cleaners, cashiers and security guards), recruited by convenient sampling. Sterile swab sticks moistened with physiological saline were used to swab about three quarter of the surface of each phone. The swabs were cultured on MacConkey and Mannitol Salt agar plates which were incubated aerobically at 37°C for 24 hours, while Chocolate agar plate was incubated in a candle extinction jar for microaerophilic condition. The isolates were identified using standard biochemical tests including catalase, coagulase, and the analytical profile index (API) system. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0.

Results: Mobile phones of 75 of the 78 (96.2%) health workers were contaminated, with highest contamination rates for the phones of laboratory scientists (100%, 12/12), followed by support staff (98.9%, 13/14), nurses (97.7%, 43/44) and physicians (87.3%, 7/8), but the difference in contamination rates was not statistically significant ($p=0.349$). A total of 112 bacteria belonging to 12 genera were isolated, with predominance of *Staphylococcus aureus* (31.3%, $n=35$), *Micrococcus* spp (30.4%, $n=34$), coagulase negative staphylococci (10.7%, $n=12$) and *Pseudomonas* spp (5.4%, $n=6$). The laboratory (18.8%, 21/112) and medical wards (16.1%, 18/112) had the highest bacterial contamination of mobile phones ($p=0.041$), and more bacterial species were isolated from smartphones (68.8%, $n=77/112$) than keypad phones (31.2%, $n=35/112$) ($p=0.032$). There was no significant difference between phone contamination rates and the practice of hand hygiene or decontamination of work surfaces ($p>0.05$).

Conclusion: The presence of potentially pathogenic bacteria on cell phones of health-care workers emphasizes the role of fomites in the transmission of infectious diseases. Consequently, good hand hygiene and decontamination practices are encouraged among health workers in order to limit the spread of hospital-acquired infections.

Keywords: mobile phones, bacterial contamination, hospital workers, risk factors, nosocomial infections

Received Dec 29, 2021; Revised Mar 28, 2022; Accepted Apr 01, 2022

Copyright 2022 AJCEM Open Access. This article is licensed and distributed under the terms of the Creative Commons Attribution 4.0 International License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, distribution and reproduction in any medium, provided credit is given to the original author(s) and the source. Editor-in-Chief: Prof. S. S. Taiwo

Les téléphones portables des personnels hospitaliers: un réservoir potentiel de transmission de bactéries pathogènes

*¹ Bissong, M. E. A., et ²Moukou, M.¹Département des Sciences Biomédicales, Université de Bamenda, P. O. Box 39, Bambili, Cameroun²Département des Sciences de Laboratoire Médical, Université de Bamenda, P. O. Box 39, Bambili, Cameroun*Correspondance à: mabissong@yahoo.com; +237675301641

Résumé:

Contexte: Les téléphones portables sont de plus en plus associés à la transmission d'agents microbiens pathogènes. Dans le cadre clinique où il y a généralement une forte exposition aux agents pathogènes, ces dispositifs peuvent servir de véhicules pour la propagation de la transmission des agents pathogènes. Cette étude a déterminé la prévalence de la contamination bactérienne des téléphones portables des agents de santé et les

facteurs prédisposants, afin de déterminer le risque de transmission de bactéries pathogènes par les téléphones portables.

Méthodologie: Cette étude a été réalisée dans un centre médical privé à Mbouda, au Cameroun, impliquant 78 agents de santé, y compris des professionnels de la santé (infirmiers, médecins, scientifiques de laboratoire) et des agents de soutien hospitalier (agents de nettoyage, caissiers et agents de sécurité), recrutés par échantillonnage pratique. Des écouvillons stériles humidifiés avec du sérum physiologique ont été utilisés pour écouvillonner environ les trois quarts de la surface de chaque téléphone. Les écouvillons ont été cultivés sur des plaques de gélose MacConkey et Mannitol Salt qui ont été incubées en aérobiose à 37°C pendant 24 heures, tandis que la plaque de gélose au chocolat a été incubée dans un pot d'extinction de bougie pour une condition microaérophile. Les isolats ont été identifiés à l'aide de tests biochimiques standard, notamment la catalase, la coagulase et le système d'indice de profil analytique (API). Les données ont été analysées à l'aide du package statistique pour les sciences sociales (SPSS) version 20.0.

Résultats: Les téléphones portables de 75 des 78 agents de santé (96,2 %) étaient contaminés, avec les taux de contamination les plus élevés pour les téléphones des scientifiques de laboratoire (100%, 12/12), suivis par le personnel de soutien (98,9%, 13/14), infirmières (97,7%, 43/44) et médecins (87,3%, 7/8), mais la différence de taux de contamination n'était pas statistiquement significative ($p=0,349$). Au total, 112 bactéries appartenant à 12 genres ont été isolées, avec une prédominance de *Staphylococcus aureus* (31,3%, $n=35$), *Micrococcus* spp (30,4%, $n=34$), staphylocoques à coagulase négative (10,7%, $n=12$) et *Pseudomonas* spp (5,4%, $n=6$). Le laboratoire (18,8%, 21/112) et les services médicaux (16,1%, 18/112) avaient la contamination bactérienne la plus élevée des téléphones portables ($p=0,041$), et plus d'espèces bactériennes ont été isolées des smartphones (68,8%, $n=77/112$) que les téléphones à clavier (31,2%, $n=35/112$) ($p=0,032$). Il n'y avait pas de différence significative entre les taux de contamination du téléphone et la pratique de l'hygiène des mains ou de la décontamination des surfaces de travail ($p>0,05$).

Conclusion: La présence de bactéries potentiellement pathogènes sur les téléphones portables des travailleurs de la santé souligne le rôle des fomites dans la transmission des maladies infectieuses. Par conséquent, de bonnes pratiques d'hygiène des mains et de décontamination sont encouragées chez les agents de santé afin de limiter la propagation des infections nosocomiales.

Mots-clés: téléphones portables, contamination bactérienne, personnels hospitaliers, facteurs de risque, infections nosocomiales

Introduction:

Mobile phones are wireless hand-held electronic devices that are used primarily for communication (1). There are three main categories of mobile phones. The basic phones used for basic communication purposes such as making voice calls, sending and receiving short message service (SMS) messages and making use of unstructured supplementary services data (USSD) (1). The feature phones offer features additional to a basic phone, including cameras and increased storage, as well as the ability to access the Internet. On the other hand, smartphones offer advanced capabilities and features over feature and basic phones. Most smartphones run a full-featured operating system, allow users add applications to their phones and have wireless-fidelity (Wi-Fi) capabilities. These additional features make smartphones more widely used than feature and basic phones. It is estimated that more than 50% of the world's population make use of mobile phones and this number is expected to increase especially with the advent of the internet (2).

Despite the importance of the mobile phones as effective communication tools, these devices are increasingly being associated with the transmission of disease agents from person to person (3-5). In the hospital milieu, mobile phones, though not direct medical tool per se, are constantly being used in nearly all the sectors. It is a fact that the hospital environment usually harbors a variety of pathogenic microbes which can be transmitted from

hospital staff to patients and vice versa (5-8).

It has been observed that health care professionals constantly handle mobile phones without disinfection in their bags and pockets or on their hands in the clinical setting (6); these practices may enhance the spread of pathogens. Thus, mobile phones of hospital workers may serve as important vehicles for nosocomial transmission of infections. Various research studies have shown that some microbes have the ability to persist on inanimate surfaces such as plastics, wooden material and mobile phones (9-13). High rates of contamination of mobile phones of health workers with potentially pathogenic microorganisms have been reported by many studies (13-16).

Amongst these microorganisms are bacterial species such as coagulase negative staphylococci, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella* spp, viridians streptococci and *Bacillus* spp (13-16). There are reports that poor hand washing, absence of regular phone disinfection practices by health professionals predispose their mobile phones and those of others to colonization by bacteria (14-16). In this light, the usage of mobile phones by health workers within the hospital milieu, coupled with poor hygienic practices may be associated with high infection risks.

Although there are several reports on microbial contamination of mobile phones of health workers, there are limited data in our setting. This study was aimed at investigating the bacterial species that contaminate mobile phones of health workers and the factors ass-

ociated with these phones' contamination.

Materials and method:

Study area:

The study site was Adlucem Medical Foundation (AMF) hospital located at Mbouda, the chief town of Bambotus division in the western region of Cameroon. This hospital is a private health institution with about 80 staff, including physicians, nurses, laboratory technicians and other paramedical staff. The hospital consists of various units; notably, emergency, laboratory, imaging, antenatal & infant welfare clinic, pharmacy, theatre, dentistry, otorhinolaryngology unit, preventive medicine, mortuary, almoner and administrative unit. It also has several wards which include pediatric, male and female medical and surgical wards, gynecological ward, post-natal ward, intensive care unit/reanimation and nursery.

Research design, participant recruitment and ethical approval:

The study is a cross sectional hospital-based design involving health professionals (nurses, physicians, laboratory scientists) and hospital support workers (cleaners, cashiers and security guards). The study participants were recruited by convenient sampling and included all consenting hospital workers present at AMF hospital during the study period.

A structured questionnaire was administered on each participant to obtain information on demographics and risk factors for mobile phone contamination. The research protocol was reviewed and approved by the Faculty of Health Sciences Ethics Review Board of University of Bamenda, Cameroon.

Sample collection

A mobile phone was sampled for each participant and for those who have more than one phone, only the most commonly used phone was sampled. The mobile phones were categorized into two groups; the smartphones and the keypad phones (comprising all the basic type phones).

Samples were collected aseptically from each participant's mobile phone as previously reported (17). Briefly, the external surface of each phone was swabbed using sterile swab slightly moistened with sterile physiological saline. About three quarter of the surface of each phone was swabbed with key areas being the mouth piece, keys buttons and outlets. Swabbing of each phone was done through the entire front and sides to the back of the phone for about 3 minutes under

aseptic conditions. The samples were transported immediately to the laboratory and kept at 4°C prior to analyses.

Isolation and identification of bacteria:

The swabs were inoculated onto Chocolate agar (CHA), Blood agar (BLA), MacConkey agar (MAC) and Mannitol Salt agar (MSA) plates. The BLA, MAC and MSA plates were incubated aerobically at 37°C for 24hrs while CHA plates were incubated at 37°C in a candle extinction jar for the isolation of fastidious bacteria.

Presumptive identification of bacterial isolates from culture plates was based on colony morphology and Gram stain reaction, as previously described (18). Further confirmation of Gram-positive bacteria was done with catalase and coagulase tests while Gram-negative bacterial isolates were identified using Analytical Profile Index for Enterobacteriaceae (API-20E) according to the manufacturer's instruction (BioMerieux, Marcy-l'Etoile, France).

Data analysis

Data from the questionnaires and laboratory results were entered in Microsoft Excel office version 24 and analysis was done using the Statistical Package for Social Sciences (SPSS) version 20.0. The Chi-square test was used to compare proportions and to establish a statistical significance between the investigated variables. Statistical significance was established when the p value was < 0.05 .

Results:

Sociodemographic characteristics of study participants

A total of 78 health workers were recruited from 19 different units of the AMF and a cell phone of each participant was sampled. The socio-demographic information of participants is presented in Table 1. There were more females (52.6%, $n=41$) than males (47.4%, $n=37$), however, this difference was not statistically significant. All the participants were above 20 years of age, with the majority in the age group 20-30 years (35.9%, $n=28$) and age group 30-40 years (34.6%, $n=27$). In addition, 40 out of the 78 (51.3%) participants were married while 33 (48.7%) were single.

The study participants were categorized into four groups based on profession, with physicians (10.3%, $n=8$), nurses (56.4%, $n=44$), laboratory scientists (15.4%, $n=12$) and support staff (17.9%, $n=14$).

Table 1: Socio-demographic characteristics of participating health worker at Adlucem Medical Foundation Hospital, Mbouda, Cameroon

Demographic parameters		Number	Percentage
Gender	Male	37	47.4
	Female	41	52.6
Age group (years)	< 20	0	0.0
	20 -30	28	35.9
	30-40	27	34.6
	>40	23	29.5
Marital status	Married	40	51.3
	Single	38	48.7
Category of hospital worker	Physicians	8	10.3
	Nurses	44	56.4
	Laboratory scientist	12	15.4
	Support staff	14	17.9
Type of phone	Smartphone	52	66.7
	Keypad phone	26	33.3

Table 2: Contamination rates of mobile phones of participating health workers at Adlucem Medical Foundation Hospital, Mbouda, Cameroon

Category of hospital worker	No of phones analysed	Number of phones contaminated	Percentage of phones contaminated	p-value
Physician	8	7	87.3	0.349
Nurse	44	43	97.7	
Laboratory Scientist	12	12	100.0	
Support staff	14	13	98.9	
Total	78	75	96.2	

Prevalence of bacterial contamination of the mobile phones of health workers

Out of the 78 phones examined, bacterial contamination occurred with 75, giving an overall bacterial contamination rate of 96.2% (Table 2). Mobile phones of laboratory scientists had the highest contamination rate (100%, 12/12) while those of physicians had the lowest contamination rate (87.3%, 7/8). However, the difference in the contamination rates of mobile phones of the various categories of health workers was not statistically significant ($p=0.349$).

Based on the type of phones, all the keypad phones (100%, 26/26) were contaminated with at least one bacterial genus while 49 of 52 (94.2%) smart phones were contaminated. On the other hand, mobile phones from the laboratory and medical wards had the highest bacterial contamination rate (18.6%, 14/75) each, followed by those from re-animation (10.6%, 8/75), surgery (9.3%, 7/75) and the PMI (8.0%, 6/75) units.

The level of contamination was also

analysed with respect to the number of bacterial species isolated from each mobile and the categories are as follows; single-contamination (single bacterial species); double-contamination (two bacterial species) and multi-contamination (three or more bacterial species). It was observed that single-contamination of mobile phones was more frequent (52%) while multi-contamination was least frequent (5.3%) (Fig. 1)

Bacterial species isolated from phones of health workers

A total of 112 bacterial pathogens belonging to 12 bacterial genera were isolated from phones of participating health workers (Table 3). Gram-positive bacteria (72.3%, $n=81$) were commonly isolated than Gram-negative bacteria (27.7%, $n=31$), however, 10 species of Gram-negative bacteria were isolated compared to 2 species of Gram-positive bacteria. The predominant bacterial species were *Staphylococcus aureus* (31.3%, $n=35$), *Micrococcus* spp (30.4%, $n=34$), coagul-

ase negative staphylococci (10.7%, n=12), *Pseudomonas* spp (5.4%, n=6) and *Haemophilus* spp (5.4%, n=6).

Generally, more bacterial species were isolated from smartphones (68.8%, 77/112) than keypad phones (31.2%, 35/112) (Table 3). Regarding the individual bacterial species, *S. aureus* was isolated about 7 times more frequently from smartphones (91.4%, n=32) than keypad phones (8.6%, n=3), and this difference was statistically significant (OR=7.585; 95% CI=2.135-26.944, $p=0.0004$).

The distribution of bacterial isolates

with respect to the various hospital units was statistically significant ($p=0.041$), with laboratory (18.8%, 21/112) having the highest proportion, followed by medical wards (16.1%, 18/112), PMI (8.9%, 10/112), reanimation (8.0%, 9/112), surgery (7.1%, 8/112) and reception (7.1%, 8/112) (Fig 2). Although Gram-positive bacteria were predominantly isolated, Gram-negative bacteria were isolated more frequently than Gram-positive bacteria from mobile phones in PMI (16.1% and 6.2%, respectively) and mortuary (9.7% and 0.0% respectively).

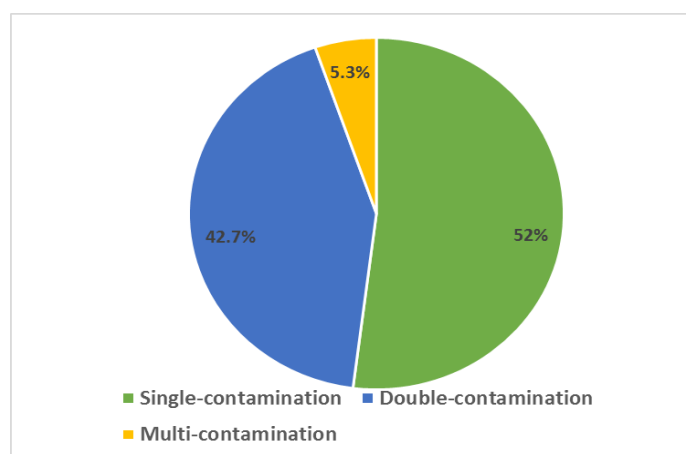


Fig 1: Percentage contamination of mobile phones based on the number of bacterial species (Single-contamination: one bacterial species; double-contamination: two bacterial species; multi-contamination: three or more bacterial species)

Table 3: Bacterial pathogens isolated from mobile phones of participating health workers at Adlucem Medical Foundation Hospital, Mbouda, Cameroon

Bacterial species	Number of bacteria isolated from phones (%)				p value
	Smartphone	Keypad phone	Total	OR (95% CI)	
<i>Staphylococcus aureus</i>	32 (91.4)	3 (8.6)	35 (31.3)	7.585 (2.135-26.944)	0.0004*
CoNS	7 (58.3)	5 (41.7)	12 (10.7)	0.600 (0.1762-2.043)	0.5115
<i>Micrococcus</i> spp	19 (55.9)	15 (44.1)	34 (30.4)	0.4524 (0.1937-1.056)	0.0782
<i>Klebsiella</i> spp	1 (33.3)	2 (66.7)	3 (2.7)	0.2171 (0.019-2.480)	0.2297
<i>Citrobacter</i> spp	2 (66.7)	1 (33.3)	3 (2.7)	0.9067 (0.079-10.351)	1.000
<i>Pseudomonas</i> spp	3 (50.0)	3 (50.0)	6 (5.4)	0.4324 (0.0828-2.260)	0.3744
<i>Haemophilus</i> spp	3 (50.0)	3 (50.0)	6 (5.4)	0.4324 (0.0828-2.260)	0.3744
<i>Escherichia coli</i>	1 (100)	0	1 (0.9)	1.392 (0.055-35.055)	1.000
<i>Serratia</i> spp	4 (100)	0	4 (3.6)	4.347 (0.228-83.036)	0.3075
<i>Enterobacter</i> spp	0	1 (100)	1 (0.9)	0.1484 (0.0059-3.738)	0.3125
<i>Acinetobacter</i> spp	1 (50.0)	1 (50.0)	2 (1.8)	0.4474 (0.0272-7.370)	0.5293
<i>Cedecea</i> spp	1 (50.0)	1 (50.0)	2 (1.8)	0.4474 (0.0272-7.370)	0.5293
<i>Burkholderia</i> spp	3 (100)	0	3 (2.7)	3.336 (0.168-66.381)	0.5507
Total	77 (68.8)	35 (31.2)	112 (100)		

CoNS = coagulase negative staphylococci; OR=Odds ratio; CI = Confidence Interval; * = statistically significant

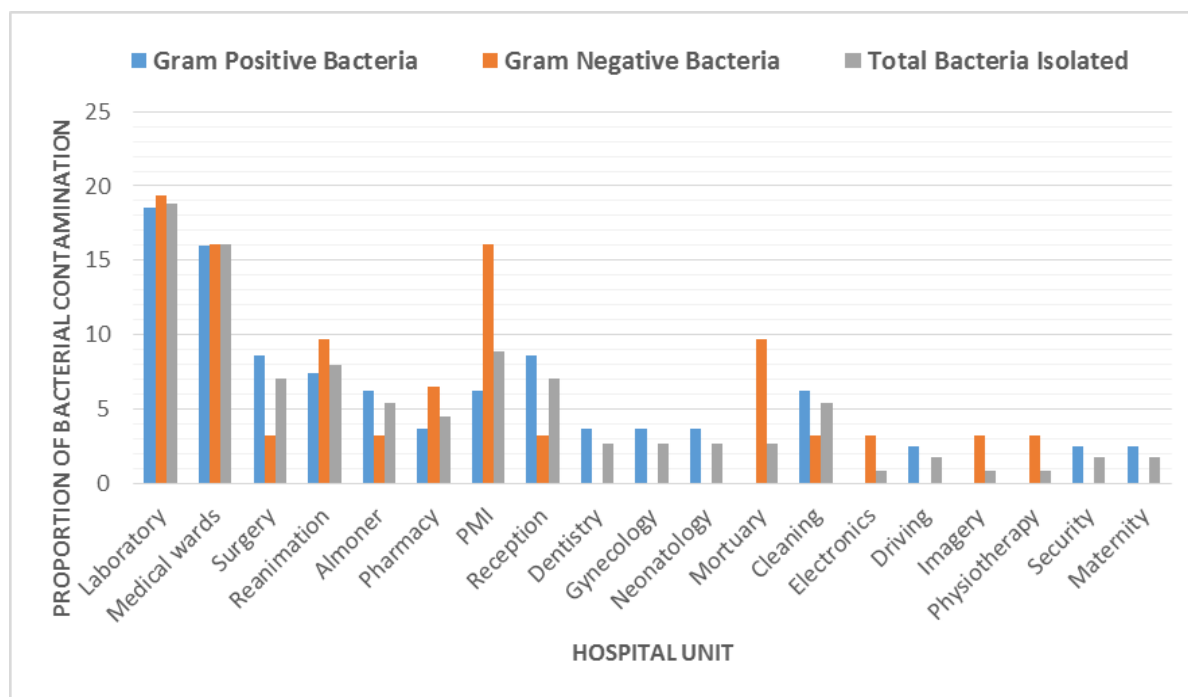


Fig 2: Distribution of bacterial isolates from mobile phones from different hospital units

Table 4: Prevalence of bacterial contamination of mobile phones of participating health workers at Adlucem Medical Foundation Hospital, Mbouda, Cameroon with respect to gender and age

Parameter	No contaminated (%)	No not contaminated (%)	p value
Gender			
Female	39 (95.1)	2 (4.9)	0.6179
Male	36 (97.3)	1 (2.7)	
Total	75 (96.2)	3 (3.8)	
Age group (years)			
20-30	27 (96.4)	1 (3.6)	0.9886
30-40	26 (96.3)	1 (3.7)	
>40	22 (95.7)	1 (4.3)	
Total	75 (96.2)	3 (3.8)	

No = Number

Predisposing factors for bacterial contamination of mobile phones:

The rate of contamination of phones was analysed with respect to the age group and gender of the study participants and the results presented in Table 4. There was no statistical significance difference in the rate of contamination based on gender ($p=0.6179$) and age group ($p=0.9886$).

Table 5 shows the rate of contamination of mobile phones with respect to hand hygiene practice, disinfection of work surface, and frequency of phone usage while working. More than half of the participants (52.0%, $n=40$) admitted they wash their hands with

water and soap while 19 (24.6%) wash their hands with water/soap or detergent and also sanitize their hands with alcohol solution.

In addition, majority of the participants (52.1%, $n=37$) always disinfect their work surfaces with 10% hypochlorite before and after work. Meanwhile, 40 (51.3%) rarely use their mobile phones (<5 times) and 38 (48.7%) often use phones while working. However, there was no significant difference between the practice of hand hygiene, decontamination of work surfaces, and frequency of phone usage with the contamination rates of the mobile phones ($p>0.05$).

Table 5: Prevalence of bacterial contamination with respect to hand hygiene and work surface decontamination

Factors	Response	Contaminated (%)	Not contaminated (%)	p value
Hand hygiene (n=77)	With water only	4 (100.0)	0	0.2102
	With water and soap	39 (97.5)	1 (2.5)	
	With water and detergent	4 (80.0)	1 (20.0)	
	With alcohol solution only	8 (88.9)	1 (11.1)	
	A mixture of all	19 (100.0)	0	
Total		74 (96.1)	3 (3.9)	
Work surface decontamination (n=71)	Before work only	18 (100.0)	0	0.4108
	After work only	9 (100.0)	0	
	Before and after work	34 (91.9)	3 (8.1)	
	Before or after work	7 (100.0)	0	
Total		68 (95.8)	3 (4.2)	
Frequency of phone usage (n=78)	Rarely	39 (97.5)	1 (2.5)	0.9639
	Often	36 (94.7)	2 (5.3)	
Total		75 (96.2)	3 (3.8)	

Discussion:

Although mobile phones play a significant role in communication in the healthcare sector, they may act as vehicles in the spread of nosocomial infections. Studies have shown that mobile phones of health workers harbor significant amounts of potentially pathogenic microbes most of which are bacterial species (19-26). The present study investigated the mobile phones of 78 hospital workers including health professionals and support staff to ascertain the level of contamination and the factors associated with risk of contamination.

The overall contamination of mobile phones of hospital workers in our study was 96.2%, and mobile phones of laboratory scientists showed the highest contamination rate (100%) while those of physicians had the least contamination rate (87.3%). These results are similar to previous findings in Saudi Arabia (13), Cameroon (14), Ethiopia (15,16) and Iran (27) in which the prevalence of contamination of mobile phones of healthcare professionals ranged from 94-100%. Although relatively lower contamination rates have been reported by others (28), these are still high (>50%). Also, based on the type of phones, all (100%) keypad phones were contaminated with at least one bacterial genus while 94.2% of the smartphones were contaminated. Although this difference was not statistically significant, keypad phones are more likely to have debris on them over a longer period due to the roughness of their surfaces (29). As a result, it might be more difficult to clean or disinfect the surfaces of key pad phones than smartphones and this may encourage the growth of microbes.

On the other hand, mobile phones from laboratory (18.7%) and medical wards (18.7%) had the highest contamination rates. Previous studies have reported varied contamination levels of mobile phones from diffe-

rent units of the hospital. In one of such studies, Asfaw and Genetu (15) reported higher rates of bacterial contamination of the mobile phones in the intensive care unit (22.6%), the surgical ward (17.8%) and the laboratory (17.8%) compared with other hospital units. The relatively higher contamination rate in the laboratory may be due to the numerous specimens handled in this unit (30). Also, the difference in the contamination rates in the various hospital units may be accounted for by the poor adherence to infection control practices.

With regard to the types of bacterial species isolated, Gram-positive bacteria (72.3%) were more frequently isolated than Gram-negative bacteria (27.7%), and the predominant species were skin commensals such as *S. aureus*, *Micrococcus* spp and coagulase negative staphylococci (CoNS), *Pseudomonas* spp and *Haemophilus* spp. Similar findings have been reported in Cameroon and elsewhere (13,14,28). In Zambia, Mushabati et al., (28) reported common bacterial isolates from phones to be CoNS, *S. aureus* and *Bacillus* spp while the study by Bodena et al., (16) in Ethiopia had CoNS, *S. aureus* and *Klebsiella* spp as predominant bacteria from mobile phones. The study conducted by Sedighi and colleagues (27) in Iran isolated more of CoNS, *S. aureus* and *P. aeruginosa*.

It is common to find Gram-positive bacteria contaminating surfaces especially the skin. *Staphylococcus aureus* is commonly found in the anterior nares of healthcare workers and can easily be transmitted on surfaces via contaminated hands (24). The predominance of CoNS reflects the fact that normal commensal of the skin can easily be transferred to any object that comes in contact with body surfaces. The combination of constant handling and heat generated during receiving phone calls may facilitate the survival and growth of microorganisms on the cell phone surface (21,31). Though CoNS is a nor-

mal skin flora, in hospital setting, this bacterium could emerge as a pathogenic microorganism causing nosocomial infections (32).

Important Gram-negative nosocomial pathogens such as *P. aeruginosa* and *E. coli* were isolated in our study. According to previous report, *Pseudomonas* is metabolically versatile, ubiquitous in both terrestrial and aquatic environments and infection caused by the organism is very difficult to manage (32). The presence of this bacterium on mobile phones of medical personnel should be very concerning. *Escherichia coli* was the most prevalent aerobic bacteria in human/animal faeces and its presence may suggest faecal contamination (21). Poor personal hygiene or contamination from already contaminated sites may account for the presence of this organism (33). Contrary to our study, Asfaw and Genetu (15) isolated more of Gram-negative (53.6%) than Gram-positive bacteria (46.4%). These differences may reflect variations in the source of contamination, hand hygiene and other infection control practices, especially as the Gram-positive bacteria isolated were mostly skin commensals while the majority of the Gram-negative bacteria were enteric bacilli.

Although more keypad phones were contaminated compared with smartphones, it was observed that more bacterial species were significantly isolated from smartphones (68.8%) than keypad phones (31.2%). It is a fact that smartphones have more features than keypad phones and coupled with their advantage of internet accessibility, smartphones are frequently being used than keypad phones (34). The high frequency of touch of these phones may explain the higher bacterial isolation rate compared with keypad phones. In the present study, there was no significant difference in the rate of contamination of the phones with respect to gender and age. Our findings are similar to those of Mushabati et al., (28) who reported no association between bacterial contamination of mobile phones and age, gender and profession. Notwithstanding, some previous studies significantly associated bacterial contamination with male gender (15, 16) and age group 20 to 35 years (15)

According to the World Health Organization (WHO), proper hand hygiene and sanitation practices may help reduce the spread of nosocomial infections (33). However, our study did not find any association between contamination rates of mobile phones and practice of hand hygiene, disinfection of work surfaces and frequency of phone usage while working. This discrepancy may be as a result of the small number of samples (n=78) used in our study as well as variations in the type of detergents used especially as some domestic soap may not be antiseptic, as previously rep-

orted (31). Bodena and colleagues (16) reported that the absence of regular hand washing was significantly associated with mobile phone contamination, and another study in Ethiopia reported a significantly higher mobile phone contamination rate among healthcare workers in intensive care unit (ICU) who neither disinfected their phones nor wash their hands, compared to their counterparts who performed these tasks (15). A similar study carried out in Cameroon reported that using mobile phones during working hours, moving around patients with phones, and lack of hand hygiene practices of health professionals were risk factors for the dissemination of multi-drug resistant (MDR) pathogens (14).

Conclusion:

The bacterial species isolated from mobile phones of hospital workers in our study were mostly skin commensals and enteric bacteria. More bacterial species were isolated from smartphones than keypad phones and the laboratory and medical units had more contamination than other units. The presence of potentially pathogenic bacteria on mobile phones of healthcare workers emphasizes the role of fomites in the transmission of infectious diseases. Consequently, good hand hygiene and decontamination practices are encouraged among healthcare workers in order to limit the spread of hospital-acquired infections.

Acknowledgements:

The authors are grateful to the department of Medical Laboratory Sciences of the University of Bamenda for hosting this study and to the staff and management of the AMF Hospital, Mbouda, for their participation and assistance in sample collection and laboratory analyses.

Conflict of interest:

Authors declare no conflict interest

Authors contributions:

MEAB was responsible for conception and design of the study, laboratory analyses, data validation and analyses, revision, general supervision and final approval of the manuscript. MM was involved in sample collection, laboratory analyses, data validation and analyses, and writing of the manuscript.

References:

1. Techopedia. Definition of a mobile phone. <https://www.techopedia.com, 2016>
2. Wikipedia: the free encyclopedia. Mobile phones https://en.wikipedia.org/wiki/Mobile_phone

3. Brady, R. R. W., Wasson, A., Stirling, I., McAllister, C., and Damani, N. N. Is Your Phone Bugged? The Incidence of Bacteria Known to Cause Nosocomial Infection on Healthcare Workers' Mobile Phones. *J Hosp Infect.* 2006; 62: 123-125.
4. Yusha'ul, M., Bello, M., and Sule, H. Isolation of Bacteria and Fungi from Personal and Public cell Phones: A case Study of Bayero University, Kano (old campus). *Int J Biomed Hlth Sci.* 2010; 6 (1): 97-102.
5. Karabay, O., Koçoglu, E., and Tahtaci, M. The role of mobile phones in the spread of bacteria associated with nosocomial infections. *J Infect Dev Ctries.* 2007; 1 (1): 72-73
6. Gashaw, M., Abteu, D., and Addis, Z. Prevalence and antimicrobial susceptibility pattern of bacteria isolated from mobile phones of health care professionals working in Gondar town health centers. *ISRN Pub Hlth.* 2014; 1-6
7. Weber, D. J., Rutala, W. A., Miller, M. B., Huslage, K., and Sickbert-Bennett, E. Role of hospital surface in the transmission of emerging healthcare associated pathogens; norovirus, *Clostridium difficile* and *Acinetobacter* species. *Am J Infect Contr.* 2010; 38: 25-33
8. Brouwer, A. F., Weir, M. H., Eisenberg, M. C., Meza, R., and Eisenberg, J. N. S. Dose-response relationships for environmentally mediated infectious disease transmission models. *PLoS Comput Biol.* 2017; 13 (4): e1005481
<https://doi.org/10.1371/journal.pcbi.1005481>
9. Enemuor, S., Apeh, T., and Oguntibeju, O. Microorganisms Associated with Computer Keyboards and Mice in A University Environment. *Afri J Microbiol Res.* 2012; 6 (20): 4424-4426.
10. Bures, S., Fishbain, J. T., Uyehara, C., Parker, J. M., and Berg, B.W. Computer keyboards and faucet handles as reservoir of nosocomial pathogens in the intensive care unit. *Am J Infect Contr.* 2000; 28: 465-471
11. Otter, J.A., Yezli, S., and French, J.L. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Contr Hosp Epidemiol.* 2011; 32: 689-699
12. Glodblatt, J. G., Krief, I., Klonsky, T., et al. Use of Cellular Telephones and Transmission of Pathogens by Medical Staff in New York and Israel. *Infect Contr Hosp Epidemiol.* 2007; 28: 500-503
13. Zakai, S., Mashat, A., Abumohssin, A., et al. Bacterial contamination of cell phones of medical students at King Abdulaziz University, Jeddah, Saudi Arabia. *J Micro Ultrastructure.* 2016; 4 (3): 143-146
<https://doi.org/10.1016/j.jmau.2015.12.004>
14. Mohamadou, M., Kountchou, L. C., Mbah, C. E., et al. Social Habits of Health Professionals and their Mobile Phones as Source of MDR Nosocomial Bacteria in Cameroon, Sub Saharan Africa. *J Infect Dis Prev Med.* 2021; 9: 214.
15. Asfaw, T., and Genetu, D. 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. *Risk Management and Healthcare Policy.* 2021; 14: 2601-2608
16. Bodena, D., Teklemariam, Z., Balakrishnan, S., and Tesfa, T. Bacterial contamination of mobile phones of health professionals in Eastern Ethiopia: antimicrobial susceptibility and associated factors *Trop Med Hlth.* 2019; 47: 15
<https://doi.org/10.1186/s41182-019-0144-y>
17. Griffith, C. Surface Sampling and the Detection of Contamination. *Handbook of Hygiene Control in the Food Industry.* 2016;673-696.
<https://doi.org/10.1016/B978-0-08-100155-4.00044-3>
18. Cheesbrough, M. *District Laboratory Practice in Tropical Countries Part 2.* 2nd Edition 2006. Cambridge University Press, UK
19. Akinyemi, K. O., Atapu, A. D., Adetona, O. O., and Coker, A. O. The potential role of mobile phones in the spread of bacterial infections. *J Infect Dev Ctries.* 2009; 5 (11): 533-535
20. Bhoonderowa, A., Gookool, S., and Biranjia-Hurdoyal, S. D. The Importance of Mobile Phones in the Possible Transmission of Bacterial Infections in the Community. *J Comm Hlth.* 2014; 39 (5): 965-967.
doi: [10.1007/s10900-014-9838-6](https://doi.org/10.1007/s10900-014-9838-6)
21. Karabay, O., Kocoglu, E., and Tahtaci, M. The role of mobile phone in the spread of bacteria associated with nosocomial infection. *J Infect Dev Ctries.* 2007; 74 (10): 1153-1158.
22. Borer, A., Gilad, J., Smolyakov, R., et al. Cell phones and *Acinetobacter* transmission. *Emerg Infect Dis.* 2005; 11: 1160-1161
23. Neely, A. N., and Sittig, D. F. Basic microbiologic and infection control information to reduce the potential transmission of pathogens to patients via computer hardware. *J Am Med.* 2002; 9: 500-508
24. Auhim, H. Bacterial Contamination of Personal Mobile Phones in Iraq. *J Chem Bio Phy Sci.* 2013; 3 (4): 2652-2656
25. Sepehri, G., Talebizadeh, N., and Mir-Shehari, T. R. Bacterial contamination and resistance of commonly used antimicrobials of health workers' mobile phone in teaching hospital, Kerman Iran. *Am J Appl Sci.* 2009; 6 (5): 806-810
26. Koscova, J., Hurnikova, Z., and Pist, J. Mobile phone and computer keyboard surfaces and efficacy of disinfection with chlorhexidine, digluconate and triclosan to its reduction. *Int J Environ Res Publ Hlth.* 2018; 15 (10): 2238
27. Sedighi, I., Alikhani, M. Y., Ramezani, S., Nazari, M., Nejad, M. A., and Ramezani, S. Bacterial Contamination of Mobile Phones of Health Care Providers in a Teaching Hospital in Hamadan Province, Iran. *Arch Clin Infect Dis.* 2015; 10 (2): e22104. doi: [10.5812/archcid.10\(2\)2015.22104](https://doi.org/10.5812/archcid.10(2)2015.22104)
28. Mushabati, N. A., Samutela, M. T., Yamba, K., et al. Bacterial contamination of mobile phones of healthcare workers at the University Teaching Hospital, Lusaka, Zambia. *Infect Prev Pract.* 2021;3(2):100-126
<https://doi.org/10.1016/j.infpip.2021.100126>
29. Pal, P., Roy, A., Moore, G., et al. Key pad mobile phones are associated with a significant increased risk of microbial contamination compared to touch screen phones. *J Infect Prev.* 2013; 14 (2): 65-68
30. Collins, S. M., Hacek, D. M., Degen, L. A., Wright, M. O., Noskin, G. A., and Peterson, L. R. Contamination of the clinical microbiology laboratory with vancomycin-resistant enterococci and multidrug-resistant Enterobacteriaceae: implications for hospital and laboratory workers. *J Clin Microbiol.* 2001;39(10):3772-3774
doi: [10.1128/JCM.39.10.3772-3774.2001](https://doi.org/10.1128/JCM.39.10.3772-3774.2001).
31. Jarvis, J. D., Wynne, C. D., Enwrigh, L., and Williams, J. D. Hand washing and antiseptic-containing soaps in hospital. *J Clin Pathol.* 1979 32 (7) :732-737
32. Marc, F., Kathleen, J., Susan, W., Phyllis, P. L., Stephamie, F., David, R., and Lisa, S. Endemic *Pseudomonas aeruginosa* infection in neonatal intensive care unit. *J Clin Microbiol.* 2000; 43: 1198 -1204
33. World Health Organization. Guidelines on hand hygiene in health care. Geneva University Hospital. WHO. 2007