Bacterial contamination of mobile phones and their use among healthcare workers in critical care units at a tertiary healthcare facility in Northern Nigeria

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Abstract

Mobile phones are essential devices for communication. However, it is implicated in transmission of microorganisms. Critically ill patients have high risk of infection from pathogenic and opportunistic bacteria. This study was conducted among healthcare workers in critical care units at a tertiary hospital, to assess their MP use and determine their rate of microbial contamination.

A point prevalence survey was conducted among healthcare workers in critical care areas, namely operating theatre, intensive care and dialysis units. Data was collected using a structured self-administered questionnaire on demographic characteristics and mobile phone use habits.Moistened sterile swabs were used to swab MPs, inserted in Amie's transport media and processed by standard microbiological methods. Data was analysed with SPSS version 23

Overall, 62 HCWs, Nurses 31(50%), Doctors 16 (25.8%) and Health Assistants 15 (24.2%) were recruited from operation theatres 36 (58.1%), intensive care 19 (30.6%) and dialysis 7 (11.3%) units. Most respondents 58 (93.5%) believe MP is an important work tool, 22(35.5%) handle MPs with gloved hands and 33(53.2%) had never disinfected their MPs. Overall, 47(75.8%) MPs were contaminated with microorganisms namely,*Coagulase negative staphylococcus* 48(77.4%),*Staphylococcus aureus* 9(14.6%),Gram negative bacteria 4(6.5%) and fungi 1(1.6%),Bivariate analysis of demographic characteristics and MP use habits with bacterial contamination were not statistically significant.

The microbial contamination rate of mobile phones belonging to healthcare workers who work in critical care units at this facility was high. There is need fortraining on safe mobile phone use to reduce risk of infection to the critically ill patient.

Key words: Healthcare workers, Mobile Phone, Critical care, Health Care Associated Infections, nosocomial pathogens

Introduction

Mobile phones (MPs) are long range, personal telecommunication devices and advancement over the stationary analog telephones. Smart phones are defined as mobile phones with the functional ability to make and receive calls, allow internet connectivity and perform

diverse functions like computing, picture taking, video recording etc. A non-smart mobile phone is one that has functional capacity for making calls and texting with no internet capacity (https://www.futurelearn.com/info/courses/an-anthropology-of-smartphones/0/steps/221639). Mobile phones have become essential devices necessary for communication and a range of other uses with the advent of smart phones.(Khan et al., 2015;Bodena et al., 2019) Globally, access to mobile phones has increased. In the United States 75% of adults own at least one mobile phone and Nigeria has reported ownership rates as high as 84%.(Cook et al., 2015). Mobile phones especially the smart ones are handy gadgets and other than their use in communication (calling, messaging) they are used for a variety of other purposes such as browsing, lighting, time keeping, picture taking or video making (Khan et al., 2015;Bodena et al., 2019;Anstey Watkins et al., 2018). Their portable size makes them easy to be carried everywhere including, markets, kitchens, work places and toilets (Mohamedin et al., 2019). In the hospital, mobile phones are increasingly being adapted as medical gadgets. They can be connected to devices such as body scanners used in clinical examinations, take medically important photos for research purposes and create videos of procedures such as is done in surgery and other specialties (Khan et al., 2015).

The mobile phone unfortunately has been reported to be contaminated with microorganisms and associated with the carriage and transmission of pathogenic organisms, (Debnath et al., 2018) ;Nwankwo et al., 2014;Maphumulo et al., 2016;Katsuse Kanayama et al., 2017). Colonization rates of MPs among healthcare workers (HCWs) in various countries have ranged from 63.2% to 97.8% (Nwankwo et al., 2014 , (Debnath et al., 2018) ;Banawas et al., 2018) Consequently, MPs have been identified as important vehicles in the occurrence of health care associated infections (Amadi et al., 2013). Most organisms isolated in hospital settings are usually multidrug resistant and are likely to be colonisers of surfaces, equipment and personal items such as MPs (Banawas et al., 2018;Chang et al., 2017). In health care settings and among HCWs, best practices on Infection Prevention and Control (IPC) lays emphasis on hand hygiene with soap and water or alcohol based hand sanitizers (Seto et al., 2015). Unfortunately it remains that cleaned hands can easily get re-contaminated from micro-organisms which have colonized MP (Missri et al., 2019 , ;Seto et al., 2015;Missri et al., 2019). Surveys among HCWs have shown phones can be contaminated with bacterial, viral, fungal and parasitic microorganisms. (Debnath et al., 2018) , ;Banawas et al., 2018 , ;Kordecka et al., 2016 ;Ucheagwu, 2015). It is therefore imperative to assess the use of this important device among HCWs as they are instrumental in the transmission of microorganisms in health care settings from HCWs to patients and vice versa (Nwankwo et al., 2014;Banawas et al., 2018). Due to the various reasons for which MP have become indispensable devices, it is important to ensure they are used hygienically to inhibit transmission of pathogenic micro-organisms in health care settings (Graveto et al.,2018). This is of practical importance especially with reference to medical tourism and in patients who are critically ill, immunocompromised or undergoing surgery as they are prone to infection with colonisers as well as multidrug resistant organisms (MDROs)(Debnath et al., 2018).

We aimed to assess MP use habits and determine the microbial contamination

of MPs among HCWs working in critical care units with a view to adequately guide its use among HCWs and provide recommendations on the proper use of these devices in health care settings.

Methodology

Study setting:

The survey was conducted at Ahmadu Bello University Teaching Hospital Zaria, a tertiary healthcare facility in Northwest Nigeria that serves as a referral centre to neighbouring states due to its specialized services such as Intensive care, Dialysis, Infectious diseases, Burns, Plastic surgery and Urology units among others. The facility has a 29 bed Intensive Care Unit(ICU), 12 bed dialysis unit and 3 operation theatres.

Study design:

A point prevalence survey was conducted among HCWs at critical care units of the facility namely the Operating theatre, dialysis and intensive care units. Ethical approval was obtained from the facility research ethical Committee (ABUTHZ/HREC/W32/2020) and informed consent was obtained from participants and personal identifiers were removed from data obtained.

Study participants:

Healthcare workers involved in direct patient care namely Doctors, Nurses and Health assistants present on the day of the survey at the Operating theatre, dialysis and intensive care units were recruited. Only those who owned at least one mobile phone were included while Medical and Nursing students present at the time of the survey were excluded from the study.

Data collection/sample collection:

A structured self-administered questionnaire (Appendix1) with sections on demography, previous training on IPC, knowledge of organisms transmitted and mobile phone use habits was used to collect data. The screen, key pads and back of mobile phones (Smart and non-smart MPs) belonging to participants were swabbed aseptically with sterile cotton wool swabs moistened in sterile saline and transported in Amies transport media to the medical microbiology laboratory of the facility. For respondents who had more than one MP, that which is used frequently at work was selected.The HCWs were not pre-informed of the survey so as to avoid bias and all HCWs present on the day of the survey were recruited. Questionnaire was validated by having 3 members of staff from each cadre (Doctors, nurses and health assistants) from General outpatient department filled the questionnaire. Ninety nine percent (99%) of the questions were clear to the respondents except for 2 questions that needed clarifications which were rephrased.

Sample processing:

Swabs collected were inoculated on 5% Sheep blood and MacConkey agar (Oxoid) using standard streak plate method and incubated aerobically at 37^0C for 24 hours. Identification of bacterial cultures was done using standard microbiological technique viz a viz, morphology, colony characteristics, Gram stain reaction and standardized identification kits (Microgen TM UK).
For quality control, all media and reagents were prepared according to manufacturer's instructions and quality control strains *Staphylococcus aureus* ATCC 25923 and *Escherichia coli* ATCC 259222 were used to assess reagents, processes and identification kits.

Data analysis

Data collected was entered into excel spreadsheet andanalysed using SPSS version 23.Descriptive statistics was used to analyse discrete variables (age,sex and others). Pearsons Chi square was used to determine relationships. Where the conditions for Pearsons Chi Square were not met the Likelihood ratio was used to determine the level of significance at 0.05.

Results

Overall, 62 HCW were recruited from 3 critical care areas namely operating theatre 36(58.1%), ICU 19 (30.6%) and dialysis units 7(11.3%). There was an equal proportion of males and females 31(50%), 46 (74.2%) were married, 14 (22.6%) single and 2 (3.2%) widowed. Their ages ranged from 25-60 years. Half of the respondents were Nurses 31(50.0%) while Doctors and health assistants were 16 (25.8%) and 15 (24.2%) respectively. (Table 1).

Table 1: Demographic characteristics of healthcare workers at critical care units

Demographic characteristics	**Frequency** (N=62)	**Proportion (%)**
Age group (years)	Sex Male	
25-34	15	24.2
35-44	24	38.7
45-54	20	32.3
>54	3	4.8
Sex		
Female	31	50.0
Male	31	50.0
Marital status		
Single	14	22.6
Married	46	74.2
Widowed	2	3.2
Designation		
Doctor	16	25.8
Nurse	31	50.0
Health assistant	15	24.2
Unit		
Operating theatre	36	58.1
ICU	19	30.6
Dialysis	7	11.3

More respondents had worked for less than 10 years, 26 (41.9%) with only 3 (4.8%) having worked for at least 30 years. A little above half of them had received training on Infection Prevention and Control 35 (56.4%). Of these, 15 (42.9%) stated that information on how to use personal effects was included in the training, while 14(40.0%) stated it was not and 6 (17.1%) were unsure. More than half of the respondents 46 (74.2%) had smart phones and most respondents 58(93.6%) felt the MP is an important work gadget. (Table 2)

Table 2: Distribution of Critical Care Healthcare workers trained on IPC and their perception on importance of Mobile Phones at work

Variable	**Frequency** (N=62)	**Proportion** (%)
Duration in service (years)		
≤9	26	41.9
10-19	19	30.6
20-29	14	22.6
≥30	3	4.8
Trained on IPC		
Yes	35	56.4
No	27	43.6
IPC trained on use of personal effects		
Yes	15	42.9
No	14	40.0
Not sure	6	17.1
Mobile phone work tool		
Yes	58	93.6
No	4	6.4
Mobile phone type		
Smart phone	46	74.2
Non-smart phone	16	25.8

Mobile phones were used at work by respondents for calls 60 (96.8%), time checking 60 (96.8%), messaging 50 (80.6%), social media 39 (62.9%), and browsing for clinical information 41 (66.1%). Other uses were taking pictures 1(1.6%) and calculating drug doses 3 (4.8%). While at work, 56 (90.3%) respondents kept MPs in pockets, 14 (22.6%) on table tops and only one (1.61%) on trolleys. Mobile phones were handled with gloved hands by 22 (35.5%) respondents and had been disinfected in 29 (46.8%) respondents. Of these, the frequency of disinfection was daily in 7(24.1%), weekly 10(34.5%) then monthly and occasionally among 5 (17.2%) respondents each. Disinfectants or cleaning materials used were methylated spirit 23 (79.3%) hand sanitizer 4(13.8%), Savlon 1(3.4%), Wipes 1(3.4%) and Cloth 1(3.4%). (Table 3)

Table 3: Mobile Phone use habits of healthcare workers at critical care units at a tertiary facility

MP use habits	**Frequency**	**Proportion** (%)
Uses of MP at work (multiple response)		
Calls	60	24.2
Text	50	38.7
Time checking	60	32.3

Browsing clinical info	41	4.8
Social media	39	
Others	7	50.0
MP kept (multiple response)		
Pocket	56	90.3
Table top	14	22.6
Bag	6	9.7
Trolley	1	1.61
Handle MP gloved hands (n=62)		
Yes	22	35.5
No	40	64.5
Ever disinfected MP (n=62)		
Yes	29	46.8
No	33	53.2
Frequency of disinfection (n=29)		
Daily	7	24.1
Weekly	10	34.5
Monthly	5	17.2
Occasionally	5	17.2
Others	2	6.9
Disinfectant used (n=29)	7	11.3
Methylated spirit	23	76.7
Hand sanitiser	4	13.8
Savlon	1	3.4
Cloth	1	3.4

Respondents' knowledge of organisms which could be transmitted by mobile phones were bacteria 53 (85.5%), viruses 38 (61.3%), fungi 35(56.5) and parasites in 30 (48.4%) respondents respectively. (Figure 1)

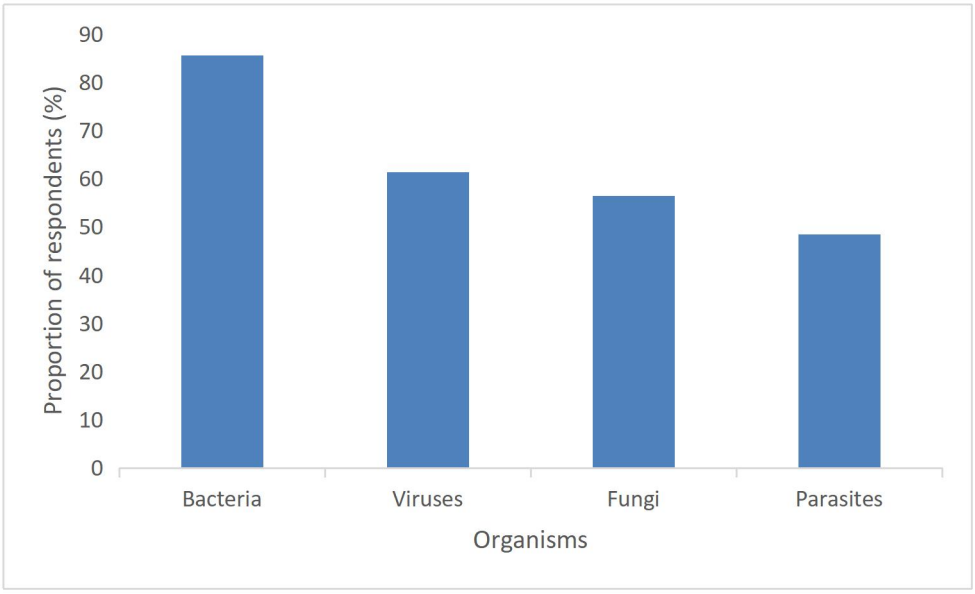

Figure 1: Knowledge of HCW at critical care units on microorganisms transmissible by MP

MPs of more than half of the respondents 47 (75.8%) had positive cultures and of these multiple organisms were isolated in 21(44.6%) respondents. Bacteria isolated were mainly Gram positive 57(91.9%),few Gram negative organisms 4(6.5%) and fungi 1 (1.6%). The Grampositive organisms comprised of *Staphylococcus aureus*(SA) 9(14.6) and *Coagulase negative staphylococcus*(CoNS)48(77.4), while the gram negative organisms were *Acinetobacterlwofii*1(1.6), *Enterobacter cloacae* 1(1.6), *Citrobacter freundi*1(1.6) and *Proteus mirabilis* 1(1.6) (Table 4)

Bivariate analysis of demographic characteristics of respondents such as Cadre, duration in service,previous IPC training on use of personal effects and mobile phone use habits were not statistically significant

Table 4: Microorganisms which colonised mobile phones of critical care healthcare workers and proportion of colonised mobile phones

Variable	**Frequency** (N=62)	**Proportion** (%)
Culture positive		
Yes	47	75.8
No	15	24.2
Type of Organisms isolated		
Gram positive bacteria	**57**	**91.9**
Staphylococcus aureus	9	14.5
Coagulase negative Staphylococcus	48	77.4
Gram negative bacteria	**4**	**6.5**
Acinetobacterlwofii	1	1.6
Enterobacter cloacae	1	1.6
Citrobacterfreundi	1	1.6
Proteus mirabilis	1	1.6
Fungi	**1**	**1.6**

Table 5: Bivariate analysis of socio-demographic characteristics of critical care healthcare workers and mobile phone use habits with mobile phone bacterial growth

Variable	**Growth**		**P value**
	No Growth (Freq/%)	Growth	
Sex			
Female	8(25.8)	7(74,2)	0.08
Male	7(22.6)	24(77.4)	
Age group			
25-34	5(33.3)	10(66.7)	3.36
35-44	7(29.2)	17(70.8)	

45-54	3(15.0)	17(85.0)	
>54	0(0.0)	3(100.0)	
Educational level			
Secondary	2(28,6)	5(71.4)	0.08
Tertiary	13(23.6)	42(76.4)	
Cadre			
Doctor	6(37.5)	10(52.5)	2.65
Nurse	5(16.1)	26(83.9)	
Health assistant	4(26.7)	11(73.3)	
Unit			
Dialysis	1(14.3)	6(85.7)	0.48
Intensive care	5(26.3)	14(73.7)	
Theatre	9(25.0)	27(75.0)	
Duration of practice (years)			
<9	8(30.8)	18(69.2)	1.65
10-19	4(21.1)	15(78.9)	
20-29	2(14.3)	12 (85.7)	
>/= 30	1(33.3)	2(66.7)	
IPC training			
No	5(18.5)	22(81.5)	0.84
Yes	10(28.6)	25(71.4)	
IPC Training on personal effects use			
No	11(28.4)	36(76.6)	0.06
Yes	4(26.7)	11(73.3)	
Mobile phone use at work			
No	1(14.3)	6(85.7)	0.46
Yes	14(25.5)	41(74.5)	
Handle MP with gloved hands			

No	9(22.0)	32(78.0)	0.33
Yes	6(28.6)	15(71.4)	
Ever disinfected mobile phone			
No	5(16.7)	25(83.3)	1.79
Yes	10(31.3)	22(68.8)	
MP type			
Non smart	4(25.0)	12(75.0)	0.008
Smart	11(23.9)	35(76.1)	

Discussion

The MP bacterial contamination rate among HCWs in critical care areas was high as two thirds of the mobile phones showed evidence of contamination. This is a cause for concern as it poses a risk for transmission of pathogens to critically ill patients resulting in healthcare associated infections (HCAIs). The high prevalence (75.8%)of microbial contamination of MPs from this study is similar to that in other studies where rates as high as 63.2 % - 80.6% ,73.4% and 94.2% were found among HCWs in Nigeria, Kuwait and Ethiopia respectively. (Bodena et al., 2019; · Nwankwo et al., 2014; · Amala &Ejikema, 2015). High prevalence observed from this our study with similarity to the findings from other climes as documented above highlights the need to address the use of MPs among HCWs for patient as well as their own safety. The Kuwait study with a MP contamination prevalence of 73.4%, the closest to our finding (75.8%) was conducted among HCWs in Intensive care units, a study population similar to ours. The other studies were conducted among HCWs generally with no preference for specialty or unit which may explain some of the differences observed. In addition, varying IPC practices at the various hospitals may also result in the differences observed. In this light, the high rate of bacterial MP contamination observed in this studymay be attributed to the lack of training on IPC as reported by most of the respondent despite their long years of practice. This can result in inappropriate use and care of personal items and predispose to high rates of MP microbial contamination.

This study further reiterates the important role MPs have assumed in healthcare delivery. Majority of respondents (93.6%) agree it is an important work tool required for communication, obtaining clinical information, keeping up with social networks, taking of pictures, videotaping procedures, time piece, monitoring vital signs and calculating patient drug doses. This is consistent with the perception of healthcare workers from other climes as there are mobile phone apps to aid clinical practice. For example, medical devices that can be connected to MPs and used to administer health care have been invented and being used in assessing vision and hearing. (Ventola, 2014) Since the MP is increasingly being utilized in clinical practice and healthcare delivery, it has also become important to ensure that the numerous benefits are not deterred by the increasing risk of transmission of

microorganisms and subsequent occurrence of HCAIs. More than ever, it has become imperative to ensure MPs are used safely in healthcare settings to improve health care delivery with advancing technology without causing harm. This fact has been shown in mobile phone reviews such that it is now being advocated guidelines should be developed to ensure safe use of MPs HCW because of their increasing necessity in health care settings.(Bodena et al., 2019;Ibrahim et al., 2020; Olsen et al., 2020)

Other than the various uses MPs are put into, this survey has also elaborated on practices that can predispose MPs to contamination with bacteria. Some respondents keep their phones in their pockets while at work some keep MPs on surfaces which are potentially colonized with hospital pathogens such as table tops and trolleys. This practice can result in the contamination of MPs and subsequent transmission of pathogens. In addition, some undesirable habits such as handling MPs with gloved hands in a third of respondents are a harbinger of device contamination. It is noteworthy that less than half of the respondents practiced MP decontamination and only a small proportion carried it out regularly.Though this finding was not statistically significant in our study nevertheless this practice has to be emphasized among HCWs to improve its adoption especially as lack of regular cleaning and decontamination of HCWs MPs have been found to be determinants of bacterial contamination.(Bodena et al., 2019;Gashaw et al., 2014). In this study, most of the materials used for decontamination by the few healthcare workers who practiced it such as methylated spirit and hand sanitizers have had proven efficacy in reducing microbial populations and so should be encouraged (Graveto et al., 2018.;Gashaw et al., 2014; Tiwari et al., 2016 , (Mohamedin et al., 2019) Mobile phones can be contaminated with all microbial organisms namely bacteria, viruses, fungi and parasites. (Debnath et al., 2018)Banawas et al., 2018;Kordecka et al., 2016;Ucheagwu, 2015;Olsen et al., 2020) The fact that most respondents in this survey stated MPs can transmit bacteria more than other microbial organisms is a pointer to the fact that this lack of awareness can aid increased risk of contamination and subsequent transmission of these microorganisms.

The commonest bacteria isolated from this study was *coagulase negative Staphylococci*(77.4%) followed by *Staphylococcus aureus*(14.5%).This is similar to findings from studies conducted in a teaching hospital in Croatia (68%:26%), healthcare setting in AlexandriaEgypt (SA-48.7%)and also University teaching hospital Portharcourt (CoNS-35.5%: SA-20.7%), River State Nigeria respectively (Kotris et al., 2017 ;Mohamedin et al., 2019 ;Amala&Ejikema, 2015) .These are normal flora of the skin which could explain the high prevalence observed.However, these groups of organisms are implicated in HCAIs when found in sites other than the skin especially in critically ill patients. Of the organisms isolated, three Genuses are part of ESKAPE group of organisms which have propensity to developing antimicrobial resistance and also important causes of HCAIs. (Jadimurthy et al., 2022)

Bivariate analysis of sociodemographic characteristics and mobile phone use habits with bacterial contamination showed there was no statistically significant association. This is similar to the findings of (Banawas et al., 2018) where there was no significant relationship between MP contamination level and the usage of cell phones at the work area and cleaning cell phones with

disinfectant. This however is not in keeping with another study where there were proven associations between male sex and infrequent decontamination of mobile phones with bacterial contamination (Bodena et al., 2019) .Nevertheless this does not underscore the importance of regular cleaning and decontamination of MPs and hand hygiene as these are basic fundamentals of infection prevention and control.

Conclusion

There was a high bacterial contamination rate of mobile phones belonging to HCWs at critical care units in this facility. Bacteria isolated from mobile phones included normal flora and pathogens which are implicated in healthcare associated infections.This highlights the need to develop guidelines and educate HCWs on infection prevention and control measures required for safe use of mobile phones to limit transmission of microorganisms and occurrence of healthcare associated infections. As this study only explored bacterial contamination of HCWs mobile phones in critical care settings, expanding future studies to include genomic surveillance of HCAIs and organisms isolated from personal effects like mobile phones will be explored.

Limitation

It was point prevalence survey so only those on duty on the day of surveillance were assessed. This survey did not assess for viral, parasitic and fungal microorganisms as mainly bacteria supporting media was used for culture.

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Appendix 1

Infection prevention control ABUTH Hand Set use surveillance among healthcare workers

S/NO ----- Unit---------- Date---------- Age --------- Sex Female/Male: Marital status: Single/Married/Divorced/Separated/Widowed

Highest educational qualification----------

Instructions: Please fill in the gaps and circle all relevant options which apply

1. Designation---------- Duration of practice---------- Duration in Unit----------
2. Have you ever received training on Infection Prevention and Control? Yes/No
3. IF yes to (2) above was there any mention on the use of personal effects such as mobile phones? Yes/No/Can't remember/Not Sure
4. Do you have a mobile phone? Yes /No
5. If Yes to (4) above what type is it? Smart phone/Keyboard/others (specify)----------
6. Do you use it to do any of the following at work?Receive calls/Make calls/Check time/send text/social media/Browse for clinical information/others (specify)----------
7. Do you think your mobile phone is an important working tool? Yes/No
8. If Yes to (7) above why?
9. Where do you keep phone during work? Bag/pocket/table top/drawer/others (specify)----------
10. Do you handle your phone with gloved hands? Yes/No/Sometimes/Never
11. Do you disinfect your phone? Yes/No
12. If yes to (11) above, what do you use to disinfect the phone?----------
13. If Yes to (11) above, when last did you disinfect it?----------
14. If Yes to (11) above,how often do you disinfect it? Daily/weekly/monthly/quarterly/ yearly/ others----------
15. Do you disinfect other personal patient care equipment? Yes/No
16. If Yes to 15 above, which do you disinfect?Stethoscope/Thermometer/Tape/Others(Specify)----------
17. Do you think your mobile phone can transmit any of the following?(Circle all that apply)Bacteria/Viruses/Parasites/ Fungi
18. Do you wash your hands before work? Yes/No/Always/Sometimes/Never
19. Do you wash your hands after work? Yes/No/Always/Sometimes/Never

Thank you for your time

If you want your results please fill section below

Name
Signature

S/No (Above)----------

Appendix 2 :Similarity index report