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RESEARCH ARTICLE OPEN ACCESS

Elucidation of Practices of Mobile Phone Hygiene and Identification of the Microorganisms: A Perspective Study from Riyadh, Saudi Arabia

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Abstract

Mobile phones (MPs) have become a tool for the transmission of microorganisms due to lack of personal hygiene and maybe the sharing of the mobile phone by more than one person that which leads it to be a suitable carrier for microbes. This study aimed to draw a bead on the practices of hygiene of MPs among people living in Riyadh, Saudi Arabia, by performing a cross-sectional survey of 204 participants. The response rate of this study was above ~95%. Results showed that 19.6 % of responders clean their MPs once in a day, but the majority (33.8%) never cleaned their MPs. More than a quarter of the respondents (28.4%) use tissue paper to clean MPs. Among the users, ~60% use MPs while eating, 76% realized that their MPs might be resource of transmitting microorganisms. The study was also carried out using standard techniques to identify and count the bacterial contamination using the MPs. A combined number of 75 MPs of the participants in the shopping malls of Riyadh were screened for microorganism identification. From 75 public MPs, 109 bacteria were isolated. Coagulase-negative *staphylococci* were the predominant organisms isolate (76.1%) and with 1.8% by *Staphylococcus aureus*. *Micrococcus* sps. was also found (12.8%). A small number of *Kocuria* sps. were also isolated (4.6%). These results showed that common peoples' mobile phones were contaminated with various types of microorganisms. The results provide an evidence base for the development and enhancement of hygienic MPs using practices.

Keywords: Mobile phones, bacterial contamination, infectious agent, hygiene practices, coagulase-negative *staphylococci*

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INTRODUCTION

The reservoir of any community-based pathogens, either biotic or abiotic objects, is very important in the epidemiology of any bacterial disease like gastrointestinal, respiratory, and skin infections. Our own hands play an apparent role in the transmission of many pathogens, either from animate or inanimate objects. It has been confirmed from numerous epidemiological studies that many contaminated surfaces played a significant role in the spread of infectious diseases[1,2]. Indeed, mobile phones (MPs) have become not only an essential tool for communication but also one of the most essential accessories in our daily lives. The importance of MPs involves in social, professional and entertainment matters. Saudi commission of communications and information technology estimated 47.9 million subscriptions to MPs services in Saudi Arabia in 2017, indicating a prevalence of 151% at population census level[3]. Possible risks of using mobile phones cause disturbances, unable to maintain the concentration, data safety, and transmission of microorganisms, possibly leading to infections[4]. Consequently, spreading infection by MPs could be one of the adversities that may affect humankind in our era. Users frequently handled MPs at all places. It is assumed that the human hands and surroundings such as hospitals, colleges, kitchens, restaurants, toilets have a very high density of microorganisms, including potentially pathogenic bacteria, mobile phones could also act as a significant vehicle of disease transmission in the community. According to Bhoonderowa et al. 2014[5], their findings showed that 176 (91.7%) mobile phones of random volunteers in the community have bacterial contamination. Significant associations were also found between bacterial growth and female participants, agricultural workers, mobile phones older than six months and sharing of mobile phones[5]. It is clear that due to continuous handling of the MPs, which leads to the generation of heat, an ideal environment is therefore provided for the propagation of many microorganisms which are normally found on the skin[6]. In fact, it has been reported that a mobile phone may harbor more microorganisms than a toilet seat, the sole or lace of a shoe or even the door handle[7]. Many sources, such as a handbag, phone pouch, pockets, environment, and food particles, were revealed to be a possible route for contamination of the MPs. These sources provide a path for which microorganisms can colonize the phone; thereby causing diseases that range from mild to chronic.

Furthermore, mobile phones as vectors to a potential cause of nosocomial infection have also been studied[7, 8]. If pathogenic bacteria contaminate the MPs, the rate of infection and death rate from these infectious agents will continue to rise. Hygiene of MPs is a without a question, is a vital component for controlling the spread of infection. Nonetheless, keeping the aforementioned facts in view, the present study was aimed to not only assess the practices of hygiene of MPs, but also to determine the load and to the evaluation of the microorganisms' colonizing MPs of Riyadh region for hygiene and public health knowledge purposefulness.

MATERIAL AND METHODS

Study design

A community-based cross-sectional study was performed to elucidate the practices of hygiene of MPs use among people of Riyadh, Saudi Arabia and collected the samples from individuals visiting shopping centers in Riyadh. The cluster sampling technique used to select 8 out of 31 grand malls in Riyadh. The study was implemented in two phases. In the first phase, the selection of a big mall (Riyadh Gallery) was determined, and 27 questionnaires were randomly distributed. Sample collection technique, sample coding prosses, questionnaire disruption, sample delivery to labs, sample culture and analysis machines calibration were checked and revised to overcome all obstacles faced during this pilot study. In the second phase, 204 has participated in this study. Participants were asked to take a swap from their MPs (front and backside by a sterile swap stick) then it was inserted to transport media for analysis. All selected malls were covered in this study; Riyadh Gallery, Sahara mall, Hayat Mall, Al Nakheel Mall, Panorama Mall, Al Othaim Mall, Granada Mall and Salam Mall which are situated in in the Northern region, Western region, Eastern region and Southern region. Study area subject selected these shopping-cum-entertainment malls because they are the most prominent places where people gather from all over the city. The

ethical research committee of the Institutional Review Board (IRB) of Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia approved this study (HAPO-01-R-001, Project No. 58-2019). Verbal and written informed consent were obtained from all participants in the study. The study was conducted for four months during the period of August 2019 to November 2019.

Structure: Survey questionnaire

Survey questionnaire distribution and data collection were accomplished by skilled study personnel (3rd, 4th & 5th year MBBS students involved in this study, have acquired the knowledge about microorganism related infection and diagnosis from their Pre-clinical and Clinical years). The survey questionnaire was used to achieve the socio-demographic factors and also designed questions related to the participants' knowledge and beliefs about maintaining of MPs hygiene were asked to evaluate their basic manner of using MPs. A survey questionnaire of socio-demographic variables were asked for the present analysis which included age, gender, place of residence, how many times do clean MPs, type of cleaning, using MPs while eating, using cover in MPs, ideal cleaning method suggested from the factory for ideal cleaning purpose, surety about MPs is clean or not. Additionally, this survey also included true/false declarations and multiple response questions to elucidate the knowledge of people concerning the ideal cleaning method of MPs. Practicing of participants regarding the times they clean their MPs was also reviewed in this study.

Sample collection

Samples collected from the MPs of 75 participants from the individuals visiting shopping centers in Riyadh. A sterile cotton swab (moistened with solution of 0.15 M NaCl and 0.1% Tween 20) from the front and backside of their mobile phones (including microphone, ear speaker, camera, button and screen) and then inserted to transport media Amies transport media (Amies, Copan, Italy). A fresh pair of sterile gloves were worn by the sample collector sampling each MPs to minimize sample cross-contamination. Participants have not been asked to remove the mobile phone cover.

Samples have been labelled with an ID number, then taken to the Multi-purpose laboratories II, College of Medicine, Imam University where swabs undergo bacterial cultivation to determine if there is very low, low, moderate or high growth. Moderate and high microorganism growths were included in the study. The different media were used are Blood agar (for all microorganisms), MacConkey agar (mainly negative rods). Plates were incubated at 37°C for 24-48 h.

Isolation of microorganisms

Good growth envisioned colonies showed on plates were picked and streaked on new Blood agar and MacConkey agar plates for sub-culturing purposes. A unique morphologically distinct colony isolates were selected for further analysis and obtained the purified colony by repeated plating. All experiments were done in triplicate.

Identification of microorganisms

Identification of isolated microorganisms by using preliminary methods like Gram stain, colony counts, and all isolates were morphologically distributed to the appropriate genera determined by Bergey's Manual of Determinative Bacteriology[9]. In the last stage, the strains were biochemically identified in BIOMERIEUX VITEK® 2 Compact, Siemens MicroScan® WalkAway®-96 Plus machine (Biomerieux, Marcy L'etoil, France) for 24 hours.

Statistical analysis

All collected data were fed by coding and cleaning in Microsoft Excel and data-extrapolation for the meaningful results. Statistical analysis was performed by using SPSS software program (SPSS Version 25, SPSS Inc., Chicago, IL). The data were expressed as frequencies, percentages, and means. Categorical variables present by frequencies and percentages.

RESULTS AND DISCUSSION

Common people were the most targeted population in these kinds of studies. A handful of reports showed that daily using devices like computer keyboards, mouse, ballpoint pens, files, books, door handle, lift button, and in our case, mobile phones have an important role in the transmission and spread of microorganisms [10,11]. However, these studies give red flags regarding MPs contamination which may cause harms for the society. Moreover, studies conducted in the community show a variety of bacterial growth in MPs. *Staphylococcus epidermidis*, *Staphylococcus*

aureus, *Enterobacter aerogenes*, and *Bacillus subtilis* occurred the most common results of these studies[5,12,13].

A total of 215 questionnaires were distributed among the people of Riyadh city in this study, of them 204 (94.8%) countered with filled questionnaires. The exclusion done in 11 subjects because of incomplete responses or conflict with the pre-set inclusion criteria of this study. All group of age has participated in this study (35.8% under age 26 years, 31.4% between 26-33 years, and 32.8% above 33 years). The majority of participants were male (64.2%).

Practicing hygiene regarding how many times they clean their MPs represented in Table 1. The behavior of participants regarding the 'daily cleaning (19.6%)', 'alternate day (9.8%)', 'once a week (19.1%)', 'once a month (14.7%)', 'once a year (2.9%)'. However, majority of them (33.8%) never cleaned their MPs.

About 76% of user were aware of the fact that mobile phone could have a possible way of transmitting bacteria. The result showed about awareness of bacterial transmission reflected in terms of knowledge score was significantly high for all the items in comparison with the cleaning process.

Among those how to clean their MPs, different means have used for this purpose (tissue paper, water, sterilizer, and others). Majority of

Table 1. Behavior and practice of mobile phone hygiene in total participants (percentage)

	Total	204
Gender	Female	73 (35.8)
	Male	131 (64.2)
Age	under 26	73 (35.8)
	26-33	64 (31.4)
	above 33	67 (32.8)
How many times do you clean your phone?	once a day	40 (19.6)
	once each 2 days	20 (9.8)
	once a week	39 (19.1)
	once a month	30 (14.7)
	once a year	6 (2.9)
	Don't clean	69 (33.8)
Type of cleaning	by tissue	62 (28.4)
	by water	20 (9.2)
	by sterilizer	40 (18.3)
	others	27 (12.4)
	don't clean	69 (31.7)
	Total*	218
Do you use your mobile while eating?	No	80 (39.2)
	Yes	124 (60.8)
Do you think that mobile phone transmitting bacteria and fungi?	No	28 (13.7)
	Yes	155 (76)
	Don't know	21 (10.3)
Do you use cover for your mobile phone?	No	75 (36.8)
	Yes	129 (63.2)
Do you know the suggested cleaning technique from the factory	No	184 (90.2)
	Yes	7 (3.4)
	Missing	13 (6.4)
Do you think that your phone is clean?	No	112 (54.9)
	Yes	56 (27.5)
	Don't know	22 (10.8)
	Missing	14 (6.9)

*Total of multiple response question

them clean their phones by using tissue (28.4%), by water (9.3%), by sterilizer (18.6%), whereas 31.7 % never cleaned their MPs. The present study also showed that 124 (60.8%) MPs users use the 'mobile phone' while eating. MPs cleaning was instructed in manufacturers guide, but the knowledge of the ideal cleaning technique suggested from the factory was very poor among participants (3.4%). The questionnaire also included the usage the mobile cover. 63.2% participants reported using the mobile phone with a cover to protect the phone by damaging.

Identification of the bacteria that colonize participants MPs also conducted. A variety of bacteria has been identified, these bacteria founded in MPs surfaces are in direct contact with participants skin; consequently, they colonized the MP by this way. We have selected 75 participants MPs (among 204 participants), and contamination rate of bacteria on MPs were found to be 100%. Table 2 showed the isolated microorganisms from mobile phones. From 75 MPs, 109 bacteria were isolated. Out of which, 83 (76.1%) were coagulase-negative staphylococci (CoNS) as the major pathogen, and 14 (12.8%) showed *Micrococcus* sps. few isolates of *Bacillus*, *Kocuria* and *Enterobacter* sps were also found from MPs (3.7%, 4.6% and 0.9%). Most of them are known to cause hospital-acquired infections. Due to their role in both nosocomial and community-acquired infections, these microorganisms gained much attention. Various studies showed that CoNS as one of the major nosocomial pathogens, human life and health significantly influenced by their presence. Association usually seen in indwelling or implanted foreign bodies like catheters or other intrauterine devices. The prevalence of CoNS-related disease is primarily due to the over-use of antibiotics and artificial devices. Development and spread of antibiotics resistant strains of CoNS that associated with human beings is the major challenge [14, 15] as well as increased steadily in biofilm formation[16], is significantly indicative of selection processes simplified by modern medicine.

Table 2. Number of bacteria isolated from surfaces of mobile phones

Bacteria	No (%)
Staphylococcus epidermidis	44 (40.4)
Staphylococcus hominis ssp hominis	20 (18.3)
Micrococcus	14 (12.8)
Staphylococcus capitis	6 (5.5)
Staphylococcus haemolyticus	5 (4.6)
Kocuria kristinae	4 (3.7)
Bacillus	4 (3.7)
Staphylococcus auricularis	4 (3.7)
Staphylococcus warneri	2 (1.8)
Staphylococcus aureus	2 (1.8)
Enterobacter cloacae	1 (0.9)
Kocuria rosea	1 (0.9)
Staphylococcus sciuri	1 (0.9)
Staphylococcus cohnii	1 (0.9)
Total	109

(Results are in percentage)

Nevertheless, inpatient groups that are highly vulnerable to CoNS infections, morbidity and mortality have been significantly associated with CoNS and their clonal spread[17]. These organisms heavily colonize the skin, and mucous membranes, and are the leading cause of endogenous infections by CoNS a in host. Numerous studies investigated the role of MPs in the transmission of infection among medical and/or nursing staff[18,19]. Various potential pathogens could be spread by them directly or serves as a vehicle for nosocomial infection among hospitalized patients[20].

Among the isolates from MPs, *S. epidermidis* was the most commonly isolated organisms 44 (40.4%) followed by *S. hominis* 20 (18.3%), relating to other CoNS, the clinically defined "*S. epidermidis* group," comprising *S. epidermidis* and *S. hominis* as the most prevalent species, along with other traditionally included species e.g., *S. capitis* (5.5%), *S. haemolyticus* (4.6%), *S. warneri* (1.8%), *S. auricularis (3.7%). S. sciuri and cohnii (0.9% respectively)* were also found. Contamination with this high percentage of microorganisms showed that some participants (33.8%) never cleaned their MPs.

There was no significant *Staphylococcus* spp. that have dominated other studies in community settings[5,21,22]. This seems to be due to using manual biochemical testing for identification of bacteria. In our study, automated systems for microbial identification has been used. According to Husam et al. 2013[23], their findings indicated that *staphylococcus aureus* (45%) and *Bacillus* spp. (52.5%) were the main bacterial isolates frequently correlated with personal

mobile phones. Some studies showed a rate of bacterial contamination of food sellers' mobile phones was 100%[24], organisms isolated from their MPs, and frequency of occurrence in term of percentage were *Staphylococcus aureus* (50%), *Streptococcus faecium* (34%), *Bacillus cereus* (30%), *Escherichia coli* (26%) and *Micrococcus luteus* (10%). Another study stated that very low percentage of *Streptococcus* spp. and *S. aureus* from personal mobile phone, only 1% and 19% respectively[25]. Recently meta-analysis conducted by Lin et al. shows that 18.8% of 1159 MPs (95% Confidence interval (CI)= 12.4-26.2) were positive for *S. aureus* and 8.3% (95%CI= 4.5-13.1) were positive for Methicillin-resistant *Staphylococcus aureus* (MRSA) in 10 studies[26]. Presence of *S. aureus* strains isolated from mobile phones of 52.0% and those strains isolated from hands of 37.7% were methicillin-resistant studied in a cross-sectional study which was conducted by Ulger et al. in 2009[27]. The gram-negative strains were isolated from mobile phones of 31.3%, and the ceftazidime resistant strains from the hands were 39.5%. At the study period nosocomial isolates at ICU were: 33.3% staphylococci, 21.4% non-fermentative gram negatives, 21.4% coliforms, 7.1% enterococci, 11.9% yeasts.

Regular people do not contemplate mobile phones to be contaminated items and rarely disinfect their phones. Although in our community preform 5 times compulsory ablution (Wudu) of exposed parts prior to preforming prayers or worship, but the time gap between each prior can act as a reintroducing window for bacteria. It is not possible to provide decontamination, disinfection or sterilization of each device used personally. Regardless of the presence of some cleaning items can be restricting the growth of pathogens on mobile phones. Methods of decontamination by many studies recommended that the mobile phone is cleaned with 70% alcohol, showed substantially reduced in the number of bacterial contaminants[28,29]. Guidelines for infection control by Centers for Disease Control and Prevention (CDC)'s, the transmission of potentially pathogenic bacteria greatly reduced by cleaning instruments and surfaces that often come in contact with the hands, such as computer keyboards, mobile phones and mouse[30].

Limitations of the study

This cross-sectional study was implemented by targeting the general population in confined places like malls, Therefore, the result not comprehensive nor representative of the entire Saudi kingdom. Moreover, places like gyms and supermarkets could have yield more positive results. Also, we could not study about the resistant bacteria emergence and spread in the community.

Recommendations

Based on the findings of this study, the following has been recommended-

- More wet-lab research is needed to investigate the increased prevalence of MPs contamination in Medical college students' which may help increase awareness of the transmission of pathogenic organisms from colonized areas of healthy individuals to susceptible patients.
- One major answer about MPs carrying microorganisms or not, which was not conducted in this survey; hence we advise more research on this aspect.
- Detailed information regarding the cleaning of MPs and maintaining MPs hygiene must be provided by Mobile company before selling it either by their special application or by reading materials come up with box.
- Investigation of the long-term contaminated effects of MPs use should be continued.

CONCLUSIONS

This study provides a valuable suggestion and recommends that by enlightening the knowledge of practicing MPs hygiene for reducing the infection. The major findings of our study showed that MPs could act as transmission mediums for both pathogenic and nonpathogenic microorganisms. Hence, we recommend an efficient health awareness campaign program of hand hygiene and frequent decontamination of mobile devices should be fully implemented. Prevention is the hallmarks of reducing morbidity and mortality. Spreading of pathogenic agents like bacteria could be avoided just by active preventive strategies like routine decontamination of mobile phones with alcohol-containing disinfectant materials as reliable cleansing agents. Reduction

in the number of pathogenic agents is achieved through identification, and control of predisposing factors, education and microbial surveillance. Concurrently, it is important to continue to promote evidence-based hygiene behaviors in the community.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

MAA & RA designed the work. MAA, RA AMS, FGA, AA, OA, AAA, MAA & FKA performed laboratory investigations and results interpretations. MAA, RA and MAA analyzed and interpreted the data. RA wrote the first draft of the manuscript, which was reviewed by KBA. All authors approved the final draft of manuscript.

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ETHICS STATEMENT

Ethical research committee of the Institutional Review Board (IRB) of Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia approved this study (HAPO-01-R-001, Project No. 58-2019). Verbal and written informed consent were obtained from all participants in the study.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

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