

Original Article

Big Concern for Public Health: Microbial Contamination of Mobile Phones

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Introduction: Mobile phones are dynamic source of microorganisms in households and professional settings. The aim was to determine the prevalence of bacterial contamination of the mobile phones, identify bacterial isolates, assess their antimicrobial susceptibility patterns and define the efficiency of using disinfectant.

Methodology: This study included 233 dental students from Near East University, Faculty of Dentistry. Swab samples taken from mobile phones before and after disinfection were inoculated onto 5% sheep blood medium and eosin methylene blue medium and incubated aerobically at 37°C for 24-48 hours. Mold-growing mix cultures were sub-cultured on the sabouraud dextrose medium and allowed to grow at room temperature. Conventional microbiological techniques and VITEK 2 automated identification system were used for bacterial identification and antimicrobial susceptibility testing. Antibiotic susceptibility tests were verified by Kirby-Bauer disc diffusion technique according to the European Antimicrobial Susceptibility Test Committee criteria. Mold colonies were identified macroscopically and microscopically according to their phenotypic properties using lacto-phenol cotton blue stain.

Results: Microbial contamination of mobile phones was 81% (120.953 cfu/ml) in swab samples taken without using alcohol-based wipes however, microbial contamination in swab samples taken after one-time disinfection was determined to be 21% (201 cfu/ml). The most common microorganisms isolated were coagulase negative *Staphylococci* (69%) and *Aspergillus niger* (13%). All of the isolated bacteria were susceptible to all antibiotics used.

Conclusions: This study represents the first data on the rate of microbial contamination on mobile phones in Northern Cyprus and the efficiency of the use of alcohol to disinfect the mobile phones.

Key words: Mobile phones; microbial contamination; dental students; Northern Cyprus.

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Introduction

Mobile phones have become an essential accessory of individuals' social and professional life that provides a worldwide socializing network. Due to the effect of advanced technology on smartphones and the introduction of the internet, communication become faster and the updated news from around the world become accessible. The number of mobile cellular subscriptions have steadily growing every year with an 18.4 per cent year on year growth and almost whole world (97%) lives within reach of a mobile cellular signal [1]. The current number of mobile phone users is 4.78 billion which means that 61.51% of people in the world own mobile phones today [https://www.bankmycell.com]. In recent years, households have had internet access at home through mobile phones rather than computers since computers no longer needed to access the internet at home.

According to the GSMA real-time intelligence data, there are now 9.82 billion mobile connections globally. In 2019, globally an estimated 4.1 billion (53.6% of global population) internet users which reflects a 5.3 per cent increase compared with 2018, has been reported [1].

Most of the global populations use smart devices due to wide range of applications and benefits especially college, university students and health care professionals for rapid communication and access. Mobile phones contribute to the education system, enabling distance learning education system from different geographic countries and reducing the use of paper-based materials [2,3]. In addition to accelerating the quality of individuals' lives, mobile phones act as potential vectors for cross-transmission of infections, as they are an ideal habitat for the colonization of microorganisms [4]. Mobile phones are commonly used

in everywhere even in the toilet by households and professional users and become an ideal source of spread of infections through hand contact with contaminated hands, objects or surfaces in populations [5-7]. The widespread use of mobile phones especially between medical students and healthcare professionals in hospitals, laboratories, intensive care units, and operating rooms may also influence the risk of transmission of nosocomial infections from patient to patient through contaminated hands, which may progress with high mortality and morbidity in hospitals [8].

The studies have shown that the most frequently isolated pathogens from mobile phones were gram positive bacteria including coagulase negative *Staphylococci* (CoNS), *Staphylococcus aureus* (*S. aureus*), *Micrococcus* spp., spore forming *Bacillus* spp. and Gram-negative bacteria predominantly *Escherichia coli* (*E. coli*), *Proteus* spp., *Pseudomonas aeruginosa* (*P. aeruginosa*), *Klebsiella* spp., *Acinetobacter* spp. [9-11]. In addition to being a habitat for bacterial pathogens, mobile phones have also been implied as potential risk factor for contamination with viral pathogenic viruses such as Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV), Middle East Respiratory Syndrome Coronavirus (MERS-CoV), metapneumovirus, respiratory syncytial virus (RSV), influenza virus, rotavirus and norovirus due to poor hand hygiene and improper disinfection applications [8,12].

Although surface of commonly used smartphones could be contaminated by pathogens, factors influencing the transmission of contagious infection such as the survival period of microorganisms colonized on non-living surfaces and objects, poor environmental disinfection of commonly used devices and/or poor hand hygiene among individuals play significant role in disease transmission [13,14]. The persistence of microorganisms is associated with the environmental conditions such as temperature, humidity, presence of organic substances, the ability to produce biofilms [15]. Studies have shown that survival of clinically relevant microbial pathogens on inanimate surfaces depends on the surface and characteristics of microorganisms. For example, the most frequently isolated *S. aureus* including methicillin resistant *Staphylococcus aureus* (MRSA) and methicillin sensitive *Staphylococcus aureus* (MSSA) can survive in the environment at least 7 days to up to 1 year. This period has been given as 9 to 12 days and 72 hours for bacteria colonized on respectively plastic and stainless steel surfaces. *E. coli*, *Acinetobacter* spp., *P.*

aeruginosa, *Proteus* spp., *Klebsiella* spp. can stay infective in the environment 1.5 hours to 16 months, 3 days to 1 year, 6 hours to 16 months, 1-2 days and 2 hours to more than 30 months respectively [16]. The ability of yeasts and clinically relevant viruses to persist on dry surfaces also influence the risk for transmission of fungal and viral infectious diseases. Reports have shown that human coronaviruses including SARS-CoV and MERS-CoV can survive on inanimate surfaces and remain infective for up to 9 days at room temperature and shorter at higher temperatures. On the other hand, this period has been given as 4 weeks for influenza viruses although both viruses are transmitted by contaminated air born droplets [12,16]. Infection with respiratory pathogens such as RSV, and rhinoviruses, which tend to occur mainly in winter seasons and spread easily, can survive respectively up to 6 hours and 7 days due to inefficient use of disinfectants [16]. Molds are also associated with contamination of environments, devices and objects as they can survive for several months in house dust [16].

In Northern Cyprus, there are no data available in the literature on microbial contamination of mobile phones of dental students. Due to potential risk of disease transmission with mobile phones, this current study aimed to estimate the prevalence of microbial contamination of mobile phones used by dental students of one of the biggest University in Northern Cyprus, to evaluate the antimicrobial susceptibility patterns of those pathogens and to emphasis the importance of disinfection of mobile phones in preventing cross transmission among users.

Methodology

Study Group and Study Design

This study was conducted in Nicosia province of Northern Cyprus. Mobile phones of 233 dental students were involved in the current study. Before the collection of the swab samples from the surface of the mobile phones, users completed a self-administered questionnaire form consisting of basic questions about the frequency of daily use of the phone, how often they wash their hands and clean their mobile phones.

The ethical approval of the study was taken from Ethical Approval Committee of Near East University with the permission number no NEU/2019/73-915 and the informed consent forms were collected from all individuals included in the study.

Sample Collection

A total of 466 swab samples were collected from touch screen surfaces of mobile phones which belong to

233 dental students at Near East University, Faculty of Dentistry. This age group was preferred as they use mobile phones frequently in their daily and social lives. Sterile cotton swabs were used to collect samples before and after use of the disinfectant. For taking proper samples, laboratory staff disinfected their hands using alcohol-based hand antiseptics and wore powder free disposable gloves per sample collection in order to prevent potential cross contamination. The sterile swabs were moistured with sterile saline before use and rotated firmly over the whole surfaces of the mobile phones. A total of 2 different samples were taken from each individual's mobile phone as before and after disinfection. Disinfectant wet wipes consisting of 70% alcohol were used for disinfection of the mobile phones. The swab samples were labelled carefully to compare the effect of disinfection on the microbial contamination of the mobile phones and transported directly to the microbiology laboratory in refrigerating conditions.

A non-inoculated 5% sheep blood agar and an eosin methylene blue (EMB) agar were placed on the laboratory benches before collecting samples as the negative controls of the study.

Culture and Identification

The swabs were inoculated on to 5% sheep blood agar (Merck KGaA, Germany) and EMB agar (Merck KGaA, Germany) immediately and incubated aerobically at 37°C for 24 to 48 hours for bacterial culture and antimicrobial susceptibility tests. The isolated organisms were identified by conventional microbiological methods by macroscopic examination based on colony counting, colony characteristics, hemolysis formation, pigment production and microscopic examination based on the gram staining. Moreover, basic biochemical tests such as catalase, coagulase, oxidase tests were carried out for each different colony for further identification. Catalase test was processed in order to differentiate *Staphylococcus species*. from *Streptococci species*. Further, tube coagulase and oxidase tests were performed to evaluate bacteria that are able to produce catalase and oxidase enzymes such as *S. aureus* and *Pseudomonas sp.*, *Aeromonas spp.*, *Micrococcus spp.* respectively that are mainly associated with the microbial contamination of mobile phones [10].

For mycological examination, suspected mold colonies were sub-cultured on sabouraud dextrose agar and incubated at 25°C for at least 7 days. Identification was carried out by phenotypic characterization of mold

colonies together with microscopic examination of lacto-phenol cotton blue stained smears.

Antimicrobial Susceptibility Test

Especially for some gram-negative bacteria that could not be identified by conventional methods and considered to be resistant, such as *Pseudomonas spp.*, *Acinetobacter spp.*, VITEK 2 automated instrument was used in the current study. VITEK 2 automated reader incubator (VITEK2, France) was performed by using AST-GN (for gram negative bacteria), AST-PN (gram positive bacteria), AST-P641 (for *Staphylococci spp.*), AST-N325 (for *Acinetobacter spp.*, *Pseudomonas spp.*) cards. According to the gram characteristics of bacteria, different antibiotic patterns were carried out for susceptibility testing. For gram-negative bacteria, the antibiotic disks tested were; amikacin (amk), cip, colistin (cst), gen, imipenem (imp), lvx, meropenem (mem), netilmicin (net), tgc tobramycin (tob), sxt; amk, aztreonam (azt), cefepime (cpe), ceftazidime (caz), cip, cst, gen, imp, lvx, mem, net, piperacillin (pip), piperacillin/tazobactam (tzp), tob.

Antibiotic sensitivity test results were confirmed by Kirby-Bauer disk diffusion method according to the EUCAST criteria for gram negative bacteria that were thought to be pathogenic bacteria.

Statistical Analysis

The statistical analysis of the data was performed with SPSS Ver 13.0 (SPSS Inc., Chicago, IL, USA). The Pearson correlation coefficient and the Fisher's chi-square test were used to determine any statistical significance and the statistical significance set at $p < 0.05$.

Results

In the study, 466 samples were collected from the mobile phone used by dentistry students. The study group belonged to the age group of 18 - 22 ages and 50% were male and 50% was female. According to the questionnaire forms, 35% of participants use their mobile phones for a minimum 4 hours whereas, 65% of them use their mobile phones for minimum 10 hours in a day. All participants believe that the mobile phones could carry microorganisms and hand hygiene play significant role in contaminating surfaces of mobile phones however, only 33% of them use soap and water for their hand hygiene. Additionally, majority of the users wash their hands only one time during a day. About 62% of the participants clean their mobile phones by using commercially available alcohol-free

wet wipes and the rest of the respondents indicated that they used dry wipes for cleaning.

Bacterial Distribution Profile Before Disinfection Process

Before disinfection, among 233 samples the overall prevalence of microbial contamination was determined to be 81% (n:189) and the overall bacterial isolates were counted as 120.953 colony forming unit/ml (cfu/ml). Majority of the contaminated mobile phones (181, 96%) showed poly-microbial growth with gram-positive bacteria, gram-negative bacteria and fungal isolates. Only 8 (4%) of the cultures showed mono-microbial growth and of these, all of them were fungal growth. The most common microorganisms isolated from the mobile phones were CoNS (69%) and *Aspergillus niger* (*A. niger*) (13%) Figure 1.

Among a total of 53 mold isolates, *A. niger* (n=32, 60%) and *Microsporium audouinii* (*M. audouinii*) (n=13, 25%) were the major isolates. Of 181 mobile phones with poly-microbial contamination, gram positive bacteria and gram-negative bacteria were isolated in 181 (78%) and 17 (9%) respectively. Of the gram positive-bacteria, the only isolates were CoNS and *Micrococcus* spp. with the percentage 96% and 4% respectively. Amongst gram negative bacterial isolates, *Pantoea* spp. (53%) and *P. aeruginosa* (18%) were the main isolates.

Bacterial Distribution Profile After Disinfection Process

After disinfection process with 70% alcohol based wet wipes, the overall growth was determined to be 21% (n=50) and the overall bacterial isolates counting reduced to 201 cfu/ml. There was no growth detected in

Figure 2. Percentage of isolated microorganisms from mobile phones after disinfection.

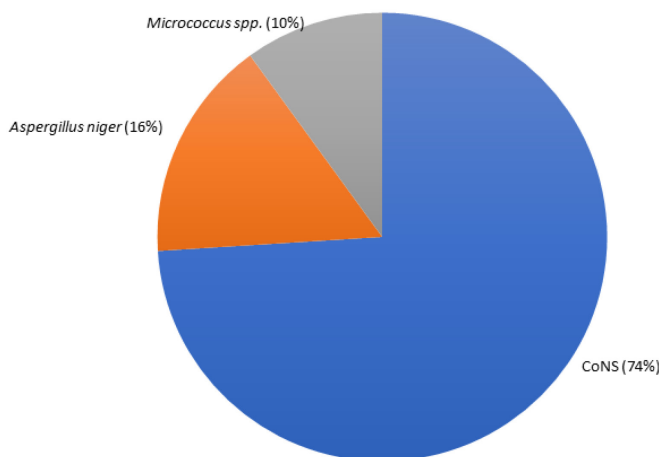
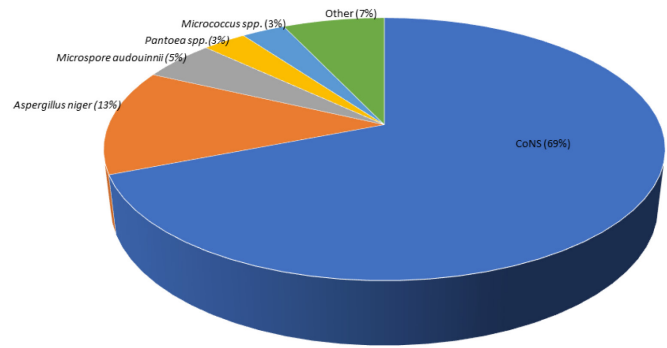


Figure 1. Percentage of isolated microorganisms from mobile phones before disinfection.



Pseudomonas aeruginosa (1.2%); *Aspergillus niger* (1.2%); *Trichosporon asahii* (1%); *Penicillium* spp. (1%); *Aeromonas salmonicida* (1%); *Alternarias* spp. (1%); *Acinetobacter bumannii* (0.4%); *Aeromonas* spp. (0.4%); *Pseudomonas stutzezi* (0.4%).

183 (79%) of the mobile phones. The prevalence of microbial contamination of mobile phones were reduced significantly (80%) by the use of disinfectant. Most of the isolated pathogens were gram-positive bacteria (n=42, 18%) and 16% were fungal pathogens. (Figure 2). Among gram positive bacteria, CoNS (n=37, 74%) and *Micrococcus* spp. (5, 10%) were the isolates. The microbial contamination of mobile phones was reduced by 42% and 100% in the cases of molds and gram-negative bacteria respectively. Total number of bacterial and fungal isolates on mobile phones before and after disinfection process and the percentage of reduction contamination is given in Table 1.

The mean and standard deviation of bacterial groups before and after disinfection processes were calculated as 0.80 ± 0.399 and 0.27 ± 0.447 respectively. There was a statistically significant relationship between the rate of bacterial contamination before and after disinfection (P=0.000).

Antibiogram Patterns for Isolated Bacteria

According to the both automated system and disc diffusion technique, antibiotic susceptibility patterns performed for *P. aeruginosa*, *Pseudomonas stutzezi* (*P. stutzezi*), *Aeromonas* spp., *Acinetobacter baumannii* (*A. baumannii*) showed that all isolates were susceptible to all antibiotics tested for.

Discussion

Mobile phones are widely used in households, healthcare and other professional settings as they provide many applications to facilitate work,

communicate, socialize, organize and play and it is predicted that mobile owners worldwide will increase to several hundred million in the next few years [17]. Due to the constant use of mobile phones and accompanying individuals everywhere, it would be reasonable for mobile phones to carry microbiota of their users and the microorganisms found in the environment. Moreover, the concerns have also increased as mobile phones become a dynamic source for pathogens and can transmit pathogenic and non-pathogenic microorganism due to lack of education and poor hand hygiene [4,18].

Our study was the first investigation that presents the rate of prevalence of microbial contamination of mobile phones used in dental students living in Northern Cyprus, the resistance patterns of the isolated microorganisms and the effect of the use of disinfecting practices in the rate of microbial contamination. A questionnaire was also conducted among participants to collect data on factors that may contribute to the rate of microbial contamination. Our study confirmed that mobile phones are potential risk for transmission of infection in Northern Cyprus as the rate of contamination in the mobile phones was determined to be quite high (81%). In the study, it was predicted according to the questionnaire forms that microbial contamination would be detected in most of the cell phones as only less than half of the respondents indicated that they wash their hands properly and more

than half used alcohol-free wipes for disinfection of mobile phone surfaces.

Similarly, many studies have focused on the rate of contamination of mobile phones and their spread in healthcare professionals, as they have the potential to carry pathogen bacteria. Therefore, in the current study, we concentrated on the percentage of contamination of mobile phones used by Near East University, Faculty of Dentistry students and the necessity of the disinfection on commonly used devices such as mobile phones in Northern Cyprus [4,5,9]. The majority of the mobile phones showed poly-microbial growth (78%), mainly coagulase negative bacteria (69%) and *A. niger* and *M. audouinii*, *Pantoeae* spp. and *Micrococcus* spp. as lower levels respectively. Coagulase negative bacteria are part of normal microbiota of human skin however, especially in immunocompromised individuals, they may lead to highly devastate and damaging consequences [9, 19]. Similar to our finding, studies of Sedighi *et al.* (82.4%) [20]. Bodena *et al.* (58.8%) [9] and Koscova *et al.* (76%) [10]. Coagulase negative bacteria were also the most common isolates and others such as *Pantoea* spp. were also isolated at lower levels [21]. This correlation reveals that CoNS contaminate the mobile phones at the highest rate. Our determination of *A. niger* (13%) at the second highest rate on mobile phone surfaces showed that these devices could also be contaminated with other microorganisms especially with yeast and mold, similar to other studies [3,10]. Most strains of molds are harmless and are found

Table 1. Total number of bacterial and fungal isolates on mobile phones before and after disinfection process and percentage of reduction contamination.

Organisms	Before disinfection		After disinfection		Reduction of contamination
	n plate (%)	Count of bacteria (cfu/ml)	n plate (%)	Count of bacteria (cfu/ml)	
Gram positive bacteria	181 (78%)	120,910	42 (18%)	170	77%
<i>CoNS</i>	174 (96%)	116,418	37 (74%)	153	
<i>Micrococcus</i> spp.	7 (4 %)	4,492	5 (10%)	17	
Fungus (mold)	53 (28%)	-	8 (16%)	-	42%
<i>Aspergillus niger</i>	32 (60%)	-	-	-	
<i>Aspergillus flavus</i>	3 (5%)	-	-	-	
<i>Trichosporon asahii</i>	2 (4%)	-	-	-	
<i>Penicillium</i> spp.	2 (4%)	-	-	-	
<i>Microspore audouinii</i>	13 (25%)	-	-	-	
<i>Alternarias</i> spp.	1 (2%)	-	-	-	
Gram negative bacteria	17 (9%)	43	-	-	100%
<i>Pantoea</i> spp.	9 (53%)	-	-	-	
<i>Pseudomonas aeruginosa</i>	3 (18%)	-	-	-	
<i>Aeromonas salmonicida</i>	2 (11%)	-	-	-	
<i>Acinetobacter baumannii</i>	1 (6%)	-	-	-	
<i>Aeromonas</i> spp.	1 (6%)	-	-	-	
<i>Pseudomonas stutzeri</i>	1 (6%)	-	-	-	
TOTAL	189	120,953	50	170	80%

CoNS: coagulase negative staphylococci; CfU/ml: colony forming unit/milliliter.

everywhere, indoors and outdoors, however they may also cause serious illness such as lung disease or asthma when spores are inhaled by individuals with weakened immune systems [22].

Apart from gram-positive-bacteria and fungal pathogens, the mobile phones were also contaminated with important gram-negative bacteria at low rates such as *P. aeruginosa* (1.2%) and *A. baumannii* (1.2%) which are associated with nosocomial infections and major resistant pathogens of concern [23,24]. Our findings were similar to Banawas *et al.* who reported different species of *Pseudomonas spp.* and *Acinetobacter spp.* from mobile phones of healthcare professionals as important gram-negative isolates [25]. Unlike our study, as Morubagal *et al.* evaluated the mobile phones belonging to health care workers, the rate of *A. baumannii* was at higher rate (21.8%) [26]. Colonization of such potentially pathogenic microorganism on commonly touched surfaces, may lead to increase in the prevalence of multidrug resistant bacteria associated with mobile phones. Gratifyingly, our antimicrobial susceptibility results indicated that all isolates were susceptible to all antibiotics tested. Emergence of colistin resistance strains of *P. aeruginosa* and *A. baumannii* due to increasing use of colistin in clinical settings, is a serious problem as colistin is an effective therapeutic option for extensively drug resistant gram-negative bacteria however, we did not determine any resistant isolate in this study [27]. The fact that the probability to isolate resistant strains of gram negatives, shows how mobile phones would pose high risk for transmission of drug resistant infections.

Further, to compare the number of microbial contaminations in the samples taken before and after disinfection, we used 70% alcohol-based wipes, which is one of the most recommended method to reduce the rate of microbial contamination [21]. There have been different trials with various disinfectants such as chlorhexidine digluconate and triclosan, evernet spray (98%) (100% herbal ingredient + free from acids and alcoholic substances) to reduce the degree of bacterial contamination [310]. In our study, the use of 70% alcohol for disinfection procedure has significantly reduced the number of bacteria (80%) and variety of microorganism on the surfaces of mobile phones. In accordance with the results, the questionnaire forms revealed that the participants in adolescent ages had lack of knowledge on proper disinfection procedures, as the majority of the group (62%) used alcohol free wet wipes or dry wipes to disinfect their mobile phones. A similar result was obtained through a study with medical students of the same age group (68%) in Saudi

Arabia [21]. The high rate of microbial contamination and the lack of consciousness of the population about disinfection procedures emphasize the necessity of educations on universal disinfection protocols and maintaining hand hygiene practices among dental students in Northern Cyprus.

Conclusion

Mobile phones have become essential accessories for the lives of people and professionals and are carried with people everywhere. Due to the regular use of mobile phones, contaminated surfaces of mobile phones can function as a source of contamination of pathogens that can eventually spread through the hands. Therefore, maintaining disinfection of the surfaces of mobile phones and improve consciousness of proper hand hygiene can be the main measures to prevent the spread of infections in the population.

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