Mobile phones as fomites in microbial dissemination
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Abstract

The increased use of mobile phones is seen against a background of rise in microbial infection rates. These mobile phones act as reservoir of microbial flora. The objective of the study was to determine the rate of microbial contamination of mobile phones of college students. The mobile phone of students belonging to Quaid-E-millath Government College for Woman was surveyed for microbial load. The microbial swabs were cultured in a nutritive agar and the microbial isolates obtained were qualitative analyzed. The results obtained showed 98% of isolates and 2% non isolates. The 98% isolated include Gram positive bacillus, Gram negative bacillus, Staphylococcus sp, E. coli, Enterococcus, Coliform, Micrococcus and Aerobic spores. This study thus highlights the fact that mobile phones are potential threat in the dissemination of infections pathogens. It can thus be concluded that development of effective preventive strategies such as regular decontamination of mobile phones with disinfectant and personal hygiene can help reduce the burden of contamination.

Keywords: Mobile phone, pathogens, fomites, mobile phones

Introduction

Until the late 1980s, most mobile phones were sufficiently large in that they were permanently installed in vehicles as car phones. With the advancement in technology however, leading to the miniaturization of circuitry, the vast majority of mobile phones are hand held. In addition to the standard voice function of a telephone, a mobile phone can support many additional services such as SMS for text messaging, email, pocket switching for access to the Internet, and MMS for sending and receiving photos and video. In fewer than 20 years, mobile phones have gone from being rare and expensive pieces of equipment used primarily by the business elite, to a pervasive low cost personal item. In many countries, the quantity of mobile phones outnumbers landline telephones with most adults and many children now owning mobile phones. At present, Africa has the largest growth rate of cellular subscribers in the world with African markets expanding nearly twice as fast as Asian markets. The availability of prepaid or pay as you go services, where the subscriber does not have to commit to a long term contract, has helped fuel this growth on a monumental scale, not only in Africa but on other continents as well. With high level of mobile phone penetration, a mobile culture has evolved, where the phone becomes a key social tool, and people rely on their mobile phone address book to keep in touch with their family and friends. Mobile phones serve as clocks, organizers, reminders, calculators etc., depending on the mobile phone accessories. With all the achievements and benefits of the mobile phone especially public handsets, it is easy to over look the health hazard; it might pose to its many users. This is against the background that
many users may not have regard for personal hygiene coupled with the location of call centre and the likely number of users per day.

The constant handling of the phone by different users makes it open for arrays of microorganisms, making it a harbour and a breeding ground for microbes especially those associated with the skin, and from this phone, different microorganisms are spread from user to user (Ekrakene, 2007). Research has shown that the mobile phone could constitute a major health hazard. With tens of thousands of microbes living on each square inch, they harbour more bacteria than a man’s lavatory seat, the sole of a shoe or the door handle. Microbiologists say that the combination of constant handling and the heat generated by the phones creates a prime breeding ground for all sorts of microorganisms that are normally found on our skin.

The human surface tissue (skin) is constantly in contact with environmental microorganisms and become readily colonized by certain microbial species (Prescott et al., 2005). The adult human is covered with approximately sms of skin, with surface area supporting about 1012 bacteria (Mackowiak et al., 1982). The normal microbiota of the skin include among others; coagulase negative staphylococci, Diphtheroids, Staphylococcus aureus, streptococci (various species), Bacillus sp, Mallassesia furfur and candida sp. Others include Mycobactenium sp (occassionally), pseudomonads and Enterobacteriaceae (occasionally) (Roth et al., 1998).

**Material and Methods**

The study was conducted in the campus of the Quaid-E-Millath Goverment College for women among the students of the department of zoology. Mobile phones were randomly sampled from the students during the period of November 2011 to April 2012. A total of 100 mobile phones were randomly sampled from students. The mobile phone of each student person was held with the aid of sterile gloves. Sterile swabs moistened with sterile saline were used. The samples were collected aseptically by rotating the swabs over the mouthpiece, earpiece, keypads and external cover of the mobile phones.

**Specimen Collection**

Student’s cells phones were randomly selected. Sterile disposable swabs were dipped in sterile normal saline. Sample were collected by rubbing the moisten swab on the surface of the cell phones. The swabs were transported to the laboratory in a sterile test tube.

**Microbial Isolation**

Microbial load was analyzed by performing a surface agar culture of Brain heart infusion agar (BH1). The swabs were rolled on the surface of the BHI agar taken in 100 mm petridis. The plates were incubated at 37°C for 24 hrs. Then transferred to Mackneys medium and kept for forty eight hours. After this incubation the bacterial colonies were counted. The number of microbial colonies present in each swab collected from each cell phone was noted. Isolated microbes were identified on the basis of colony morphology, Gram’s stain findings.

**Results**

The participants in this study varied from the age group of 18 to 25 years. All of the participants were women. All of students sampled used their mobile phones often. It was also observed using their device. The rate of routine cleaning of mobile among students was found to be only which means that 85% them did not have the habit of cleaning their mobile phones. The 15% who cleaned the mobile phone used only a dry cloth for the purpose of cleaning and never used any disinfectants (Fig.1). The cleaning habits of these 15% was also recorded where it
was observed that only 2% cleaned their phones regularly and the rest of the students reported that they cleaned their phones either once a week or sometimes occasionally. Out of the 100 samples evaluated growth was observed in most of the samples 98.0% of mobile phones demonstrated evidence of bacterial contamination. The bacterial contamination was dominated by 30% of gram positive bacteria and 8% by gram negative bacteria. Staphylococcus was present in 14% of the samples and E. coli was found in 16% of the isolates. Enterococcus sp. was present in 18% of the samples analyzed and 8% of the mobile phones were contaminated with coliform bacteria. Micrococcus sp. and aerobic spores contributed to 2% of the bacterial isolates (Table 1) (Figs.1, 2 and 3).

Fig. 1. Cleaning practices of mobile phones by students

Considerable improvement in technology can bring about enhancement in the quality and in the duration of life enjoyed by present generations but at the same time may bring a worse existence for future generations.

Fig. 2. Graphical representation of the presence and absences of microbes in the cell phones of the students of Quaid-E-millath Government College for Women (%)

Discussion

Advancement in culture and social evolution, contemporary technology, results in endless quantities of scientific knowledge that has a decisive power on human existence and on the natural system supporting it. It has the ability, to attain a vast improvement in the quality of life and prolonged life for decades. On the other hand, its results may also go in a totally opposite direction, either against us or our descendants, or other population. Thus considering the dimension of the stakes, one may have to wonder whether we should fully commit ourselves to understanding thoroughly the power of science driven technology, its origins, its long-term effects, and the possibilities that are there are to govern it and harness it more effectively for human purposes. Or whether we should implement more democracy to govern technology and the science it incorporates, and at the same time, to
attempt to guide technology towards new uses to improve its function. One of the mass technologies that are in use is that of mobile phones. In the nineties, when mobile phones started to spread very quickly, worries were expressed about their possible negative effects on human health. Mobile phones function through radio frequencies. A subgroup of electromagnetic radiations, small amounts of which also exist in the natural environment., When it receives or transmits a phone, call, the device generates all around it an electromagnetic field (Electro Magnetic Field) with a diameter of 8-10 centimeters, large enough if the phone is held near to ones ears therefore to deeply expose ones brain, mouth and eyes to the Electro Magnetic Field. This was the reason why many countries have seen a large enough if the phone is held near your ears - to deeply expose your brain, mouth ad eyes to the electromagnetic field. This was the reason why many countries have seen a large number of families, doctors, biologists, consumers' associations and environmentalist NGOs expressing their worries about the fact that using a harboring microbial contaminants on it.

The publicly-expressed worries have prompted several related research projects, involving wider and wider populations and substantially longer periods. One of the widest and most rigorous studies, according to experts, was carried out in Denmark and was published in late 2006. It involved 420,000 adults who had been using mobile phones for many years, including a certain member of people who had used those phones since 1982, and others who had used it for over a decade. Maryam et al. (2011) carried out a descriptive analytical study in 2010 at Islamic Azad university Falavaryan branch Esfahan, Iran where of hundred and fifty health care workers mobile phones were taken randomly. Their results showed presence of bacterial contaminants in more than ninety percent of the mobile phones. Thus their bacteriological isolates percentage coincides with the bacteriological isolate percentage observed in the present study.

A microbiological analysis of 75 doctor's mobile phones was carried out in Amravati city. A total of 90 bacterial pathogens were isolated Staphylococcus aureus 20% was prominent following by Micrococcus luteus 18% Pseudomonas aeruginosa 15% Escherichia coli 11% Enterobacter 9% and Salomonella typhi 5%. The male doctors mobile phones were more (69%) contaminated as compared to female doctors phones (31%) Thus study demonstrates that mobile phones in a clinical setting becomes contaminated by contact with health care worker's hands and acts as a potential source to spread infection (Tambekar et al., 2008). Thus results of the present study reveals many microbial isolates that are similar to the ones isolated from the mobile phones of doctors indicating that isolates of the present study can also lead to spread of nosocomial infection.

### Table 1. Qualitative analysis of the Microbial isolates present on the mobile phones of the students of Quaid-E-Millath Government College for Women (%)

<table>
<thead>
<tr>
<th>Microbial Isolation (%) n = 100%</th>
<th>No. of Samples Collected</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.of Positive Sample</td>
<td>98%</td>
</tr>
<tr>
<td>Gram Positive Bacteria</td>
<td></td>
<td>30%</td>
</tr>
<tr>
<td>Gram Negative Bacteria</td>
<td></td>
<td>8%</td>
</tr>
<tr>
<td>Staphylococcus</td>
<td></td>
<td>14%</td>
</tr>
<tr>
<td>E.coli</td>
<td></td>
<td>16%</td>
</tr>
<tr>
<td>Enterococcus</td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>Coliform</td>
<td></td>
<td>8%</td>
</tr>
<tr>
<td>Micrococcus</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>Aerobic spores</td>
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</table>
Thus the commercial success of mobile phones, whose number is larger in the European countries is approaching or overtaking the number of citizens on the other hand, the rapid diffusion of Wi-fi (wireless internet connection) and WiMax (broadband wireless internet connection) technologies, whose networks covers today not only universities and airports, but entire cities. The simultaneous activity of millions of mobile phones and of millions of PCs and laptops connected to a wireless internet requires dozens of millions of antennas, transmitters, routers, parabolic antennas. The ubiquitous presence of these devices, and their uninterrupted functioning over the day, has caused a dramatic million-fold increase in the background level of electromagnetic radiations, in the cities, comparing to ten years ago. It is this exponential increase in Electro magnetic fields that has led to the concept of electromagnetic pollution or electronic smog. Evidently, it affects also the people not using mobile phones. Whereas those using them multiply the dose of radiations absorbed, adding their individual contribution to the background level.

A significant event was the Benevento Resolution, signed by about thirty researchers, including a number of Italians, after a congress organised in February 2006 in Campania, Italy, by the International Commission for Electromagnetic Safety (ICEMS). It maintains that "more evidence has accumulated suggesting that there are adverse health effects from occupational and public exposures to electric, magnetic and electromagnetic fields, or electromagnetic field, at current exposure levels. What is needed, but not yet realized, is a comprehensive, independent demand transparent examination of the evidence pointing to this emerging, potential public health issue (Lucano Gallino, 2007). Another astonishing fact is that there is a close relationship between the emission of electromagnetic radiation and the microbial load on the mobile phones. Studies conducted by Hans Giertz, 2010 revealed the fact that a large range of bacteria have one thing in common that is an electromagnetic process absorbing electromagnetic energy. Thus from the above fact it can inferred that as mobile phones emit electromagnetic radiations these radiations form a conducive medium for the bacterial growth as the bacteria observe EM energy. This reason is an important evidence for the presence of microbes on mobile phones.

Though mobile phones are indispensable accessories both professionally and socially, they serve as a reservoir of bacteria (Kilic et al., 2009). Mobile phones due to their personal nature and proximity to sensitive part of our bodies in usage such a face, ears, lips and hands of users could become veritable reservoirs of pathogens that could result in infections (Danial et al., 2011).

Thus the results of the present study showed high levels of bacterial contamination of mobile phones used by the students of department of zoology at Quaid-E-Millath Government College at Chennai where the isolates included gram negative bacilli, gram positive bacilli, Staphylococcus, Enterococcus, E. coli, Micrococcus and aerobic spores. The observations of the present study coincide with the findings of Daniel et al., 2011. His study on the mobile phones, of students of cape coast university revealed high levels of bacterial contamination. The bacterial isolate included staphylococci and Escherichia coli both of which were present in the isolates of the present study. The presence of E. coli and Enterobacter as coliform contaminants on different paper currency was observed by Sushil Kumar et al., (2011) on the paper currency of Ajmer at Rajasthan. These forms were also
reported in the present study. The presence of such coliforms suggests fecal contamination of these phones, which can result in community acquired infections and disease outbreaks. The broad spectra of bacteria isolated in the present study in a indicative of the potential nature of the mobile phones to act as fomites, which is similar to the research work carried out by Sham et al. (2011) at the medical and dental institution at Mangalore, India. Where out of the two hundred and four mobile phones screened two hundred and one showed bacterial growth. The bacterial load included *Staphylococcus*, *Escherichian coli*, *Enterobacter* spp. All of which were also observed in the isolates of the present study. Our mobile phones are ideal breeding sites for these microbes as they are kept warm and snug in our pockets and handbags. Also there are no guidelines for the care cleaning and restriction of mobile phones in a country like ours where mobile phones play an important role in the transmission of infection.

In a study conducted by Fatma ulger et al. (2009) to determine the contaminations of mobile phones used at the intensive care unit and operating rooms revealed the fact that 94.5% of the mobile phones were contaminated with bacterial isolates. A similar percentage of 98% contaminants observed in the isolates of the present study. Their study further showed isolates that were similar to those observed in the present study. Their isolates included Staphycococci 21.4% gram negative 21.4% coliforms and 7.1% enterococci. Here in mobile phones are particularly problematic when compared to immobile devices for it facilitates transmission of bacterial isolates from one person to another. Research findings on the rate of bacterial contamination of cell phones belonging to students of Bayero University Kano were screened (Yusha et al., 2010) and the findings of their research indicated presence of staphylococcus in most of their isolates. In the present study staphylococcus was present in about 100 of the mobile phone isolates. These organisms may probably have their entry to the phone through skin and hand to hand mechanism. This is because the isolated bacteria are subset of the normal biota of the skin. Frequent handling with poor hygiene and regular skin contacts with the phones have lead to these isolates (EKrakene and Igeleke, 2007).

Research findings in accordance to the present study were obtained by Dalta et al. (2009) on his investigation of the bacterial contaminants of the mobile phones of health care workers employed in the tertiary health care teaching hospital of Chandigarh (India) and their bacteriological analysis revealed presence of *Staphylococcus*, *Microoccus* sp and *Enterococcus* species.

*Staphylococcus* are present in almost one third of the adult human population. Man being the principle reservoir of *Staphylococcus* infection can never be eradicted because of its carrier state in man. They are normally present in anterior nares, skin gland, mucous membranes and conjunctive all in proximity to mobile phones there by enabling spread of infection (Munish and Asha, 2009).

Studies conducted for a period of six months at Himachal Dental College and hospital at Sundernagar (Himachal Pradesh) recorded a 94.5% contamination of mobile phones and the isolates included Staphylococcus, enterococci and Micrococcus species. All of this are gram positive cocci and more closely associated with the normal habitait on human body and this has enabled their entry to the mobile phones (Munish et al., 2009). On comparing these studies with the present it can be concluded that a high percentage of mobile phones are contaminated with either one type of bacteria.
In a study conducted by Kabir et al. (2009) at Nigeria, they had observed that there was an increase in the use of mobile phones among the general population. So, a study was conducted to determine whether mobile phones could play a role in the spread of bacterial pathogens. A total of 400 mobile phones were randomly sampled where the subjects were divided into four groups consisting of Group A comprising of vendors, Group B includes teachers and students, Group C and Group D were public servants and health workers. Out of the 400 samples evaluated, bacterial load was observed in 248 samples and in 152 samples no isolates were found. Out of the 248 samples which comprised of Group A to group D. Group A (marketers and food vendors) had the highest rate of contamination and the Group B that comprised of lectures and students was the next highest. Thus establishing the fact that the mobile phones of colleges student and staffs harbor bacterial contaminants. The isolates of Group B included staphylococci, enterococcus gram positive, gram negative bacillus, *E. coli*, Coliform, aerospores fomers, micro coccus. The isolates of the above study are much in accordance with the isolates observed in the present study. Thus contaminated, close - contact objects could serve as reservoirs of bacterial agents which could easily be transmitted from the mobile phones to the hands and then from the hands to other areas of the body.

Rusin et al. (2002) had documented both gram positive and gram negative bacteria in the hand to mouth transfer during casual activities. The present findings thus imply that mobile phones may serve as vehicles of transmission of diseases such as diarrhea, pneumonia, boils and abscesses. Thus this study highlights the fact that mobile phones are potential threat in infection control practices and could bring about health care, associate infections. Mobile phones are found to carry these bacteria because of two reasons. Primarily bacteria are masters in mutation and this leads to the prime cause of the emerging crisis for antimicrobial resistance ie. multi resister bacteria.

A large range of bacteria have one thing in common an EM (Electron Magnetic) process absorbing EM energy (Hans, 2010). All mobile phones thus emit EM energy, this forms a conducive environment for the bacteria, so these bacteria find their way onto the mobile phones. Secondarily one reaching the mobile phones the count of these bacteria's increases as bacterial count increases in high temperature and our phones are ideal breeding sites for these microbes as they are kept warm in the pockets and handbags. Thus this is the reason for increased load of bacteria on our mobile phones (Braddy et al., 2006; Jeske et al., 2007).

The overall implication of this result is that the mobile phones which are meant to make communication easy and assessable by many, if not all, is gradually assuming the status of pathogenic agent of disease transmission and if care's not taken it could be vehicle for the transmission of biological weapon for mass destruction (Ekrakene et al., 2007). Todays mobile phones are important devices for both the professional and social lives of their users. However, a restriction on the use of mobile phones is difficult and thus is not a practical solution. Thus users of mobile phones can hence be advice to use antimicrobials wipes to make their mobile phones germ free at all times. Also strict adherence to injection control and precautions such as hand washing and good hygiene practice among the users of mobile phones is advocated, to prevent the possibility of phones as vehicles of transmission community acquired bacterial diseases (Kabir et al., 2009). Thus the study showed that age mobile phones were infected by several microbes, most of which
belonged to the natural flora of the human body. This means it is necessary to carry out hygiene practices after contact with phone since it is a source of disease transmission. Scientists have created a scanner that can be attached to a mobile phone, to detect the presence of *E. coli* bacteria such kinds of investigation can help detect and prevention bacterial contamination.

Soon, you may never have to play Russian roulette with Potato Salad again. Instead of just hoping (That *E. coli* bacteria aren’t present in your foods or drinks, you could instead use your mobile phones to find out for sure). That phone would have to be equipped with a bacteria detecting scanner, which researchers from the UCLA Henry Samueli School of Engineering and Applied Science recently created in a Prototype version, for now. The device attached to the phone's camera and incorporates Semiconducting quantum dots, combined with a grouping of glass capillary tubes that contain antibodies when *E. coli* bacteria from liquid samples are placed within the scanner, They are captured on the Capillary Surface, where they get "existed" by the light from built in Led bulbs. This reaction causes the quantum dots to emit fluorescent light, which is magnified by a lens located beneath the capillaries, and then captured by the Phone's camera - essentially, the device scanner serves as an inexpensive miniature fluorescent microscope. The specific concentration of *E. coli* is determined by quantifying the amount of light being emitted within each tube. So far, there's no hard on when or if a commercial version f the device might be available.

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