SCIENTIA

Peer Reviewed National Science Journal

Volume 15. No.1 ◆ Jan-Dec.2019 ◆ ISSN: 0976-8289

Published by

MERCY COLLEGE

PALAKKAD 678006, KERALA, INDIA

Scientia ISSN: 0976-8289
Vol. 15, No.1, Jan.-Dec., 2019, pp.90-97

Transmission of bacterial pathogens through Mobile phone cases–an emerging threat

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Abstract

Recently, mobile phones have become a potent vector for the transmission of pathogens. The average person checks their mobile phone approximately once in every 12 minutes, or 80 times per day. This means our hands are on our devices nonstop, and they are likely accompanying us on nearly every errand and activity. Hands are in use constantly, touching everything from door handles to cash to sink taps. Along the way hands are capable of collecting enormous amounts of germs. So, touching the mobile devices handled by the person also has serious germ potential. Means that mobile devices act as potential source of germs that end on mobile phone while the person carries. A second reason that our phones are so dirty is the heat they produce. Warm environments are where bacteria thrive. This was ascertained in the current work by analyzing 22 mobile phone used by students community. Of the collected 22 samples, 6 samples showed overloaded number of population of organisms. The number of organisms exceeded to more than 1000 which is indicative of immediate requirement of safety measures. Few samples showed less than less than 1000 number of bacterial population, but the various types of bacteria were present. About 46 bacteria species were isolated and among them *Staphylococcus aureus* was identified as maximum (24%), followed by *Bacillus* sp., accounts for 20% followed by *E. coli* accounted for 15%, *Proteus* sp., unidentified organisms and *Staphylococcus citrus* for 9%, *Klebsiella* sp., for 6%, *Shigella* sp., for 4% and to the least level of saprophytic organism *Serratia* sp. The results indicated that mobile phone are much populated with bacterial pathogens and normal flora of the skin. Necessary measures need to be taken care to avoid such spread of pathogens and control the emergence of drug resistant organisms.

Keywords: Mobile phone, microbial load, identification of bacteria, transmission of bacteria.

Introduction

Mobile phone users in India are increasing gradually that accounts for about 550 million persons in the year 2020. Mobile phones are the hand held devices that are a major part of communication system. Apart from its function as means of communication, they have evolved due to human intelligence after the collaboration of various technologies within a single mobile device. They are used by all types of people irrespective of their social or occupational background[1]. This device keeps the population updated with the surroundings and had maintained the work pace of the cooperate world.

New applications and technologies helpful for the society and in another way also have trouble in the lives of human. They offer as a source of contamination. It is necessary to aware public regarding the prevention of infection and highlighting their duty to control infections. The vast majority of mobile phones are hand-held. Our phone remains in close contact with our body, majorly with our hands, mouth, ears and face. Apart from this, it is very common practice of carrying the phone to washroom. Also, people have habit of operating phone while consuming meals permitting the direct transfer of microorganisms from the mobiles to our gut[2]. Mobile phones are absolutely essential devices but also majorly operated in the areas of excessive microbial load.

Firm actions must be incorporated in our daily activities like proper washing of hands before and after meals, cleaning of phones with disinfectant. There is no such known practice to clean the mobile phones that result in its contamination by the microbes. Most microorganisms face a constant battle for resources and vast numbers of microbes are present in all environments close contact with human body[3]. We can view the dust by our naked

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eyes that get deposited on the mobiles surface but unable to see the microbes that would be flourishing on phone. Because of the achievements and benefits of the mobile phone, it is easy to overlook its hazard to health; this is against the background that many users may have no regard for personal hygiene, and the number of people who may use the same phone. This constant handling of the phone by different users exposes it to an array of microorganisms, and makes it a good carrier for microbes, especially those associated with the skin resulting in the spread of different microorganisms from user to user. Our research has shown that the mobile phone could be a health hazard with tens of thousands of microbes living on each square inch of the phone.[4]

These days, mobile phones used daily everywhere by households, workers, healthcare staffs, etc. as communication medium. No strict rules have been followed to avoid mobile phones in ICU where contamination risk is higher[5]. Mobile phones being in touch with our body and different objects are creating frequent health issues. Hand comes in contact with our phones very frequently therefore serving as an infectious source. The current research work investigate on bacterial transmission through mobile phone and identify the microbes regularly associated with mobile phones.

Materials and methods

Collection of mobile phones and swabs

Before taking a swab, both hands of laboratory technicians were cleaned using an alcohol-based hand sanitizer, and powder-free disposable gloves were worn per sample throughout the work to prevent cross-contamination. The samples of mobile phones, 22 devices were collected from the college students age ranging between 16 and 23 during three-week period of January 2020, in Coimbatore, India. Sterilized cotton swab moisten by sterile normal saline was rotated to swipe from overall (screen, keypad, sides, and back) area of the mobile phone. In case of mobile phones with covers, the swab taken from the outer surfaces of the cover, besides the screen.

Culture of bacteria and microbial count

Each collected swab placed immediately into sterile normal nutrient broth, transported to the Microbiology Laboratory and incubated at 37^{o}C for an hour. The suspension was plated by spread plate technique on nutrient agar, Mac Conkey and Mannitol salt agar plates. The plates were incubated at 37°C for 48 hours and observed for growth and colonial description of the isolates. After incubation, each culture plate analysed for the number of colonies on the plate and different types

Table 1. Total count and number of organisms present on the mobile phone Sample

No	Total no. of organisms/ swab	Types of organisms	Sample identity
1	462	4	B-1,B-2, B-3, B-4
2	10064	1	B-5
3	347	4	B-6, B-7, B-8, B-9
4	5427	3	B-10, B-11, B-12
5	436	2	B-13, B-14
6	459	1	B - 15
7	764	4	B-16, B-17, B-18, B-19
8	75	2	B-20, B-21
9	548	1	B-22
10	4689	3	B-23, B-24, B-25
11	3906	2	B-26, B-27
12	278	1	B-28
13	659	2	B-29, B-30
14	678	1	B-31
15	3588	1	B-32
16	55	2	B-33, B-34
17	68	1	B-35
18	864	2	B-36, B-37
19	446	3	B-38, B-39, B - 40
20	754	2	B-41, B-42
21	642	1	B-43
22	3740	3	B-44, B - 45, B - 46

of microbial population using a colony counter. Each type of isolate subcultued and analysed by the standard microscopic and biochemical test for identification of common Gram negative and Gram positive bacterial pathogens[11].

Results and discussion

Total bacterial count

The samples of mobile phones used in the study were in regular use by the person and were not cleaned for past one months. Collected swab inoculated in nutrient broth immediately turned yellow to brown colour and also turned little turbid after one hour of incubation. Microbiological standards in hygiene are necessary for a healthy life. It is not uncommon, however to observe practices that deviate from normal standards of hygiene in both the developing and the developed world. This investigation confirms deviation, as variety of microbes were found on mobile phones.

Nutrient agar plates seeded with samples 2, 4, 10, 11, 15, and 22 showed overloaded number of population of organisms. Total number of bacterial exceeded more than 1000 which is indicative of immediate requirement of safety measures. Though the sample number 4 and 7 were having less than 1000 number of bacterial population, 4 different types of pathogens were recognized. The following table – 1 indicates the number and types of organisms isolated from the samples. Of the remaining 14 samples, three samples 8, 16 and 17 showed insignificant level of microbial population.

Biochemical test results

The isolated bacteria from the mobile devices subjected to standard biochemical tests[7] and identified list tabulated (Table 2). Table 2 showed that all isolates of *Klebsiella* sp., *Staphylococcus* sp., *Streptococcus* sp., and *Escherichia coli* were negative result for indole while positive by *E. coli*. Utilization of citrate is one of several important physiological test used to diagnose members of all Enterobacteriaceae except *E.coli* which is negative for citrate, while *P. aeruginosa* is positive for citrate. *Klebsiella* sp., produce CO_2, turns the pH indicator (bromthymol blue) from green to blue, reflecting it as positive for citrate test. Whereas in urease test, positive for *Klebsiella* sp., *Staphylococcus aureus* and negative for *E. coli*[8]. *Klebsiella* sp., can produce urease enzyme and gives urease positive test[6].

In motility test, *Klebsiella* sp., were non-motile. But the linear growth in SIM agar indicated negative result for *Klebsiella* sp.,[9] and positive for *E.coli*, *Pseudomonas aeruginosa*, *Enterobacter* spp, and *Proteus* spp isolates[10, 11, 12]. Another way to confirm bacterial genus by catalase test, catalase positive and oxidase negative for *Klebsiella* sp., *E. coli*[13], whereas *Pseudomonas aeruoginosa* oxidase and catalase positive, while *Staphylococcus aureus* isolates were oxidase negative and catalase positive[14]. The coagulase test is specific to differentiate *Staphylococcus aureus* from other species[15].

Identification of bacterial isolates

Based on morphological, cultural, microscopic, physiological and biochemical tests list of bacteria identified in agreement with previous studies given in the table 3.

Among the 46 isolates, *Staph. aureus* was identified as maximum of 24%, followed by *Bacillus* sp., accounts for 20% followed by *E. coli* counted for 15%, *Proteus* sp., unidentified organisms and *Staphylococcus citrus* for 9% each, *Klebsiella* sp., for 6%, *Shigella* sp., for 4% and to the least level of saprophytic organism *Serratia* sp. The results indicated that mobile phone are much populated with normal flora of the skin such as *Staph. aureus, Staph. citrus* and *E. coli* (Fig. 1).

The heat generated by the phones creates a prime breeding ground for many microorganisms that are normally found on the skin. Staphylococci, particularly S. epidermidis are members of the normal flora of the human skin, respiratory and gastrointestinal tracts. Nasal carriage of S. aureus occurs in %50-20 of human beings. The hand serves as a major vehicle of transmission of various microbes including the enteric species.

Table 2. Biochemical test results of isolated organisms

Identification		Staphylococcus aureus	Bacillus sp.	E. coli	Proteus sp.	Shigella sp.	Unidentified	Serratia sp.	Staph. citrus	Klebsiella sp.	Pseudomonas sp.
Biochemical test results	Starch hydrolysis	–	+	–	–	–	–	–	–	–	–
	Nitrate Reduction	+	+	–	+	+	+	+	+	+	+
	Urease test	+	–	–	–	–	+	–	+	–	–
	IMViC	_+ ++	_ _ ++	++ _ _	_ + _ +	_ + _ _	_ + _ _	_ _ + _	_ + _ +	_ _ + +	_ _ _+
	Catalase test	+	+	+	+	+	+	+	+	+	+
Microscopic tests	Spore staining	–	+	–	–	–	–	–	–	–	–
	Capsule staining	–	–	–	–	–	–	–	+	+	–
	Motility	–	–	+	+	–	–	+	–	+	+
	Gram staining	+	+	–	–	–	–	–	+	–	–
Colony morphology	Mannitol salt agar	Yellow colonies	No growth	No growth	No growth	No growth	No growth	No growth	Yellow colonies	No growth	No growth
	Mac Conkey agar	No growth	No growth	Pink colour colonies	Yellow colonies	Yellow colonies	No growth	Dark red colonies	No growth	Pink colonies	Yellow to green colonies
	Nutrient agar	Large, entire colonie	Large, irregular colony	Large, dome shaped colony	Wavery growth	Small, entire	Small, pinhead colony	Large, orange colony	Small, lemon	Large, mucoid	Green colony
Isolate No		B-1,5, 9, 10,11,23 26, 31, 35,37,42	B-2, 6, 27, 28, 29, 39, 41,43,45	B-3, 8, 16, 21, 33, 36, 44,	B-4, 12, 19, 24,	B-7, 18,	B-13,17, 30, 34	B-14	B – 15, 25,38, 46	B – 20, 22, 32,	B – 40,

Table 3. List of organisms identified from the isolated organisms

Sample No.	Types of organisms	Genus name of the isolate
1	4	B1- Staphylococcus aureus B-2 - Bacillus sp. B-3 – Escherichia coli B-4 – Proteus sp.
2	1	B-5- Staph. aureus
3	4	B-6 - Bacillus sp. B-7 – Shigella sp. B-8 – E. coli B-9 - Staph. aureus
4	3	B-10 - Staph.aureus B-11– E. coli, B-12 - Proteus sp.
5	2	B-13 - Unidentified, B-14 – Serratia sp.
6	1	B - 15 – Staph. citrus
7	4	B-16 – E. coli B-17 – Unidentified B-18 – Shigella sp., B-19 – Proteus sp.,
8	2	B-20 – Klebsiella sp., B-21 - E. coli
9	1	B-22 - Klebsiella sp.,
10	3	B-23 –Staph. aureus B-24 - Proteus sp. B-25 - Staph.citrus
11	2	B-26 – Staph.aureus B-27 – Bacillus sp.
12	1	B-28 – Bacillus sp.
13	2	B-29 – Bacillus sp. B-30 – Unidentified organism
14	1	B-31 - Staph.aureus
15	1	B-32 – Klebsiella sp.
16	2	B-33 – E. coli B-34 – unidentified
17	1	B-35- Staph. aureus
18	2	B-36 - E. coli B-37- Staph. aureus
19	3	B-38 –Staph. citrus B-39 – Bacillus sp. B-40 – Pseudomonas sp.
20	2	B-41 – Bacillus sp. B-42 – Staph.aureus
21	1	B-43 - Bacillus sp.
22	3	B-44 - E. coli B-45- Bacillus sp. B-46 - Staph. citrus

Proteus mirabilis is one of the most common Gram-negative pathogens encountered in clinical specimens. It can cause a variety of community or hospital-acquired infections, including those of the urinary tract, respiratory tract, wounds and burns, bacteraemia, neonatal meningoencephalitis, empyema and osteomyelitis[16]. Next to *Staph. aureus*, E.coli and P. mirabilis belonging to Enterobacteriaceae most often isolated in European clinical microbiology laboratories[17], accounting for ~3% of nosocomial infections in the United States[18]. *Pseudomonas aeruginosa* is a metabolically versatile γ-Proteobacterium, which inhabits terrestrial, aquatic, animal, human, and plant -host-associated environments[19].

Previous similar study also indicated that *Staph. aureus, Staph. epidermidis, P. aeruginosa, Neisseria sicca, Micrococcus luteus, Proteus mirabilis, Bacillus subtilis* and *Enterobacter aerogenes* are the major bacterial isolates frequently associated with mobile phones. These organisms may probably have found their way into the phone through the skin and from hand to hand. This is because the isolated bacteria are a subset of the normal microbiota of the skin as advanced by earlier researchers[20]. Frequent handling by many users with different hygiene profiles producing regular skin contact with the phones may have resulted in the frequency and the degree of population of the isolates. This has many health implications.

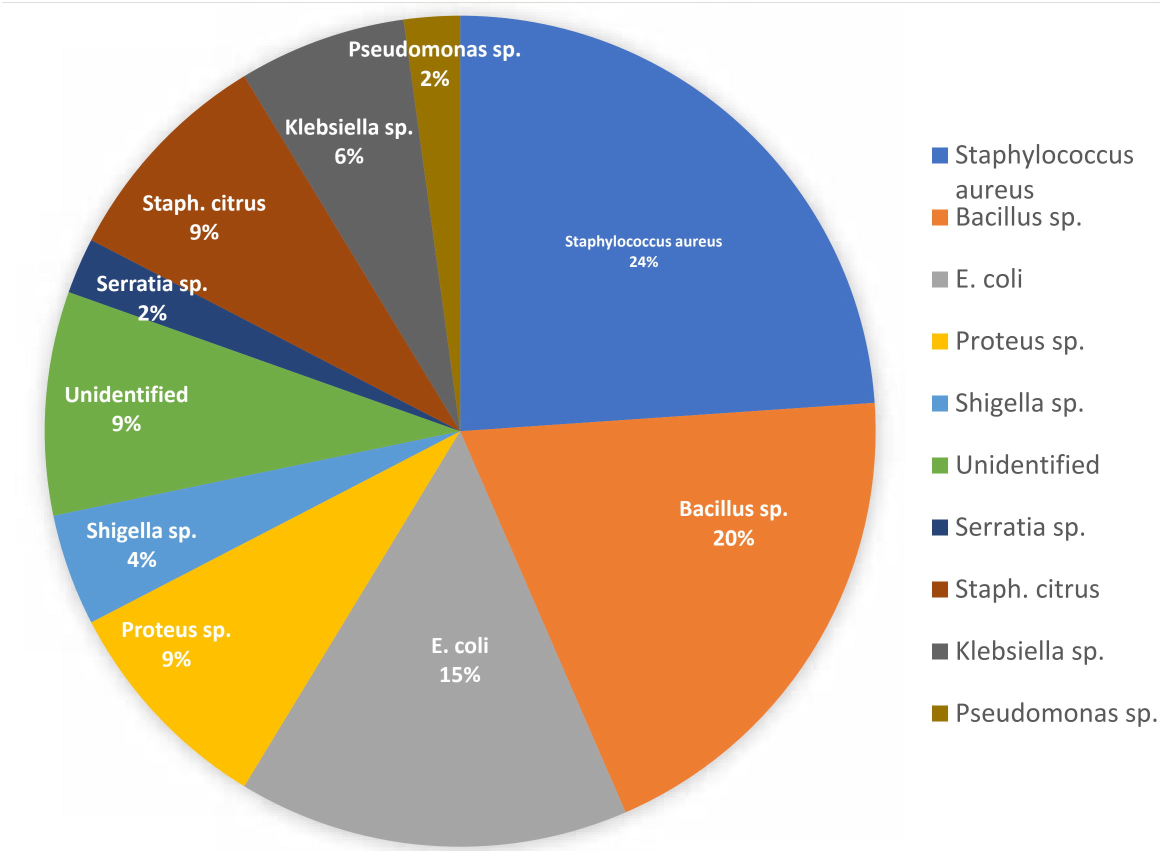

Fig. 1. Chart showing distribution of different bacteria on mobile phone

Staphylococcus aureus is known to cause illnesses ranging from pimples and boils to pneumonia and meningitis, a scenario supported by the high population of colony isolates.

The overall implication of these results is that mobile phones which make communication easy and accessible also form good carriers of pathogenic agents of disease transmission. If care is not taken, they could be vehicles for the transmission of biological weapons. Karabay *et al.*, in 2007 reported that mobile phones may get contaminated with such bacteria as *E. coli, P. aeruginosa* and *K. pneumoniae*, which cause hospital borne infections, and may serve as a vehicle for the spread of nosocomial pathogens[21]. Users of mobile phones are found everywhere: in the market, the home, hospitals, and schools. They could therefore, be the cause of the spread of the infection in the community.

Today, mobile phones are important equipment for physicians and other health workers. Since restrictions on the use of mobile phones is not a practical solution, many researchers suggest that adherence to such infection control precautions as hand hygiene should be strict. In addition, people should be informed that these devices may be a source for transmission of hospital-acquired infections to and from the community. Further studies for the possible means of decontamination of mobile phones, such as the use of alcohol and/or disinfection tissues, should be found and employed in hospitals that have large bed capacities and Intensive Care Units.

Karabay *et al.*, in 2007 found that most of the organisms isolated were skin flora. However, %16.7 of the samples were positive for pathogens known to be associated with nosocomial transmission[21], such as *Enterococci* spp, *S. aureus* and *K. pneumonia*. Vancomycin-Resistant Enterococci (VRE) and Methicillin-Resistant *S. aureus* (MRSA) were not isolated. Other investigators reported that telephones, intercoms, dictaphones and bedpan flusher handles may be contaminated with potentially pathogenic bacteria[22, 23, 24, 25]. Jeske *et al.*, in 2007 also reported that bacterial contamination of anesthetists hands by personal mobile phones occurred, (38/40 physicians, 4/40 with human pathogen bacteria) in the operating theatre[26]. The use of mobile phones in the Intensive Care Unit, burn wards and operative rooms may have more serious hygiene consequences, because unlike fixed phones, mobile phones are often used close to patients. Intensive Care Unit patients and burn patients are very vulnerable to infectious diseases, so the risk of transmission of organisms associated with nosocomial infections is increased[27].

Since the restriction of the use of mobile phones by health care workers is not effective for the prevention of the spread of nosocomial infections, it is also necessary to develop effective preventive strategies that will include environmental decontamination, hand hygiene, surveillance, and contact isolation for the prevention of these nosocomial infections[28]. Simple cleaning of computers and telephones with 70% isopropyl alcohol may decrease the bacterial load[29].

Control measures are quite simple and can include engineering modifications, such as the use of hands-free mobile phones, surfaces that are easy to clean and disinfect, hand washing, and the wearing of gloves by the appropriate personnel. In general, resident infection control staff of the medical facility can advise on the routine control practices for medical devices. Observance of these simple control procedures can decrease morbidity and mortality and thereby reduce medical care costs for hospitals and other care providers.

Conclusion

The mobile cases were analysed for microbial population, among the 46 isolates, *Staph. aureus* was identified as maximum of 24%, followed by *Bacillus* sp., accounts for 20% followed by *E. coli* counted for 15%, *Proteus* sp., unidentified organisms and *Staphylococcus citrus* for 9%, *Klebsiella* sp., for 6%, *Shigella* sp., for 4% and to the least level of saprophytic organism *Serratia* sp. The results indicated that mobile phone are much populated with normal flora of the skin such as *Staph. aureus*, *Staph. citrus* and *E. coli.* The overall implication of these results is that mobile phones which make communication easy and accessible also form good carriers of pathogenic agents of disease transmission. If care is not taken, they could be vehicles for the transmission of biological weapons.

Acknowledgements

We thank the Principal and Management of the Rathnavel Subramaniam College of Arts and Science, Coimbatore for permission to use the laboratory and other facilities.

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Scientia (Annual)

Volume 15. No.1 ◆ Jan-Dec.2019 ◆ ISSN: 0976-8289

ISSN 0976-8289

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