

Isolation and Identification of Common Bacterial Contaminants in Mobile Phones Owned by Veterinary Undergraduate Students

Vivekanandan Annet Viveka
Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Kandy, Sri Lanka

Abstract
The ability of the microbes to survive on the touch-pads of the smart phone makes it as one of the important fomites in the spread of microorganisms between users. The objectives of this study were to identify the microorganisms present on the touch screens of smart phones, to determine the possible factors that could influence the bacterial contamination of mobile phone surfaces and to study the usage pattern of mobile phones by veterinary undergraduates. The sample of this study included 40 mobile phones owned by veterinary undergraduates representing all four batches (n=10 per batch) with equal proportion of male and female students.The bacteria from touch screens were isolated and identified using conventional bacteriological techniques.At least one or more species of bacteria were found in all 40 mobile phones sampled. Eleven species of bacteria, such as Coagulase negative *Staphylococcus* spp. (87.5%), *Bacillus* spp. (60%), *Pseudomonas* (50%), Coagulase positive *Staphylococcus* spp. (22.5%), *Klebsiella* (22.5%), *Acinetobacter* (15%), *Proteus* (12.5%), *Staphylococcus aureus* (5%), *Flavobacterium* (5%), *Enterobacter* (2.5%), *Citrobacter* (2.5%) and *Escherichia coli* (2.5%) were identified from the phones sampled.There were no difference in the occurrence of bacterial species in phones obtained from different batches of students (Chi Square Test: $P>0.05$). The occurrence of *Pseudomonas* (28.6%) and *Bacillus* (28.6%) was significantly low (Chi Square Test: $P<0.05$) in the touch pads that were said to be cleaned regularly**.** Further, it is evident from this study that the veterinary undergraduates are using modern technology for educational purposes and they are aware of the adverse effects of mobile-phone addiction.It appears the contamination of smart phones with Gram positive and Gram negative bacteria owned by veterinary undergraduate students is widely prevalent and regular cleaning of mobile phones and frequent hand washing might reduce the microbial load on the touch pads of the smart phones.

1. Introduction

An American engineer Martin Cooper, who was attached to the Motorola Inc., invented the first mobile phone (*weighed a staggering 1.1kg with a dimension of 228.6 x 127 x 44.4 mm*) in 1973 and led the team that brought it to market in 1983. He is considered as the "*father of the cell phone*" and is also cited as the first person in the history to make a handheld cellular phone call in public (Wikipedia). Early cell phones were used just for talking. Subsequent to the introduction of early mobiles to the market, the mobile phone technology has undergone tremendous advances. Gradually, cell phone manufacturers began to integrate many features into the phone and the smart phones with touch screen display and advanced mobile operating system combining the features of email, internet access, video chatting and entertainment features was introduced in 1994 (Wikipedia).

Cellular telephone services in Sri Lanka began in 1989 as first generation (1G) analog network. There were just 15.5 % of the Sri Lankan population had mobile-cellular telephone subscription in 2001, but this figure has been increased year on year basis. In 2014, the number of mobile phones in Sri Lanka (21,012,025) is higher than the population (20,771,000) of this country (www.statistics.gov.lk). Similar trend has been observed throughout the world and there are about 7.5 billion mobiles in the world at present, compared to the world estimated population of 7.2 billion (US Census Bureau, 2014).

In recent years, the purpose of the cell phone has shifted from a verbal communication tool to a multimedia tool. Nowadays people increasingly use the mobile phones for video calls, Short Message Service (SMS), Multimedia Message Service (MMS), surfing the web, checking email, snapping photos, and updating social media status than actually placing calls.

The mobile phones of today also tend to replace our other gadgets, such as cameras and video cameras, calculators and flash light, radio, computer etc. The recent trend in the growth of mobile phone usage throughout the world defies all gender, racial, and age boundaries.

Smart phones are widely used to integrate contact information that enable to keep in touch with friends, family and co-workers much easier. Further it also enables the navigation of important life activities, finding information on health conditions, accessing the educational resources, online banking, reading news, finding driving directions and search for job and employment resources etc.

As mobile phone usage has been expanded, there are many concerns about overuse of the technology. Despite the many advantages of the mobile phones, there are certain disadvantages like addiction, hindering real human to human interaction or socialization, leading to serious accidents while using the mobiles during driving, decreasing worker productivity, etc. In certain instances the mobile phone overuse violates traditional norms of social behaviour and becoming an emerging safety concern. Mobile phone addiction, "*the newest* *cigarette*" in the world, has affected many people's life quality and the relationship with others and the *addiction* of children to *mobile phones* could threaten the very fabric of the society (King *et al* 2012).

Apart from socio-psychological risks, it is important to assess the new or emerging health risks associated or caused by mobile phones use. It is a known fact that the electromagnetic field used by the mobile phones and the radiations emitted by them could harm the human body. Overexposure to electromagnetic waves and/or radiations from mobile phones might cause disturbance in sleep, difficulty in concentration, fatigue, headache, earache, disorientation, muscle and eye strain, dizziness, increase the resting blood pressure, reduce the production of melatonin, brain tumours, infertility and implicated in DNA strand breaks (Khan, 2008; Samkange-Zeeb & Blettner, 2009; Hardell & Sage, 2008).

Moreover, compared to the other stationary objects, mobile phones have become part of so-called emotional technology and are frequently used in the environment with heavy microbial presence. Constant handling of the phone by different users, heat generated by the phones and humid conditions creates a prime breeding ground for many microorganisms. The ability of the microbes to survive on the contact surfaces of the mobile phone makes it as one of the important fomites that may play a role in the spread of different microorganisms from user to user. Further, hand washing may not be performed often during the course of a working day and therefore the likelihood of the mobile phones as a potential source of microbial contamination and transmission is considerable.

Bacterial cells could readily adhere to mobile phone surfaces and could form organized colonies (Beveridge *et al*. 1997). A study to determine the transfer efficiency of micro-organisms by fomites suggests that the Gram-positive bacteria are transmitted most readily followed by viruses and Gram-negative bacteria (Rusin *et al*. 2002). It has been shown that a significant number of germs could be transferred between the hands of the users of mobile phones, and vice versa (Ulger *et al*. 2009).

Further, it is alarming that mobile phones have been found to harbour a variety of multidrug-resistant pathogens and there are several reports from various countries regarding the role of mobile phones in transmission of nosocomial infections. A study assessed the frequency and antimicrobial susceptibility pattern of bacteria from mobile phones of health care workers showed 17% of the isolates were resistant to commonly used antibiotics (Mutkar & Gashow 2014) and in another study involving the phones of 200 hospital staff members, it was found that 94.5 percent of the phones were contaminated with some kind of bacteria and many of which were resistant to multiple antibiotics (Ulger *et al*. 2009). Another study on the role of cell phone on the transmission of *Acinetobacter* revealed that nosocomial *Acinetobacter baumannii* was commonly acquired through cross-transmission because of its ability to survive in the hospital environment and contaminated fomites like mobile phones.

A study done in the mobile phones of Health Care workers and Non-Health care Workers in Karnataka, India found methicillin sensitive *Staphylococcus aureus* (MSSA), methicillin resistant *Staphylococcus aureus* (MRSA), coliforms, *Corynebacterium* spp., *Enterococcus faecalis*, *Clostridium perfringens*, *Klebsiella* spp., *Enterobacter* spp., *Pseudomonas* spp., *Aeromonas* spp, *Acinetobacter* and *Stenotrophonmonas maltophilia*. Further the above study has found that the carriage of MRSA on the cell phones of health care workers is significantly higher than those mobiles from non-health care workers (Ojhas *et al*. 2009).

Apart from the studies on the bacterial contamination of mobile phones among health care workers and non -health care workers, many studies indicate bacterial contamination in mobile phones owned by university students pursuing health care sciences. Studies on bacterial contamination of mobile phones and their antibiotic susceptibility pattern among students of University of Cape coast Ghana revealed that all sampled mobile phones had high contamination of variety of bacteria with high resistance to common antibiotics (Tagoe *et al*. 2011). Another study done among the students of Faculty of Health Sciences, University of Ljubljana, Slovenia had shown that there was a statistically significant relationship between gender and microbiological contamination of the mobile phones, such as mobiles from female users were highly colonized with bacteria compared with those mobiles from male students (Andrej & Barbara,2012). A study carried out in an Indian Dental school revealed that the mobile phones may act as an important source of nosocomial pathogens in the dental setting. The most common organisms isolated from the mobiles from the above study were Coagulase-negative *Staphylococcus, Staphylococcus aureus, Bacillus* spp., *Acinetobacter, Pseudomonas, Micrococci, Staphylococcus citreus,* and Diphtheroids (Singh *et al*. 2010).

Smart mobile phones are extensively used by the students of the Faculty of Veterinary Medicine & Animal Science, University of Peradeniya for variety of purposes. Despite the extensive use, there is a dearth of information on the bacterial contamination of the mobile phones owned by the veterinary undergraduates from Peradeniya. Therefore this study has been performed with the following objectives.

2. Objectives

- Identify microorganisms present on the surface of the touch screens of smart mobile phones owned by selected veterinary undergraduate students from different batches.

- Determine the possible factors that could influence the bacterial contamination of mobile phone surfaces.
- Study the usage pattern of mobile phones by veterinary undergraduates.

3. Materials and methods

3.1 Sample

The sample of this study included 40 mobile phones owned by first (n=10), second (n=10), third (n=10) and final year (n=10) students of the Faculty of Veterinary Medicine and Animal Science of the University of Peradeniya. The sample for microbiological investigation represented mobile phones from five male and five female students from each batch. Before the experiment a pilot study was carried out using four mobile phones (two phones each from first and final year students) to determine the optimal technique to sample the touch pad of the smart phone for the isolation of bacteria.

This study was carried out over two month period from May to July, 2015. At the time of sampling, the degree of cleanliness, presence of scratches and the presence of phone cover of the smart phone screen were noted. In addition questionnaire (*Annexure I*) was administered to study the usage pattern of the smart phones by veterinary students.

3.2 Isolation and identification of bacteria from the touch pads of smart phones

Eighty sterile swabs were used to take samples from the touch-pads of the 40 smart phone screens to determine the bacterial contamination. The sampling was done around 4.00 pm that represents the end of a working day. One moist sterile swab was (dipped in sterile normal saline) used to sample the right half of the smart phone screens by moving the swab on the touch-pad in a zig-zag pattern while rotating the swab and the swab was cultured directly on blood agar (**Figure 3**). Further, the left half of the phone was sampled on the same way and the swab was inoculated into buffered peptone water for enrichment. The blood agar plates and buffered peptone water were incubated at 37ºC for 24 hours. After enrichment, a loopful of buffered peptone water was cultured on MacConkey and TCBS agar.

Further, 1 ml of enriched buffered peptone water was inoculated into selenite broth and incubated at 37ºC for 24 hours and thereafter a loopful of selenite broth was cultured on both MacConkey and XLD agar.

Selected colonies with different morphology were screened using Gram stain. Gram positive cocci from blood agar was further cultured on Mannitol Salt Agar (MSA) and identified based on colony characteristics on MSA (**Figure 4**) and catalase and coagulase tests. The CAMP test (**Figure 5**) was performed to the Gram positive cocci with yellow colonies on MSA. The Gram negative rods from MacConkey agar (**Figure 6**) were identified by using phenotypic characters such as, oxidase, urease, citrate, TSI, motility and indole production.

3.3 Data Analysis

Microbial analysis and questionnaire data was entered and tabulated using Microsoft excel and analyzed using Minitab (Version 15). Perason's Chi Square test or Fishers Exact test were used to determine the association between categorical variables. A value of $P<0.05$ was considered statistically significant.

4. Results

4.1 Occurrence of bacteria in the touch-pads of smart phones

In this study, at least one or more species of bacteria were found in all 40 mobile phones sampled. The occurrence of Gram positive bacteria on the touch-pads were 100%, while 85% (34/40) were contaminated with Gram negative bacteria. There was a slight but statistically non-significant (Chi Square Test: $P>0.05$) difference between the occurrence of Gram negative bacteria on the smart phones from male [90% (18/20)] and female students [80% (16/20)].

Eleven species of bacteria such as *Pseudomonas* (50%), *Bacillus* spp. (60%), Coagulase negative *Staphylococcus* spp. (87.5%), Coagulase positive *Staphylococcus* spp. (22.5%), *Staphylococcus aureus* (5%), *Klebsiella* (22.5%), *Proteus* (12.5%), *Acinetobacter* (15%), *Citrobacter* (2.5%), *Flavobacterium* (5%), *Enterobacter* (2.5%) and *Escherichia coli* (2.5%), were identified from the 40 smart phones sampled(**Figure 1**).

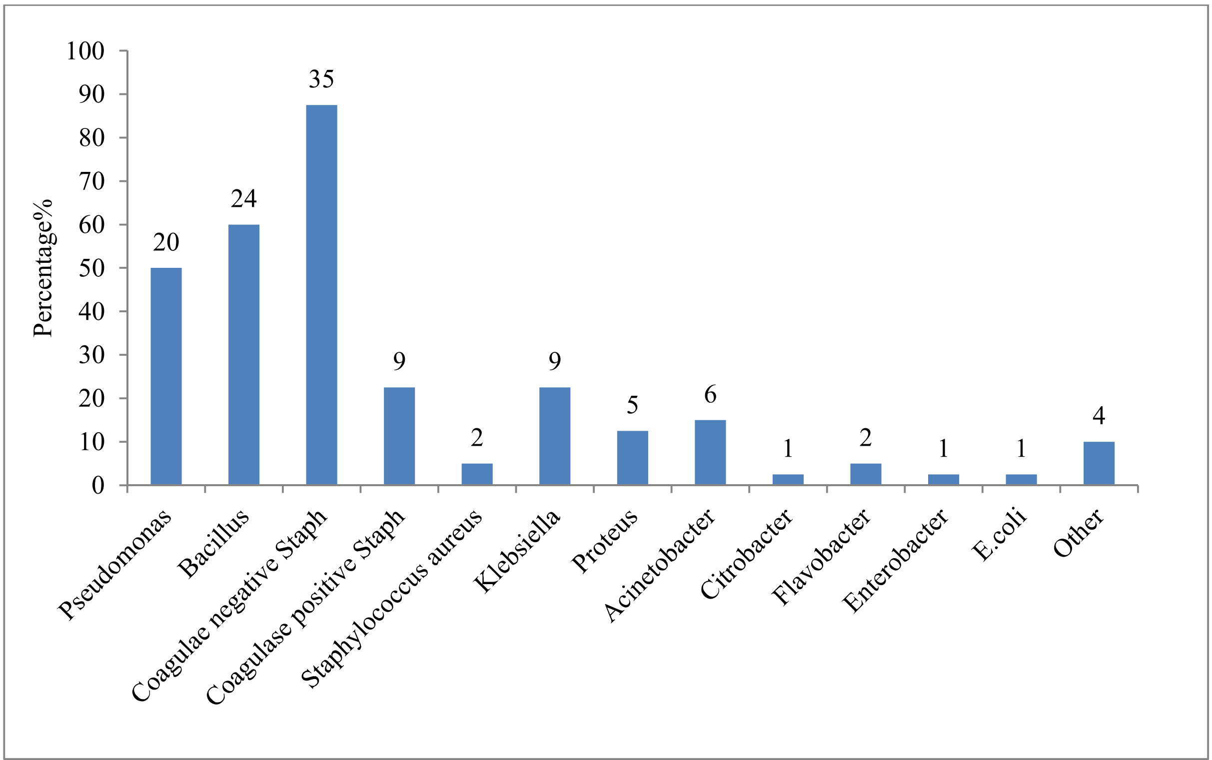


Figure 1: The overall occurrence of different bacterial species on the mobile phone (n=40) touch-pads (*The numbers above the bars indicate the number of phones positive for the given bacteria*).

Table 1: Occurrence of bacterial species on the mobile phones owned by different batch of students.

Bacterial species	No. Positive (%)				
	1st year (n=10)	2nd year (n=10)	3rd year (n=10)	4th year (n=10)	Overall (n=40)
Pseudomonas spp	5 (50)	5 (50)	6 (60)	4 (40)	20 (50)
Bacillus spp	6 (60)	9 (90)	3 (30)	6 (60)	24 (60)
Coagulase negative *Staphylococcus* spp.	9 (90)	10 (100)	7 (70)	9 (90)	35 (87.5)
Coagulase positive *Staphylococcus* spp.	2 (20)	1 (10)	4 (40)	2 (20)	9 (22.5)
Staphylococcus aureus	0 (0)	0 (0)	0 (0)	2 (20)	2 (5)
Klebsiella spp	1 (10)	3 (30)	4 (40)	1 (10)	9 (22.5)
Proteus spp	1 (10)	3 (30)	1 (10)	0 (0)	5 (12.5)
Acinetobacter spp	3 (30)	2 (20)	0 (0)	1 (10)	6 (15)
Citrobacter spp	0 (0)	0 (0)	0 (0)	1 (10)	1 (2.5)
Flavobacterium spp	1 (10)	0 (0)	1 (10)	0 (0)	2 (5)
Enterobacter spp	0 (0)	0 (0)	1 (10)	0 (0)	1 (2.5)
Escherichia coli	0 (0)	0 (0)	0 (0)	1 (10)	1 (2.5)
Other (Unidentified)	1 (10)	0 (0)	1 (10)	2 (20)	4 (10)

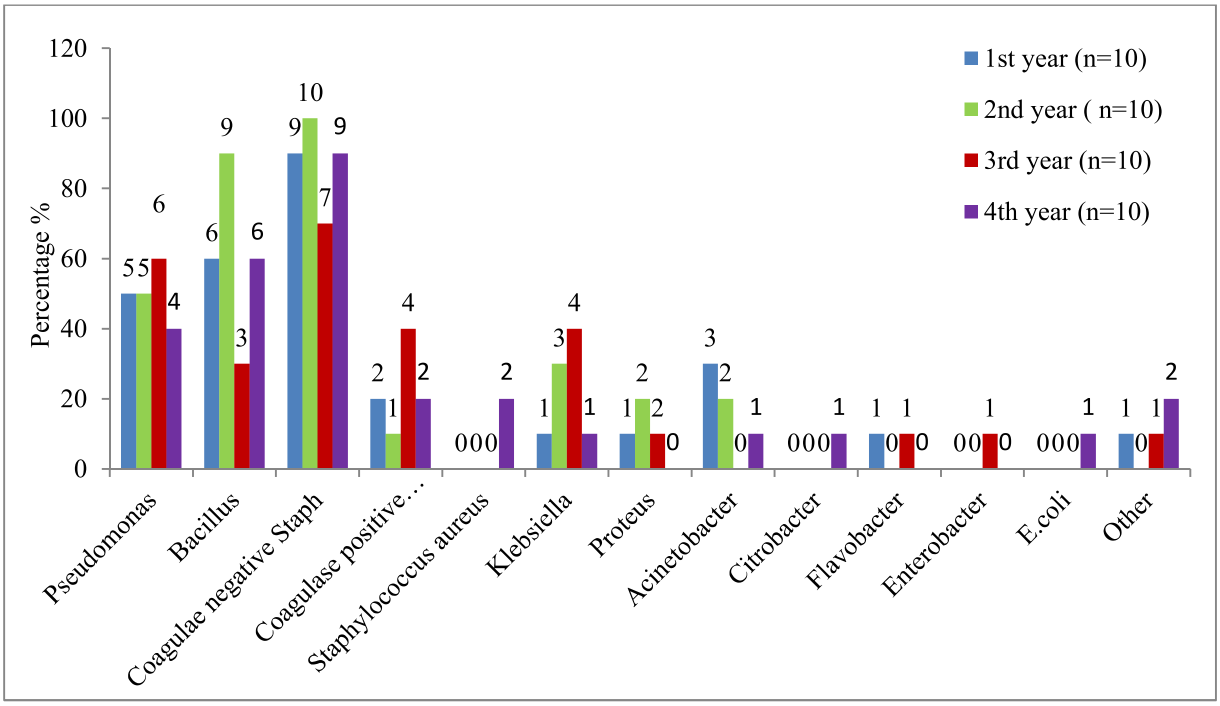
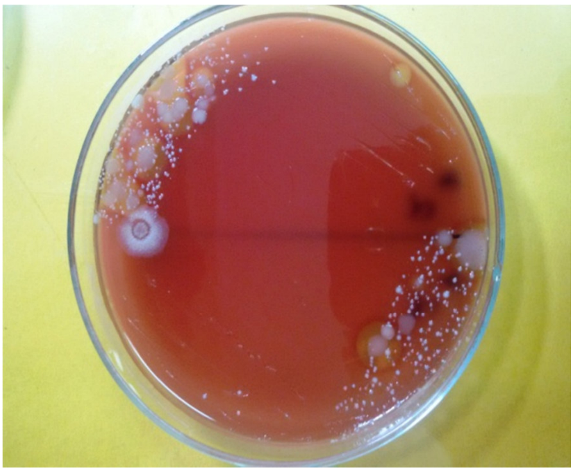


Figure 2: The occurrence of bacterial species on the mobile phone from different batch of students. (*The numbers above the bars indicate the number of phones positive for the given bacteria*)



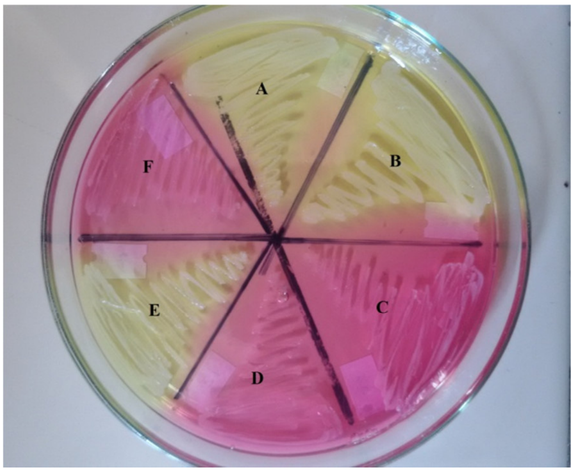
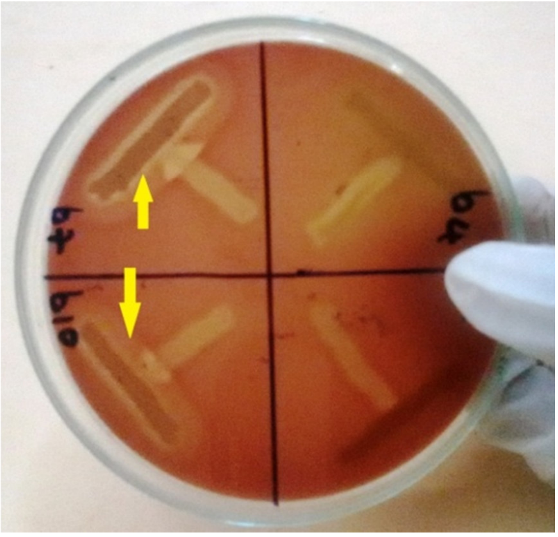


Figure 3 **Figure 4**

Figure 3: Bacterial **c**olonies on blood agar after direct inoculation from a mobile phone.

Figure 4: Pathogenic (A, B & E) and non-pathogenic (C, D & F) *Staphylococcus* spp. on Mannitol Salt Agar.



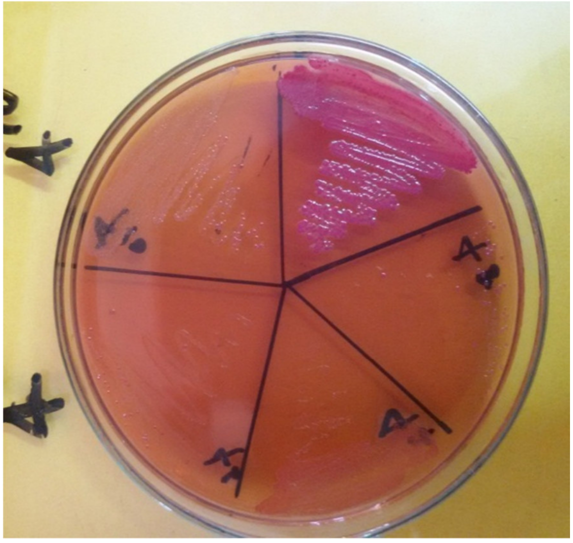


Figure 5 **Figure 6**
Figure 5: CAMP test (Yellow arrows indicate *Staphylococcus aureus*).
Figure 6: Different types of colonies on MacConkey agar.

4.2 Factors affecting the occurrence of bacteria on the smart phone touch-pads

There were slight variations in the occurrence of bacterial species in phones obtained from different batches of students (**Table 1; Figure 2**), but the difference was not statistically significant (Chi Square Test: $P>0.05$). Comparing the mobile phones owned by male and female students, the occurrence of coagulase positive *Staphylococcus* (35%; Chi Square Test: $P<0.05$) and *Pseudomonas* (55%) were high in phones from male students. On the other hand, *Staphylococcus* (10%), Coagulase Negative *Staphylococcus* (95%), E.coli (5%), *Klebsiella* (30%), *Proteus* (15%), *Acinetobacter* (25%), *Citrobacter* (5%) and *Flavobacterium* (10%) were slightly high in smart phones from female students (**Figure 7**).

Interestingly, although not statistically significant (Chi Square Test: $P>0.05$) the occurrence of different bacterial species on the touch-pads of smart phones tends to decrease with the increase in usage time (**Figure 8**). According to the information obtained from the students, there were 35% (14/40) of the students regularly clean their phones by using tissues, handkerchiefs, with the dress, eau de cologne, surgical spirit, etc. The occurrence of *Pseudomonas* (28.6%) and *Bacillus* (28.6%) was significantly low (Chi Square Test: $P<0.05$) in the touch pads that were said to be cleaned regularly **(Figure 9)**.

Although there were slight differences, statistically significant differences were not observed (Chi Square Test: $P>0.05$) between the occurrence of different species of bacteria and the presence of front cover in the phone or age of the phone and the presence of scratches on the phone (**Figures 10, 11 and 12**). Significantly (Chi Square Test: $P<0.05$) high percentage (96.3%) of Coagulase negative *Staphylococcus* and significantly (Chi Square Test: $P<0.05$) low percentage (25.8%) of Coagulase positive *Staphylococcus* was observed in the phones that were said to be shared among friends **(Figure 13)**.

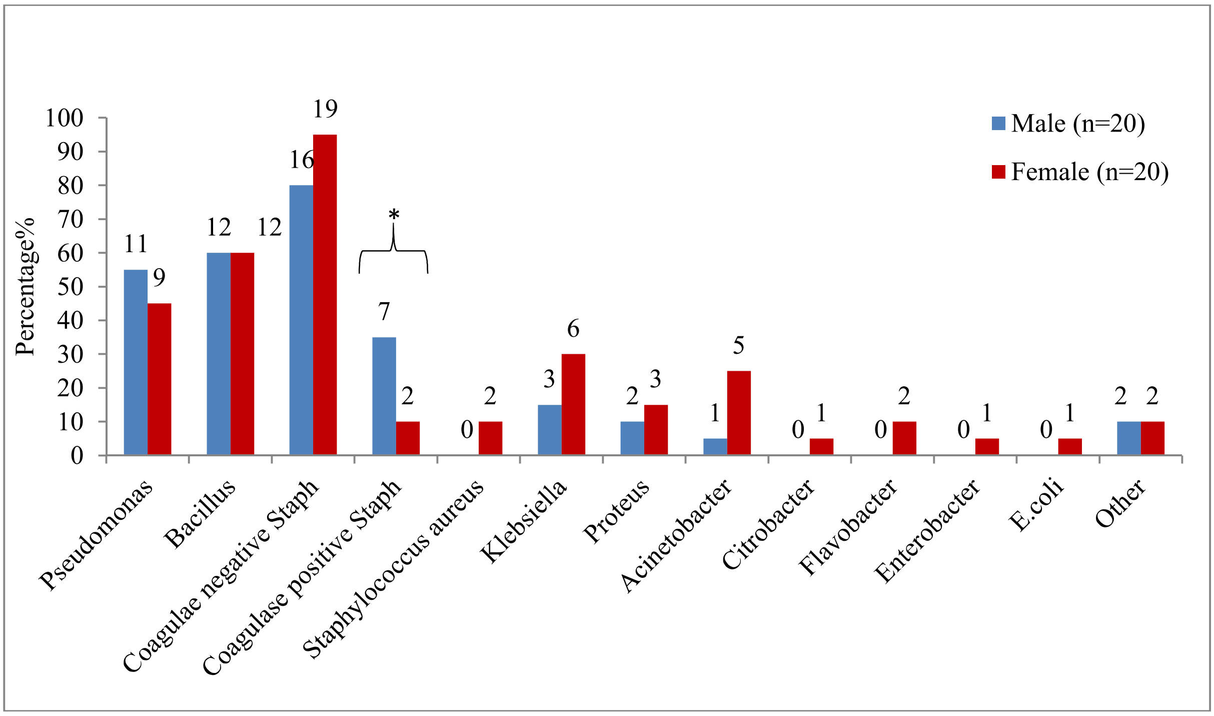


Figure 7: The difference in occurrence of bacterial species on the mobile phones owned by male and female students (*The numbers above the bars indicate the number of phones positive for the given bacteria*). **P*<0.05 (Chi Square test).

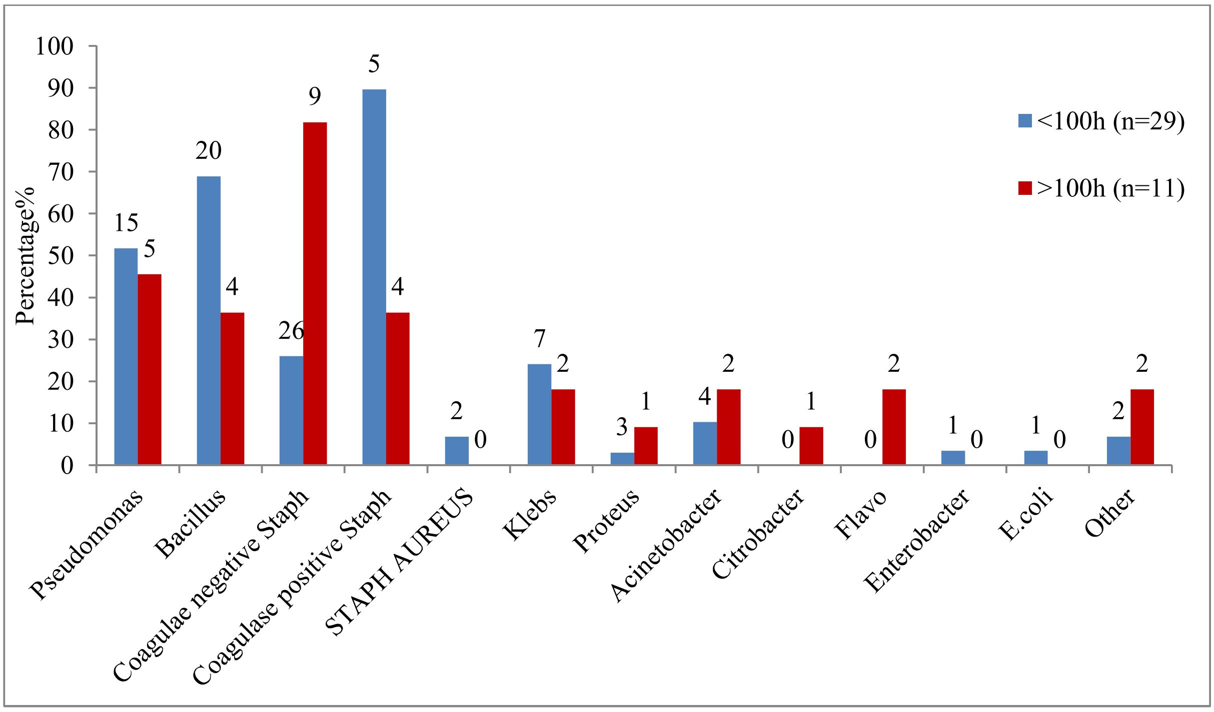


Figure 8: The difference in occurrence of bacterial species on the mobile phones against approximate usage time per week (*The numbers above the bars indicate the number of phones positive for the given bacteria*).

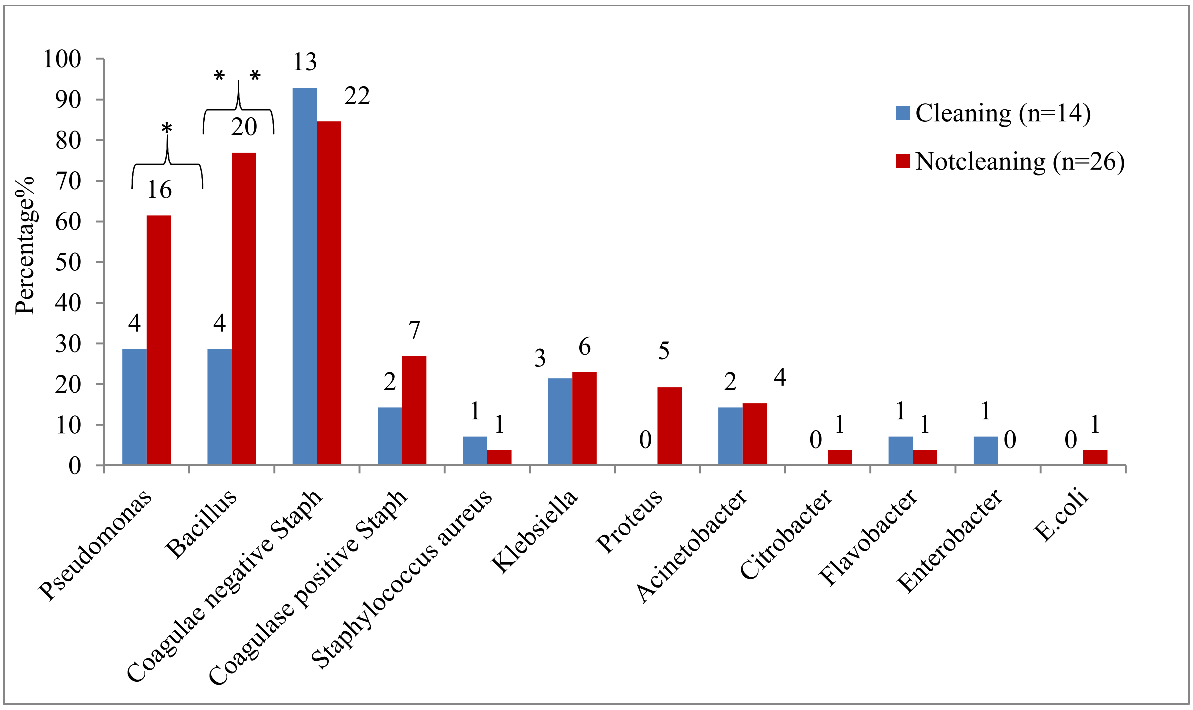


Figure 9: The relationship with the regular cleaning of the mobiles with the occurrence of bacteria (*The numbers above the bars indicate the number of phones positive for the given bacteria*). **P*<0.05 (Chi Square test).

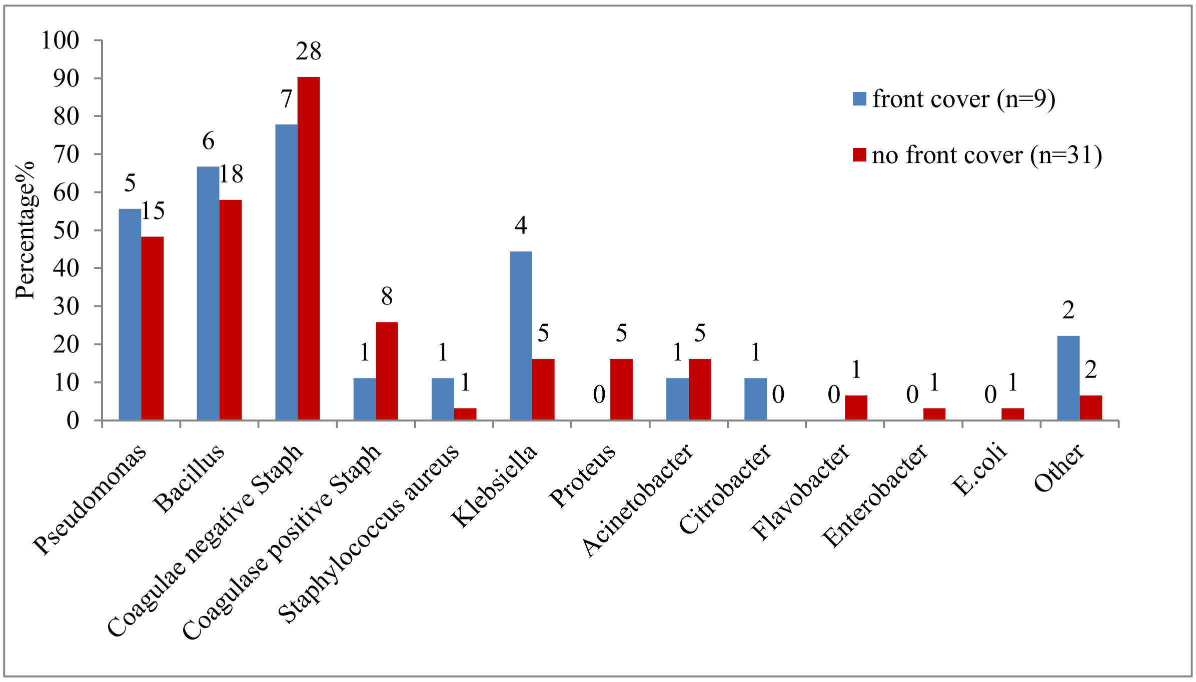


Figure 10: The relationship with the presence of a front cover in the mobile phone with the occurrence of bacteria (*The numbers above the bars indicate the number of phones positive for the given bacteria*).

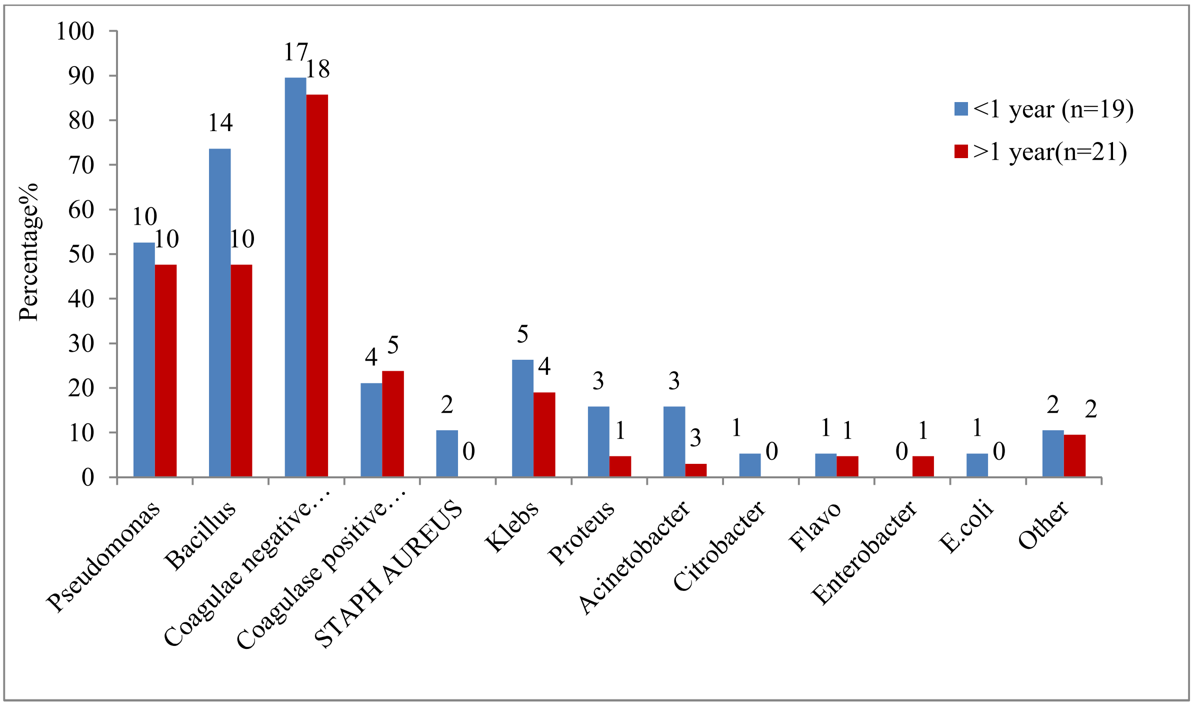


Figure 11: The relationship between the age of the mobile and the occurrence of bacteria (*The numbers above the bars indicate the number of phones positive for the given bacteria*).

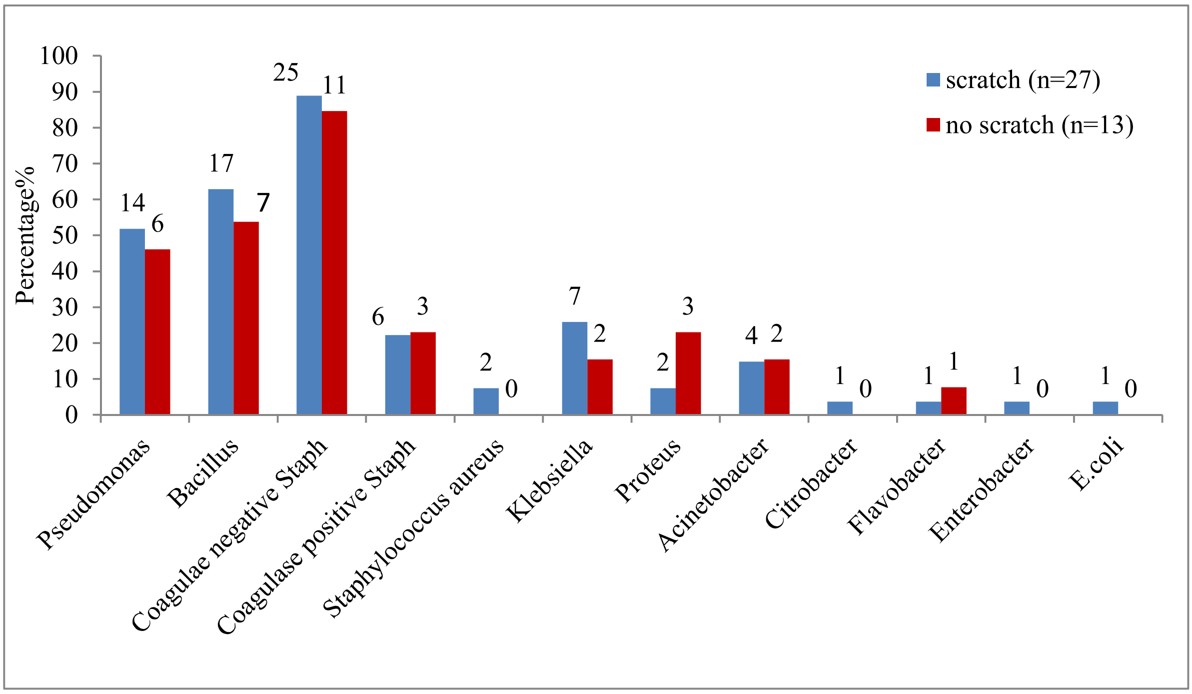


Figure 12: The relationship between the presence of scratches on the smart phone screen and the occurrence of bacteria (*The numbers above the bars indicate the number of phones positive for the given bacteria*).

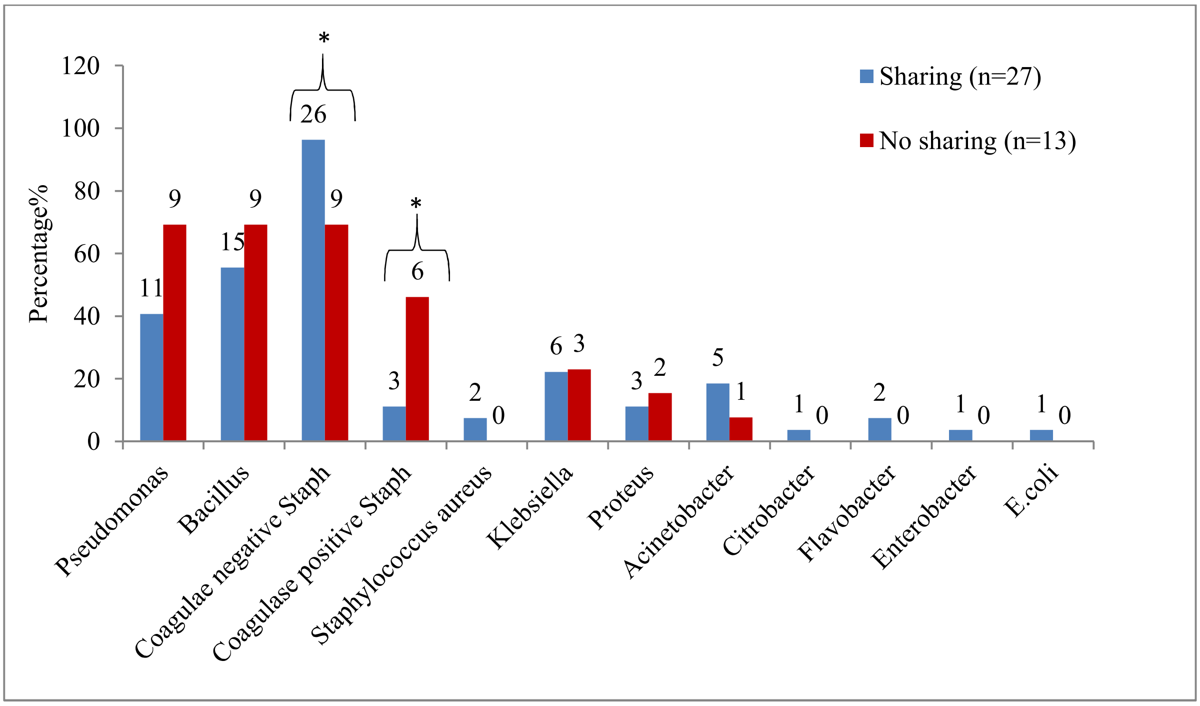


Figure 13: The relationship between the sharing of mobile phones with friends and the occurrence of bacteria (*The numbers above the bars indicate the number of phones positive for the given bacteria*). *P<0.05 (Chi Square test).

4.3 Usage pattern of smart phones by the students

According to the responses provided in the questionnaire by the students (n=40), 2.5% had ordinary phones from primary schooling, 20% from secondary schooling, 30% from Advance level and 50% after entering to university. Further, 17.5% had smart phones since secondary schooling, 37.5% from advance level and 45% after entering to the university. The percentage of students having post-paid connections was 85% and the duration between reloading varied between students **(Figure 14).** Further, according to the information provided by the students, the monthly expenses for mobile varied between Rs. 150.00 to Rs. 2000.00 **(Figure 15).**

In the sample of students surveyed, the smart phones are used for taking pictures during practicals (87.5%), internet surfing (77.5%), for reading eBooks (55%) and having lecture notes (42.5%) (**Figure 16**).

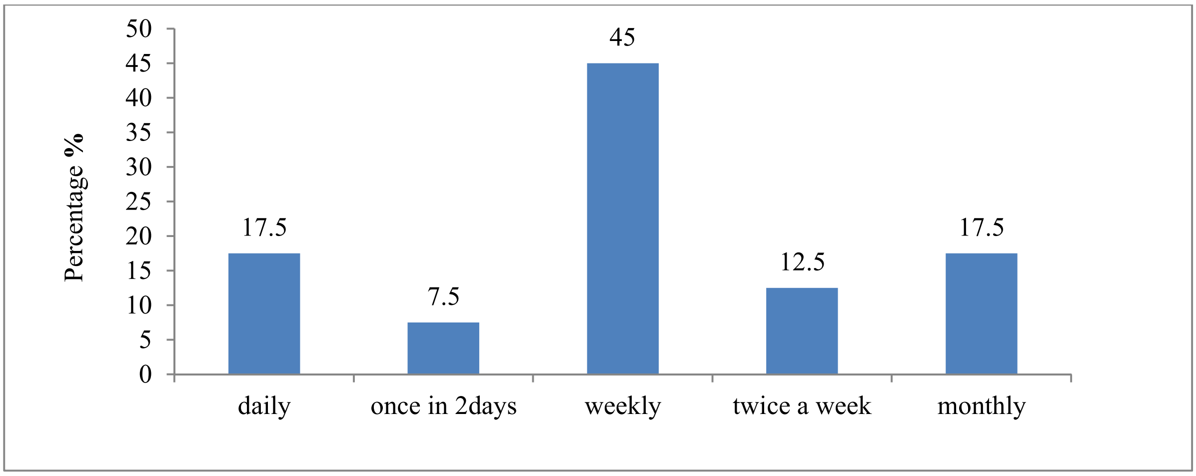


Figure 14: Reloading frequency of mobiles by the students.

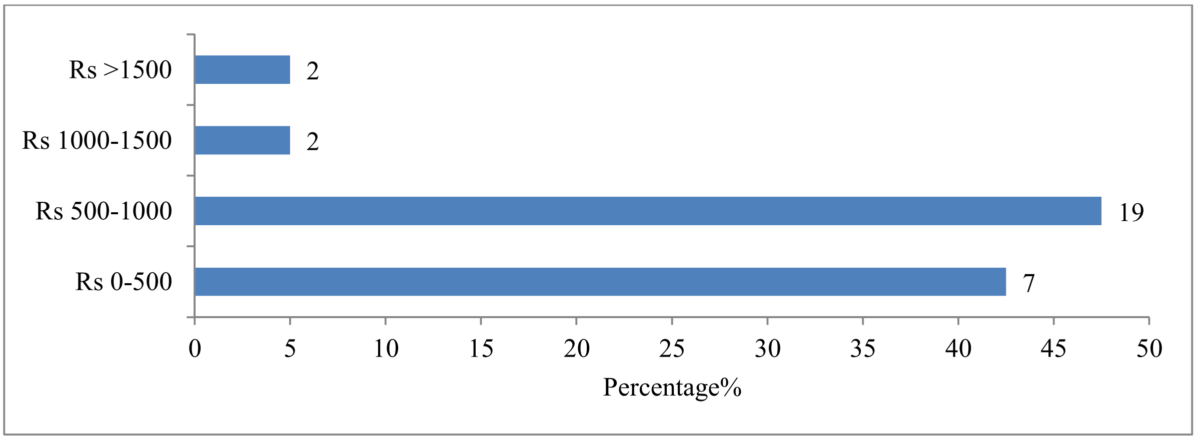


Figure 15: Monthly expenses for mobile phones by students.

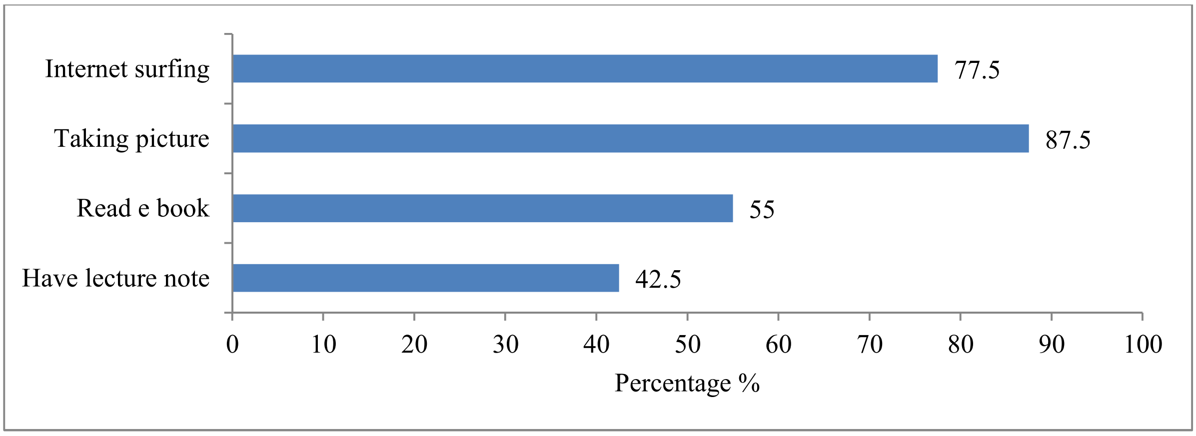


Figure 16: Percentage of the students use smart phones for educational purposes.

4.4 Awareness of risks associated with mobile phones among the students

Amongst the 40 students, only a few (15%) were aware about the ability of mobile phone to passively carry microorganisms. But, many were aware about the other adverse effects associated with overuse of mobiles such as, headache, sleep disturbances, muscle and eye strain, concentration problems, and anxiety **(Figure 17).**

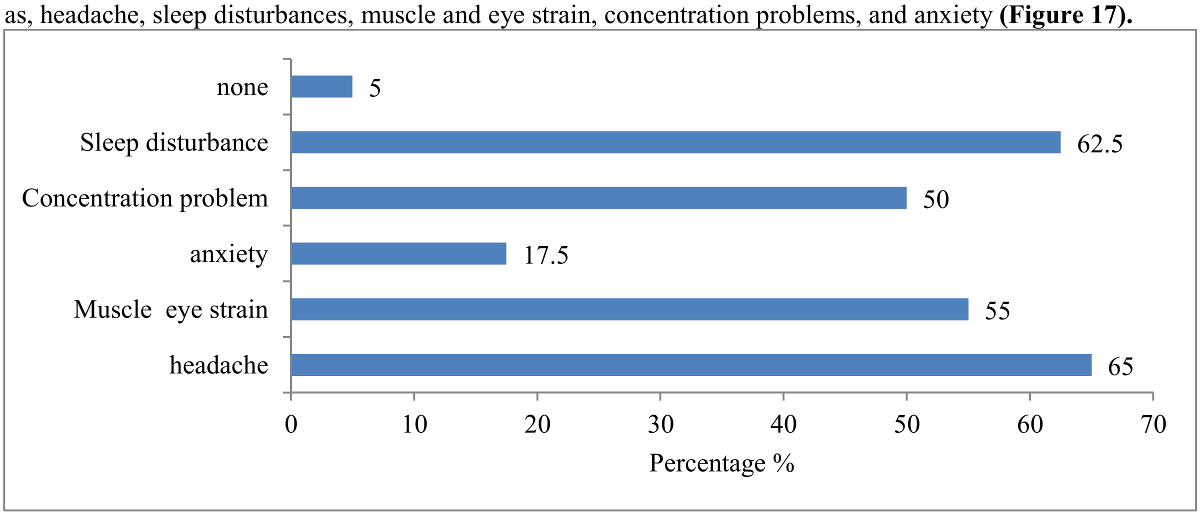


Figure 17: Percentage of the students who know the adverse effects of over usage of mobile phones.

5. Discussion

Mobile phones might become a veritable reservoir of pathogens that may result in infection due to personal nature and proximity to body parts such as faces, ears, lips and hands. In this study, the factors influence the occurrence bacteria on the touch-pad of mobile phones owned by veterinary undergraduates was explored. The results of this study revealed that the occurrence of one or more species of bacteria in the smart phone screens were 100%. As the isolated bacteria are a subset of the normal microbiota of the skin, the bacteria encountered in this study might probably have found their way to the phone via the skin and hand of the owner or users due to the frequent handling. Further, there were no statistical differences in the occurrence of different bacteria on the mobile phones owned by different batch of students. This could be related to similar usage pattern of the mobiles by all students irrespective of their batches. Similarly, in a study among different group of students of health science, food science and computer science faculties, the difference in the occurrence of bacteria with regard to the study course were not statistically significant (Tagoe *et al*. 2011).

The common bacteria isolated from the mobiles were *Pseudomonas* (50%), *Bacillus* (60%) and Coagulase negative *Staphylococci* (87.5%). Similarly, coagulase negative *Staphylococcus* was the most prevalent bacteria isolated from the smart phones in a similar study carried out by Oguz Karabay (2007). *Staphylococcus aureus* is known to cause illnesses ranging from pimples and boils to pneumonia and meningitis (Amira *et al*.2010). Statistically significant relationship ($P<0.05$) was found between gender in the occurrence of Coagulase positive *Staphylococcus* **(Figure 7)**. This finding resembles a similar study (Andrej & Barbara 2012) where relationship between gender of the owner of the phone and microbiological status of the mobiles has been shown statistically significant.

The considerably high isolation rate of *Bacillus* spp in this study might be related to its greater colonization ability as well as the ability of its spores to resist environmental changes and its ability to withstand dry heat and certain chemical disinfectants. A study among University students in science based disciplines, it was found that the *Bacillus cereus* to be the dominant isolate (Tagoe *et al*. 2011). *Bacillus* has been identified as in important organism in food spoilage (Amira *et al*. 2010).

Personal hygiene and hand hygiene are the most important procedures in preventing human pathogenic and opportunistic bacteria (Kampf *et al*. 2004). In this study, a significantly (Chi Square Test: $P<0.05$) high percentage (96.3%) of Coagulase negative *Staphylococcus* was observed in the phones that were said to be shared among friends **(Figure 13).** This implies that the sharing mobile phones among others should be avoided in order to get rid of community acquired infections. Once pathogenic microorganisms deposited on surfaces of the mobile phones, many infectious agents can survive for extended periods unless they are eliminated by disinfection or sterilization procedures. In this study, the occurrence of *Pseudomonas* (28.6%) and *Bacillus* (28.6%) was significantly low (Chi Square Test: $P<0.05$) in the touch pads that were said to be cleaned regularly **(Figure 9),** which implies the importance of regular cleaning of the mobiles to prevent the bacterial contamination without damaging the sensitive device.

Although there were no statistically significant differences were observed (Chi Square Test: $P>0.05$) between the occurrence of different species of bacteria and the age of the phone and the presence of scratches, there was a declining trend of occurrence observed for many bacterial species (**Figures 11 and 12**). It might be related to change of adhesiveness due the physical changes in the touch screen with aging of the device or continuous usage or presence of scratches on the touch screen.

The possible health risks associated with its overuse might be addiction, anxiety, depression, eye strain, motor vehicle accidents, lack of sleep, brain tumours, low sperm counts, headache and hearing loss (Manjeet Singh Bhatia, 2008). It is evident from this study that the veterinary undergraduate students are using modern technology for educational purposes and they were aware of the adverse effects of overusing this technology.

6. Conclusion

1. It appears the contamination of smart phones with Gram positive and Gram negative bacteria owned by veterinary undergraduate students is widely prevalent.
2. Some of the factors like regular cleaning, presence of scratches, age of the phone and sharing mobile phones with others trends to alter the occurrence of different species of bacteria on the touch pad.
3. It is evident from this study that the veterinary undergraduate students are using modern technology for educational purposes and they were aware of the adverse effects of overusing this technology.

7. Suggestions

1. People should be made aware of the potential threats of mobile phones in harbouring pathogens in order to reduce the risk of community acquired infections.
2. Contaminated phones should be kept away from children and immune-compromised patients to prevent potential microbial threats.
3. Regular cleaning of mobile phones with a suitable cleaning fluid as well as frequent hand washing should be encouraged as means of curtailing any potential disease transmission from mobile phones.

References

Beveridge, T. J., Martin, S. A., Kadurugamuwa, J. L., & Li, Z.. (1997). Interactions between biofilms and the environment. *FEMS Microbiology Reviews, 20(3-4),* 291-303.

Hardell, L., & Sage, C. (2008). Biological effects from electromagnetic field exposure and public exposue standards. *Biomedicine & Pharmacotherapy = Biomedicine & Pharmacotherapie, 62*(2), 104-9.

Ismail, R., Aviat, F., Michel, Le Bayon, I., Gay-Perret, P., Kutnik, M., & Federighi, M. (2013). Methods for recovering microorganism from solid surfaces used in the food industry: a review of the literature. International Journal Journal of Environmental Research and Public Health 10(11) 6169-83.

Kampf, G., & Kramer, A. (2004). Epidemiologic background of hand hygiene and evaluation of the most important agents for scrubs and rubs. *Clinical Microbiology Reviews, 17*(4), 863-93, table of contents.

Khan, M. M. (2008). Adverse effects of excessive mobile phone use. *International Journal of Occupational Medicine and Environmental Health, 21*(4), 289-93.

King, D. L., Delfabbro, P. H., Gniffiths, M. D., & Gradisar, M. (2012). Cognitive-behavioral approaches to outpatient treatment of interest addiction in children and adolescents. *Journal of clinical Psychology, 68(*11), 1185-95.

OJHAS: 2009-1-8 – Chawla K et al Bacterial Cell Phones: Do cell phones carry potential pathogens? (n.d.). Retrieved July 10, 2015.

Ramesh, J., Carter, A. O., Campbell, M. H., Gibbons, N, N., Powlett, C., Moseley, H.., …Carter, T. (2008). Use of mobile phones by medical staff at Queen Elizabeth Hospital, Barbados: evidence for both benefit and harm. *The Journal of Hospital Infection, 70* (2)

RIDA®STAMP Cereus – R-Biopharm AG. (nd.). Retreived July 10, 2015, from http://www.r-biopham.com/products/food-feed-analysis/microbiology-hygiene/bacillus-cereus/item.ridastamp-cereus-2

Rusin, P., Maxwell, S, S., & Gerba, C. (2002). Comparative surface- to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, ggram-negative bacteria, and phage. *Journal of Applied Microbiology, 93*(4),585-592.

Rutherford, S. T., & Bassler, B.L.(2012). Bacterial quorum sensing: its role in virulence and possibilities for its control. *Cold Spring Harbor Perspectives in Medicine, 2*(11), a012427

Samkange-Zeeb, F.,& Blettner, M. (2009). Emerging aspects of mobile phone use. *Emerging Health Threats Journal, 2*, e5. http:// doi.org/10.3134/ehtj.09.005

Singh, S., Acharya, S., Bhat, M., Rao, S. K, & Pentapati, K.C. (2010). Mobile Phone Hygiene: Potential Risks Posed by Use in the Clinics of an Indian Dental School. *J Dent Educ., 74*(10), 1153-1158.

Tagoe, D. N., Gyande, V. K, & Ansah, E. O. (2011). Bacterial Contamination Of Mobile Phones: When Your Mobile phone Could Transmit More Than Just A Call.

Ulger, F., Esen, S., Dilek, A., Yanik, K, Gunaydin, M., & Leblebicioglu, H. (2009). Are we aware how contaminated our mobile phones with nosocomial pathogens? *Annals of Clinical Microbiology and Antimicrobials, 8* (1), 7

Vanitha, J. (2014). Nomophobia –do we really need to worry about? *The Journal of Nursing Trendz, 5*(3), 14-17

Adams, B G, Marrie, T J(1982).Hand carriage of aerobic Gram-negative rods by health care personnel.

Akinyemi, Kabir O.,Atapu, Audu D.,Adetona, Olabisi O.,Coker, Akitoye O.(2009).The potential role of mobile phones in the spread of bacterial infections

Brady, R R,Hunt, A C,Visvanathan,Rodrigues, A,Graham,C,Rae,C,Kalima,P,Paterson,H.MGibb, A P (2011)Mobile phone technology and hospitalized patients: a cross-sectional surveillance study of bacterial colonization, and patient opinions and behaviours.

Ilusanya, O. A F,Adesanya, O.,Adesemowo, O.,Amushan, N. A.(2012) Personal hygiene and microbial contamination of mobile phones of food vendors in Ago-Iwoye town, Ogun State, Nigeria.

Lee, Yeon Joo,Yoo, Chul-Gyu,Lee, Choon-Taek,Chung, Hee Soon,Kim, Young Whan,Han, Sung Koo,Yim, Jae-Joon (2013) Contamination rates between smart cell phones and non-smart cell phones of healthcare workers.

Mark, D,Leonard, C,Breen, H,Graydon, R,O'Gorman, Kirk, S (2014) Mobile phones in clinical practice: reducing the risk of bacterial contamination.

James F.Meadow, James F,Altrichter, Adam E,Green, Jessica L (2014)Mobile phones carry the personal microbiome of their owners.

Pal, P.,Roy, A.,Moore, G.,Muzslay, M.,Lee, E.,Alder, S.,Wilson, P.,Powles, T.,Kelly, J. (2013) Keypad mobile phones are associated with a significant increased risk of microbial contamination compared to touch screen phones

Nikhil N. Tambe, Chitra Pai (2012) A study of microbial flora and MRSA harboured by mobile phones of health care workers.

Mutkar Gashaw, Daniel Abtew, and Zelalem Addis (2014) Prevalence of antimicrobial susceptibility pattern of bacterial isolatesd from mobile phones of health care professionals working in Gondar town health centers.

Repacholi, M H (2001)Health risks from the use of mobile phones.
Rusin, P.,Maxwell, S.,Gerba, C. (2002) Comparative surface-to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage.
Salehan, Mohammad,Negahban, Arash (2013) Social networking on smartphones: When mobile phones become addictive.
Selim, Heba Sayed,Abaza, Amani Farouk (2015)Microbial contamination of mobile phones in a health care setting in Alexandria, Egypt.
Famurewa.O and David.O.M,(2009) Cell phone : A medium of transmission of bacterial pathogens.
Najmeh Parhizagari, Ahmed farajzadeh Sheikh, Pairisa Sadeghi (2012) Identification of bacteria isolated from mobile phones of three medical and teaching hospitals administrative and medical staff in ahvaz.
Andrej OVCA, Barbara REDNAK, Karmen TORKAR, Mojka , Martin (2012) Students' mobile phones- how clean are they?
Rawia Ibrahim Badr, Hatem Ibrahim Badr, Nabil mansour Ali (2012) Mobile phones and nosocomial infections.
Ogus Karabay, Esra Kocoglu, Mustafa Tahtaci (2007) The role of mobile phones in the spread of bacteria associated with nosocomial infections.
Terrifying Germs That Live on Your Smartphone – TopTenREVIEWS http://cell-phones.toptenreviews.com/smartphones/terrifying-germs-that-live-on-your-smartphone.html
Text-walking lane for mobile addicts | Daily News Online : Sri Lanka's National News http://www.dailynews.lk/?q=world/text-walking-lane-mobile-addicts
Bozena Nowakowicz Debek,Lukasz Wlsio (2013) Reduction of microbial contamination of mobile phones using ultra violet UV radiation and ozone.

ANNEXURE 1: QUESTIONNAIRE

1. Name/Batch/Gender:
2. How many ordinary/smart mobile phones do you have?
3. How old is your smart phone?
4. At what age did you start using ordinary mobile phone/smart phone?
5. Do you use your smart phone for educational purposes? Yes/No
   If yes, in what ways do you use it?
6. Do your friends use your mobile phone? Yes/No
7. Do you clean your smart phone regularly? Yes/No
8. If yes, how do you clean your phone? How often you clean your phone per month?
9. What is the average duration per day that you would spend with your phone?
10. Do you aware that a mobile phone could carry pathogens due to contamination? Yes/No
11. According to your knowledge what are the adverse effects of the overuse of mobile phone?
12. Mode of payment of your mobile phone is: Prepaid/Postpaid
13. Frequency of account recharge: Daily/Weekly/Other (please specify)
14. Approximate expenses for mobile phones per month (Rupees)