© Inštitut za sanitarno inženirstvo, 2012.

Original scientific paper

Students' mobile phones – how clean are they?

Andrej **OVCA**[1*], Barbara **REDNAK**[2], Karmen **TORKAR**[1], Mojca **JEVŠNIK**[1], Martin **BAUER**[1]

ABSTRACT

Mobile phones can act as a potential microbiological threat, serving as vehicles to transfer contamination from place to place. The aim of this study was therefore *i)* to detect the contamination rate of mobile phone surfaces with microorganisms and organic matter using ATP bioluminescence tests; *ii)* to identify and to quantify the microorganisms present on mobile phones' surfaces owned by different groups of students, divided according to their course of study; *iii)* to examine the success of different methods for the elimination of microorganisms from mobile phone surfaces. About 60 % of 35 mobile phones exceeded 100 RLU according to ATP measurements. In 90 % of 90 swabs taken from mobile phones, more than 5 CFU/100cm^2 were determined. In addition to total aerobic mesophilic microorganisms (90 %), bacteria of the genera *Staphylococcus* (65 %) and the *Enterobacteriaceae* family (39 %) were most often identified. Among all tested procedures for the elimination of microorganisms from surfaces, a putty containing a special antibacterial compound proved to be the most effective. The results show that mobile phones can be considered to be a factor of microorganism cross-contamination.

Key words: mobile phone, students, microbiological examination

Received: 18. 6. 2012.
Accepted: 18. 7. 2012.

[1] University of Ljubljana
Faculty of Health Sciences
Department of Sanitary Engineering
Zdravstvena pot 5
SI-1000 Ljubljana

[2] Tomšičeva 5
SI-2380 Slovenj Gradec

[*] *Corresponding author*
Andrej Ovca
University of Ljubljana
Faculty of Health Sciences
Department of Sanitary Engineering
Zdravstvena pot 5
SI-1000 Ljubljana, Slovenia
Phone: +386 1 300 11 82
Fax: +386 1 300 11 19
E-mail: andrej.ovca@zf.uni-lj.si

INTRODUCTION

Interactions between microorganisms and contact material surfaces play an important role in biology and different technologies, including the food, pharmacy and service industries [1]. Different materials are in contact with different types of microorganisms and their forms, which can harm human health because of their pathogenic properties [2]. Bacteria readily adhere to wet surfaces and form organised colonies of cells enclosed in an extracellular polysaccharide (EPS) matrix that facilitates adhesion to surfaces and each other [3]. Materials have different characteristics for adhering and loading for various contaminants, including bacteria, yeasts, fungal and bacterial spores, and viruses. Due to adhesion, they serve as vehicles to transfer contamination vectors from place to place. If the contact materials allow microbes to survive, the probability of transferring contamination to the next recipient is consequently very high, which has strong impact on the safety and quality of final products or service [4].

Mobile phones have become an integral part of modern telecommunications. In many countries, more than half of the population uses a mobile phone. According to the recent estimation by International Telecommunication Union (ITU) there were more than 4.6 billion mobile phone subscriptions around the world at the end of year 2009, and this number surged to 5.3 billion in next year [5]. In Slovenia, the mobile telephones were used by more than 2.1 million users at the end of 2010 (1 % and 3 % more than over one and two years ago respectively), which is more than number of inhabitants, and continues to increase [6].

It is important to be aware of the new health risks that new products and new behaviours can introduce. With the emergence of the mobile phone, telephony has completely permeated public space, with people talking on the phone in most public places, such as buses, swimming pools, streets, shopping centres, gyms etc. [7]. Mobile phones have become part of so-called emotional technology and are an indispensable accessory, both professionally and privately, used frequently in environments of high bacteria presence [8]. Users are in an emotional relationship with their phone and feel connected with them, which is a consequence of personalised mobile devices and services [9].

Not much research has been done on the microbiological status of mobile phone surfaces. Mostly studies conducted in hospital environments can be found, but studies among the general population are rare. Research on the microbiological status of mobile phone surfaces in food industry could not be found. This is in spite of the fact that work positions where usage of mobile phone is unavoidable can be identified in both hospitals and the food industry. Different studies reviewed by Brady et al. [10] examining mobile phones owned by health care workers report presence of pathogenic bacteria (up to 15 % of all cases). It is alarming that mobile phones have been found to harbour a variety of multidrug-resistant pathogens. According to Cuttler et al. [11], in the general population, one of six mobile phones in Britain is contaminated

It is important to be aware of the new health risks that new products and new behaviours can introduce.

Not much research has been done on the microbiological status of mobile phone surfaces. Mostly studies conducted in hospital environments can be found, but studies among the general population are rare.

with faecal matter. As presented by Khivsara et al. [12], mobile phone contamination and hand contamination suggest cross contamination. One should be aware that mobile phones can act as a potential "Trojan horses", through which unclean device is introduced into the clean working operation.

The purpose of this study was therefore *i)* to estimate the contamination rate of mobile phones with an ATP bioluminescence test; *ii)* to identify and to quantify the microorganisms present on mobile phones' surfaces owned by three different groups of students divided according to their course of study; and *iii)* to investigate the success of different methods for eliminating microorganisms from mobile phone surfaces. Students were chosen as a population because mobile phones are very popular among them. Regarding their course of study, students of health and of food science were chosen, because personal hygiene is an important part of their study. Both groups are also foreseen as working in hygienically more sensitive environments in comparison to students of computer science, who were chosen as a control group without that special knowledge.

Although lower microbiological quality of phone surfaces was expected, the results show that mobile phones can be considered to be a factor of microorganism cross-contamination.

To detect the contamination rate of mobile phone surfaces with microorganisms and organic substances, a preliminary investigation was conducted on 35 mobile phones owned by students of health sciences.

MATERIALS AND METHODS

Sampling

To detect the contamination rate of mobile phone surfaces with microorganisms and organic substances, a preliminary investigation was conducted on 35 mobile phones owned by students of health sciences. The phones were examined using the rapid ATP bioluminescence test. Special Ultrasnap swabs (with luciferase enzyme) were taken from both front and back surfaces.

In order to determine the microbiological quality, 90 standard swabs were taken from the phone surfaces, from three sub-groups (30 swabs per sub-group) of students, according to their course of study (health science, food science or computer science).

The effectiveness of various cleaning procedures for mobile phones was tested by collecting classical swabs from 30 randomly collected mobile phones. The swab was at first taken from one half of the mobile phone. The second half of the surface was then treated with one of the cleaning or disinfection agents: 70 % alcohol, dry paper towels or a putty containing a special antibacterial compound (Cyber Clean, Joker AG/AS, Switzerland) and swabbed afterwards. The total bacterial count was estimated with standard microbiological methods.

ATP bioluminescence method

ATP bioluminescence measurements were carried out according to manufacturers' instructions (Ultrasnap™, Hygiena, Germany). The biolu-

© Inštitut za sanitarno inženirstvo, 2012.

minescence was measured with a System Sure II Luminimeter (Hygiena, Germany). The method is based on the determination of adenosine triphosphate (ATP) by means of luminescence measurement during enzymatic oxidation of luciferin by luciferase. The emitted radiation coming from the swab was measured by a luminometer and is expressed in Relative Light Units (RLU). The results are directly related to the amount of ATP on the surface of the swab and consequently to the amount of organic matter and microbiological contamination remaining on the examined surface [13]. After sampling, the Ultrasnap™ swabs were activated by breaking the tops of the containers to release the luciferaze enzyme. After 15 seconds, the emitted light was measured by luminimeter [14].

Microbiological examination

The samples were examined with standard classical microbiological tests for reliable numbers of aerobic mesophilic microorganisms, coliform microorganisms, the representatives of genera *Enterococcus*, *Staphylococcus*, *Bacillus* and fungi. After the sampling, the swabs were transferred into the tubes with 5 mL of sterile saline solution and mixed using Vortex. 1 mL of the suspension was transferred into a petri dish and mixed with melted medium. The total bacterial count at 30 °C was enumerated on PCA agar (Merck, Germany), according to the EN ISO 4833 standard [15].

For the enumeration of enterococci in swabs, KF Streptococcus agar with a TTC supplement (Merck, Germany) was used according to the ISO 7899-2 standard [16] and the manufacturer's instructions [17].

For the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species), the Manitol Salt Phenol Red Agar (Merck, Germany) and Baird Parker with RPF supplement agar (Biolife, Italy) were used [18]. The isolates were additionally identified by using API Staph biochemical tests (bioMerieux, France) and API WEB Programme V4.0. The number of yeasts and moulds in samples the yeast-extract-glucose-chloramphenicol agar (YGC) (Merck, Germany) was used.

Yeast and mould colonies growing on the plates were counted after five days of incubation at 25 °C [19].

After activating the bacterial spores with thermisation at 80 °C for 10 minutes, the number of members from the genus *Bacillus* was determined on *B. cereus* selective medium MYP (Merck, Germany) The plates with the samples were incubated at 30 °C for 24 to 48 hours. Colony morphology, cell morphological and physiological characteristics were determined using conventional procedures [20].

For the determination of the number of *Enterobacteriaceae* and presence of presumptive *E. coli*, the DEV ENDO Agar (Merck, Germany) was prepared, mixed with the sample and incubated at 37 °C for 24 hours [17].

Haemolytic activity of *Staphylococcus* and *Bacillus* isolates was determined on blood agar (Brain Heart Infusion Medium, Merck, Germany,

with defibrinated sheep blood) prepared by Institute for Microbiology and Immunology, Slovenia.

All bacterial isolates from the selection media were selected by microscopic examination according gram staining, oxidase and catalase tests.

STATISTICAL ANALYSES

Mathematical-statistical data processing was performed using Microsoft Office Excel 2010 and IBM SPSS Statistics 20.

RESULTS AND DISCUSSION

Preliminary investigation with ATP Bioluminescence

The bioluminescence method is in accordance with European Directive 93/43/EEC for the intended use of rapid methods in hygiene control, and has the widest application in the food industry, restaurants, hospitals and other facilities where rapid determination of the degree of contamination is necessary. The mean RLU value of all 35 analysed mobile phones was 158.3, with a wide range between 6 and 572 RLU. In eight cases, luminometer response was above 200 RLU and two cases even above 500 RLU. High luminometer response indicates the presence of ATP-containing living cells, meaning ATP from bacteria, yeast, and mould as well as ATP from any organic residue on the investigated surface. Although there is strong correlation between ATP and microbial cells, according to the manufacturers' instructions and some other authors, the RLU units cannot be transferred into colony-forming units (CFU) [13, 21, 22].

All bacterial isolates from the selection media were selected by microscopic examination according gram staining, oxidase and catalase tests.

Microbiological examination

Several authors have studied the microbiological colonisation of mobile phones [23, 24] particularly among healthcare workers. Studies that explore the microbial colonisation of mobile phones in the general population are much rarer. During the microbiological examination of the swab samples in 81 (90 %) of 90 cases, microorganisms were detected in 97 %, 93 % and 80 % of 30 tested samples for students of health, food and computer science courses of study, respectively. With these results, the assumption of Srikanth et al. [25] is confirmed, i.e. that the contamination of mobile phones in the everyday environment is possible. However, the differences regarding study course were not statistically significant for any of identified group of microorganisms ($p > 0.05$). The most commonly represented groups were *Enterobacteriaceae* family and genus *Staphylococcus* (Fig. 1). *Enterococcus spp.* was found only in samples of food science students, where *Bacillus* species and fungi were also more frequently identified in comparison to other two sub-groups (**Figure 1**). Relatively low average values of total aerobic mesophilic microorganisms in comparison to normal human hand skin colonisation ranging from 3.9 × 104 to 4.6 × 106 CFU/cm^2 [26] were revealed. However, as reported by Pittet et al. [27], fingertip

© Inštitut za sanitarno inženirstvo, 2012.

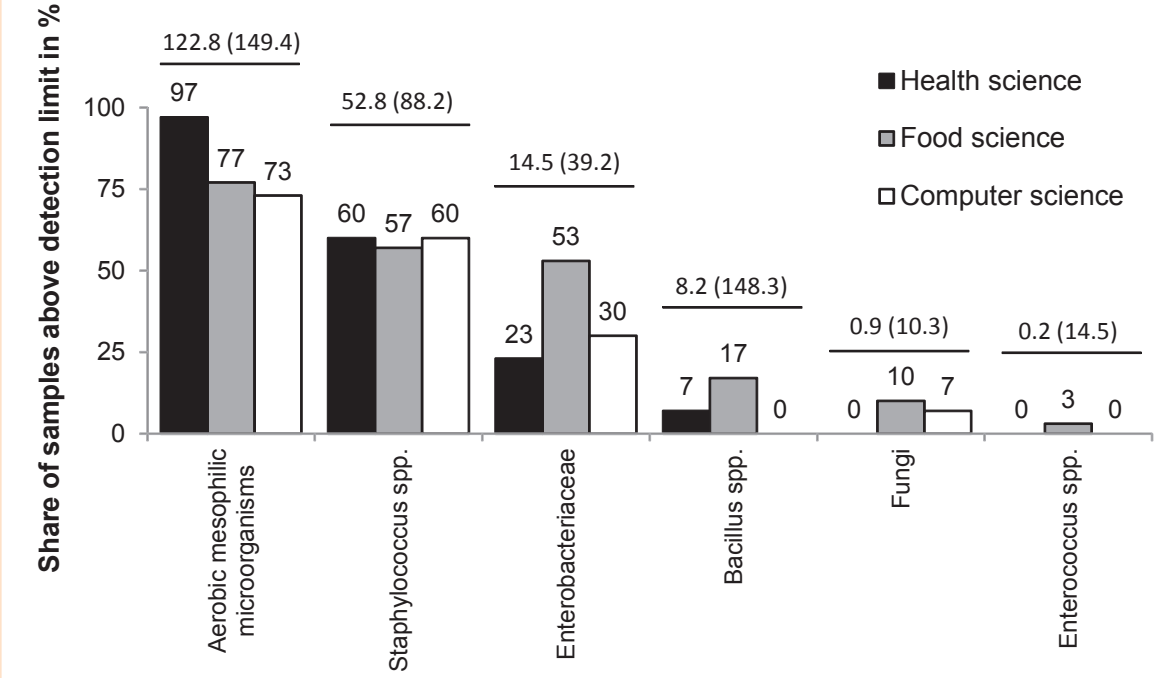

Figure 1.
Percentage distribution of individual group of microorganisms on the surface of mobile phones among students of individual courses of study. The numbers above the horizontal line represent average values (CFU/100 cm^2) of all samples and samples above detection limit only (in brackets), for each group of microorganisms regardless of the course of study.

contamination ranges from 0 to 300 CFU, when sampled by agar contact methods. Nevertheless, higher values were expected, especially for the *Staphylococcus spp.* as part of human skin resident flora and *Enterococcous spp.* as an indicator of faecal contamination, considering that almost 50 % of users of public toilets in Slovenia [28] do not wash their hands after using the toilet. Similar situations were also observed in Australia [29] and USA [30]. In general, resident flora is less likely to be associated with infections, but may cause infections in sterile body cavities, in the eyes, or on non-intact skin [31]. The *Enterobacteriaceae* is a large family that includes many of the pathogens, such as *Salmonella spp.*, *Escherichia coli*, *Yersinia pestis*, and *Shigella spp.* [32]. A similar pattern of microorganism distribution was also identified by Ulger et al. [33], who investigated the level of contamination of mobile phones with nosocomial pathogens. They also identified *Staphylococcus spp.*, *S. aureus*, *Enterococcus spp.* and fungi.

In **Table 1**, Pearson correlation coefficients between total aerobic mesophilic microorganisms and other isolated groups of microorganisms are presented. It can be concluded that number of total aerobic mesophilic microorganisms is highly synergistic with *Staphylococcus spp.* (correlation coefficient > 0.8) among health and food science students. Surprisingly, this correlation is not present among computer science students, indicating a more heterogeneous group regarding microbiological colonisation of their mobile phones. The same situation can be observed also in the case of *Enterobacteriaceae* although with lower synergy.

More detailed species of *Staphylococcus* were investigated further, to explore how many of the potentially infectious species are present. Among genus of Staphylococcus, species *S. warneri* (40 %), *S. epider-*

Table 1.
Pearson correlation coefficients between number of aerobic mesophilic microorganisms and other isolated groups of microorganisms.

	Total aerobic mesophilic microorganisms		
	Health science	**Food science**	**Computer science**
Enterococcus spp.	0.000	0.387	0.000
Staphylococcus spp.	**0.872**	**0.819**	0.172
Enterobacteriaceae	**0.678**	**0.592**	0.118
Bacillus spp.	0.000	- 0.029	- 0.054
Fungi	0.044	0.052	0.000

midis (30 %), *S. capitis* (10 %), *S. sciuri* (10 %), *S. xylosus* (5 %) and *S. aureus* (5 %) were identified. *S. aureus* was the only representative of coagulase-positive staphylococci, while all the other species belong to the group of coagulase-negative staphylococci. *S. epidermidis*, *S. warneri* along with *S. aureus* are part of human skin resident and transient flora [35] but can cause sudden illness in people, especially those with compromised immune system. They are also agents of nosocomial infections [35]. People are natural reservoirs for *S. aureus*, a frequent cause of infections in both the community and hospitals, although asymptomatic colonisation is far more common than infection. It is estimated that 20 % of people are long-term carriers of *S. aureus* [35]. Although *S. epidermidis* and S. *warneri* are not usually pathogenic, people with compromised immune systems are often at risk for developing an infection. These infections can be either nosocomial or community acquired [36].

People are natural reservoirs for *S. aureus*, a frequent cause of infections in both the community and hospitals, although asymptomatic colonisation is far more common than infection.

The gender ratio among all students whose mobile phones were analysed was 48 (54 %) women against 42 (46 %) men. In the group of health science students, females were dominant (90 %), in contrast to the group of computer science students which, with the exception of one female student, was entirely male. The group of food science students consisted of 67 % females and 33 % males. With an independent t-test, the average amount of microorganisms regarding gender was analysed. The relationship between gender and the microbiological status of mobile phones has proven to be statistically significant ($p = 0.047$) in case of *Staphylococcus spp*. The data analysis (**Figure 2**) confirmed that on the mobile phones of female users are significantly more colonised with this genus compared with males. One of the reasons for this discrepancy could be the generally known more frequent use of facial cosmetics by females. In spite of added preservatives, cosmetic products, especially those with high water content, are subject to constant and variable microbial contamination from the domestic environment, consumers' hands and body fluids, from the moment of opening until the moment of discharge. Due to their ability to proliferate on many different substrates, genera like *Pseudomonas* and *Staphylococcus* are often found in contaminated cosmetics [37]. However, this situation should be further investigated, considering also to the time and the way mobiles phone are mainly used (for texting or talking).

© Inštitut za sanitarno inženirstvo, 2012.

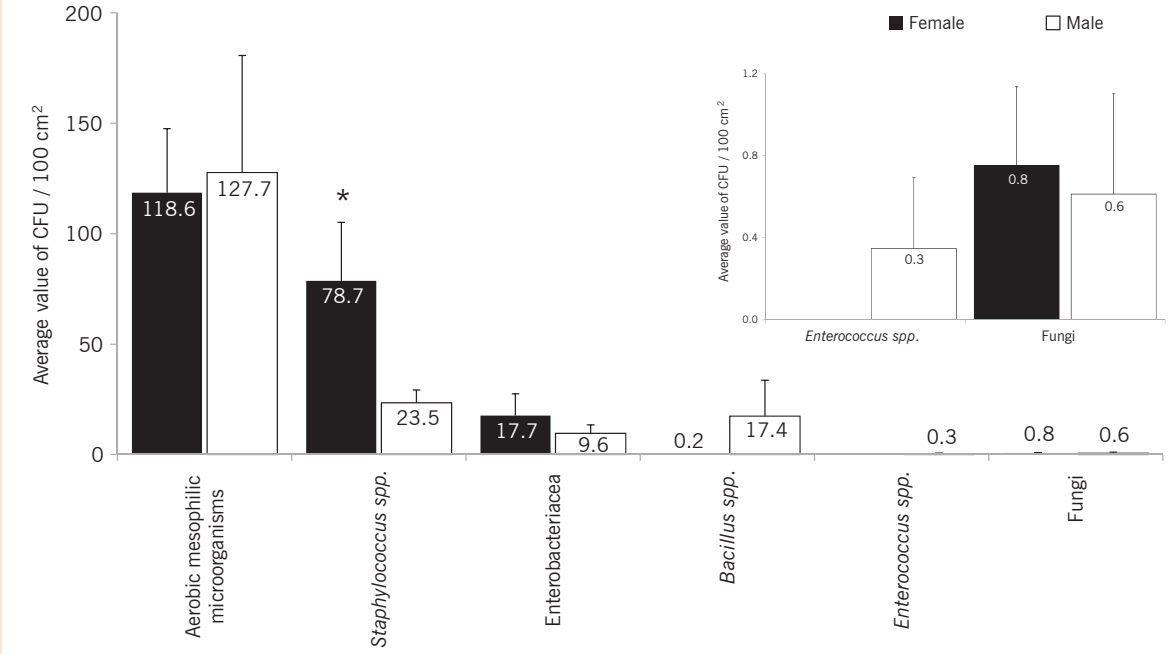

Figure 2.
The average values (CFU/100 cm²) of individual group of microorganisms according to user gender. The statistically significant difference ($p < 0.05$) is marked with an asterisk (*).

Whether the shape of the mobile phone (block, slider or flip and touchscreen) affects its microbiological status, was also investigated. The most common type was touchscreen (44.4 %) flowed by the block shape (40.0 %) and slider or flip (both at 15.6 %; hereinafter considered as one group). The difference in average values regarding total aerobic mesophilic microorganisms was the most obvious, although statistically not significant ($p > 0.05$), with values of 150.9, 105.2 and 74.4 CFU/100 cm² for block, touchscreen and flip/slider, respectively. The higher average values for older style mobile phones in comparison to the touchscreen are most probably the consequence of the shape and the fact that in spite of relatively similar material for mobile phone shells, on touchscreens fingerprints hinder clear views of the screen and owners "clean" them more often. As presented further, microorganisms can be eliminated from the mobile phone surface simply with paper towels and friction.

Removal of microorganisms from the mobile phones' surfaces

Most gram-positive bacteria, such as *Enterococcus spp.*, *S. aureus* and especially bacterial spores, can survive on dry surfaces for several months. Furthermore, many gram-negative species, such as *Acinetobacter spp.*, *E. coli*, and *Shigella spp.*, are able to spend months on dry surfaces [38]. Manufacturers of mobile phones describe in general how users should maintain their phones. The instructions for proper maintenance and cleaning provided by mobile phone manufacturers [39, 40] do not give any specific recommendations regarding cleaning itself. They just warn against the use of corrosive chemicals, cleaning solvents or strong detergents. Considering the mobile phone shape, it comes into the contact with exposed surfaces of the body (mouth, nose, ears) during each phone call. Mobile phones are usually also not a subject of standardised cleaning, and there is also a lack of professional recom-

The instructions for proper maintenance and cleaning provided by mobile phone manufacturers do not give any specific recommendations regarding cleaning itself.

mendations on how to clean/maintain the mobile phones to meet hygiene standards in everyday life, or in different working environments if their use is unavoidable.

Some recent studies [8, 33, 40] conducted in a hospital environment confirmed that the transfer of microorganisms from the hands of health workers on the mobile phone surface and vice versa. If we translate this into the general population where, according to the Co-operative Group report [40], 32 % of people use their mobile phone when they use the toilet and consider the fact that almost half of the people do not wash their hands after using it [11, 28, 29, 30], one needs to be aware that the transfer of potentially pathogenic microorganisms on the mobile phone surfaces is not exceptional. According to Cuttler et al. [11], 16 % of hands and 16 % of phones were found to harbour bacteria of a faecal origin, where those who had bacteria on their hands were more likely to have bacteria on their phone as well. In such situations, hand washing is the simplest and also the most effective measure to prevent the spread of agents responsible for communicable diseases.

In **Table 2**, the efficiency (based on reduction rate of total aerobic mesophilic microorganisms) of three different procedures for the elimination of microorganisms is presented. Paper towels were chosen to test whether elimination with physical force can be achieved. Antibacterial

Table 2.
Comparison of elimination efficiency for aerobic mesophilic microorganisms using paper towels, antibacterial putty and 70 % ethanol.

Sample number	Used method	CFU / swab before intervention	CFU / swab after intervention	Elimination efficiency (%)
1	Paper towels	12	3	75
2		12	0	100
3		212	65	69
4		15	2	87
5		11	2	82
6		178	1	99
7		29	4	86
8	Antibacterial putty	48	3	94
9		15	0	100
10		740	1	99
11		39	0	100
12		252	1	99
13		22	0	100
14		419	7	98
15	70% Ethanol	110	1	99
16		64	1	98
17		12	3	75
18		92	21	77
19		27	3	89
20		10	0	100

© Inštitut za sanitarno inženirstvo, 2012.

putty was chosen as a product meant especially for the cleaning of electronic devices, for which manufacturer claims that in one minute of contact time bacteria such as *E. coli*, *P. aeruginosa*, *S. aureus*, and fungi can be inactivated. Ethanol (70 %) was chosen as the disinfecting agent that should inactivate all the bacteria present on the surface. The antimicrobial activity of alcohols results from their ability to denature proteins. Alcohol solutions containing 60–80 % alcohol are most effective, with higher concentrations being less potent, as a consequence that proteins are not denatured in the absence of water [43]. Alcohols have an excellent in vitro germicidal activity against gram-positive and gram-negative vegetative bacteria (including multidrug-resistant pathogens such as MRSA), and a variety of fungi [43, 44]. However, they have virtually no activity against bacterial spores or protozoan oocysts, and very poor activity against some non-enveloped (non-lipophilic) viruses [44]. Alcohols are also not good cleansing agents, and their use is not recommended when visible dirt is present on the surface [43].

Each procedure was tested on 10 randomly collected mobile phones (N=30). Samples for which initial colonisation (before intervention) was below 10 CFU/ swab were not included in the calculation to avoid the risk of mislead information, considering the high differences when calculating percentages on small absolute numbers. The average elimination rate was 85.4 %, 89.7 %, and 98.6 % for paper towels, ethanol and antibacterial putty respectively. Although (or because of) the highest (219.3 CFU/swab) mobile phone average colonisation was cleaned with antibacterial putty, this procedure was most effective. The results also show that significant amount of microorganism can be removed with "dry cleaning" where only paper towel and physical force are applied. The lower efficiency of ethanol in comparison to antibacterial putty could be the consequence of several factors, such as the cleaning procedure itself, antibacterial putty physical properties, mobile surface properties and contact time.

Alcohols are also not good cleansing agents, and their use is not recommended when visible dirt is present on the surface.

During the microbiological examination, we found that mobile phones of female users are significantly more colonised.

CONCLUSIONS

Preliminary testing with ATP bioluminescence gave evidence that a significant amount of organic material is present on mobile phone surfaces. It is important to be aware that ATP bioluminescence is a fast and sensitive screening technique for hygiene control, especially for control of cleaning efficiency, although this method cannot replace standard microbiological examination, which is also able to identify the bacterial species present on surfaces. While the observed situation indicates poor hygiene awareness of mobile phone users regarding cleaning of their electronic accessories, more specific microbiological investigation was further employed. During the microbiological examination, we found that beside aerobic mesophilic micororgnisms, the most common group of microorganisms are representatives of the genus *Staphylococcus* (also part of resident human skin flora), and that mobile phones of female users are significantly more colonised. Parallel swabbing of users hands and/or ears should be taken to obtain insight regarding what is the most common

It should be noted that in addition to proper cleaning of mobile phones, prohibiting or restricting their use at the workplace in hygiene-sensitive work processes is generally more logical and, from the hygienic point of view, more effective measure.

source of this microorganism on mobile phone surfaces. Testing the success of different methods for the elimination of microorganisms from mobile phone surfaces gave surprising but not conclusive results in favour of antimicrobial putty. However, further investigation with more samples should be performed to confirm these results. The efficiency of alcohol in comparison to other antimicrobial agents should also be tested on different types of surfaces. Today's mobile phones are important devices for professional and social lives of their users. Every mobile phone is in principle and mostly controlled by hand; therefore, personal hygiene and hand hygiene are important measures in preventing the transmission of microorganisms from our hands to the different surfaces and vice versa. It should be noted that in addition to proper cleaning of mobile phones, prohibiting or restricting their use at the workplace in hygiene-sensitive work processes is generally more logical and, from the hygienic point of view, more effective measure. People, whose behaviour in their working environment and private life is not always in accordance with good hygiene practice, often present a hidden microbiological risk factor. While the usage of mobile phones has greatly increased in recent years, there is an emerging need to supplement the principles and guidelines of good hygiene practice with rules for the proper handling of mobile phones in hygiene-sensitive work processes.

REFERENCES

[1] Raspor P, Jevšnik M. Good nutritional practice from producer to consumer. Crit Rev Food Sci. 2008; 48: 276-292.

[2] Raspor P. Total food chain safety: how good practices can contribute? Trends Food Sci Tech. 2008; 19: 405-412.

[3] Vickery K, Pajkos A, Cossart Y. Removal of biofilm from endoscopes: Evaluation of detergent efficiency. Am J Infect Control. 2004; 32(3): 170-176.

[4] Vesterlund S, Paltta J, Karp M, Ouwehand A.C. Measurement of bacterial adhesion—in vitro evaluation of different methods. J Microbiol Meth. 2005; 60: 225-233.

[5] ITU. ITU sees 5 billion mobile subscriptions globally in 2010. Strong global mobile cellular growth predicted across all regions and all major markets: http://www.itu.int/newsroom/press_releases/2010/06.html (18. 8. 2011).

[6] Statistični urad republike Slovenije – SURS. Nekateri kazalniki razvoja elektronskih komunikacijskih storitev, Slovenija, 2010 – končni podatki: http://www.stat.si/novica_prikazi.aspx?id=4236 (11. 2. 2012).

[7] Pušnik M. Telefonska razmerja: O razvoju telefona in premenah družbenih interakcij. V: Mobilni telefon in transformacija vsakdana. Ljubljana: Fakulteta za družbene vede. 2009; 40: 48.

[8] Akinyemi KO, Atapu AD, Adetona OO, Coker AO. The potential role of mobile phones in the spread of bacterial infection. J Infect Dev Ctries. 2009; 3(8): 628-632.

[9] Lassen A. Affective technologies – emotions and mobile phones: http://ucm.academia.edu/AmparoLas %C3 %A9n/Papers/461823/Affective_Technologies._Emotions_and_Mobile_Phones (15. 1. 2012).

[10] Brady RR, Hunt AC, Visvanathan A, Rodrigues MA, Graham C, Rae C, Kalima P, Paterson HM, Gibb AP. Mobile phone technology and hospitalized patients: a cross-sectional surveillance study of bacterial colonization, and patient opinions and behaviours. Clin Microbiol Infect. 2011; 17: 830-5.

© Inštitut za sanitarno inženirstvo, 2012.

[11] Cuttler RR, Bowman L, Mkrtchyan H, Russell C.A., Curtis V. Survey of hand and mobile phone contamination across the UK: http://www.lshtm.ac.uk/newsevents/news/2011/global_handwashing_day_2011.html (28. 3. 2012).

[12] Khivsara A, Sushma TV, Dahashree B. Typing of Staphylococcus aureus from mobile phones and clinical samples. Curr Sci. 2006; 90: 910-912.

[13] Grbalová S, Večerek V, Tremlová B, Chloupek P, Pišteková V. Comparison of hygiene and sanitation levels by bioluminiscence method at different units produvcing components for instatnt soups. Czech J Food Sci. 2003; 21(4): 129-136.

[14] Directions for use of Ultrasnap ATP swab with Hygiena ATP hygiene monitoring system, Hygiena, Watford, UK, INS0039, Rev A.

[15] EN ISO 4833. Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of micro organisms – Colony-count technique at 30 °C. International Organization for Standardization, Genova, Switzerland. 2003; 1-9.

[16] ISO 7899-2. Water Quality. Detection and enumeration of intestinal enterococci. Part 2. membrane filtration method. Genova, Switzerland. 2000: 1-7.

[17] Merck Microbiological Manual, 12 th Edition, Merck KGaA, Darmstadt, Germany. 2006; 91: 125.

[18] SIST EN ISO 6888-2. Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species) Part 2: Technique using rabbit plasma fibrinogen agar medium. International Organization for Standardization, Genova, Switzerland. 1999: 1-7.

[19] ISO 6611 (E)/IDF 94. Milk and milk products-Enumeration of colony-forming units of yeasts and/or moulds – Colony-count technique at 25 °C, International Organization for Standardization, Genova, Switzerland. 2004: 1-6.

[20] ISO 7932. Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of presumptive *Bacillus cereus* – Colony-count technique at 30 °C, pp 7, International Standard Organization Genova, Switzerland. 2004: 1-6.

[21] Marriot NG, Gravani BR. Principles of food sanitation. Fifth edition, Springer Science Business Media. ZDA. 2006: 1–15, 25–69, 83–98.

[22] Exploding the myths about ATP hygiene monitoring. http://www.hygiena.net/docs/atp_myths.pdf/ (14. 1. 2011).

[23] Chawla K, Mukhopadhayay C, Gurung B, Bhate P, Bairy I. Bacterial "Cell" Phones: Do cell phones carry potential pathogens? OJHAS. 2009; 1(8): 1-5.

[24] Trivedi HR, Desai KJ, Trivedi LP, Malek SS, Javdekar TB. Role of Mobile Phone in Spreading Hospital Acquired Infection: A Study in Different Group of Health Care Workers. NJIRM. 2011; 2(3): 61-66.

[25] Srikanth P, Rajaram E, Sudharsanam S, Lakshman A, Sangappan Mariappan US, Jagannathan K. Mobile phones: emerging treat for infection control. JIP. 11 (3): 87-90.

[26] Adams BG, Marrie TJ. Hand carriage of aerobic gram-negative rods may not be transient. J Hyg (London). 1982; 89: 33-46.

[27] Pittet D, Dharan S, Touveneau S, Sauvan V, Perneger TV. Bacterial contamination of the hands of hospital staff during routine patient care. Arch Intern Med. 1999; 159: 821-826.

[28] Jereb G. Likar K. Umazane roke – grožnja našemu zdravju. V: Zbornik radova Međunarodni stručno – znanstveni simpozij Sanitarno inženjerstvo – Sanitary engineering, Opatija, 9. do 11. 3. 2006. Rijeka: Hrvatska udruga za sanitarno inženjerstvo. HUSI, 2006.

[29] Buchtmann L. Hand washing understanding and behaviour by Australian consumers http://www.foodsafety.asn.au/publications/articlesandsurveys/handwashingsurvey.cfm (16. 5. 2012).

[30] Another US airport travel hazard – dirty hands http://www.eurekalert.org/pub_releases/2003-09/asfm-aua091103.php (16. 5. 2012).

[31] Lark RL, VanderHyde K, Deeb GM, Dietrich S, Massey JP, Chenoweth C. An outbreak of coagulase-negative staphylococcal surgical – site infections following aortic valve replacement. Infect Cont Hosp Ep. 2001; 22: 618-623.

[32] Brenner DJ, Krieg NR, Staley JT, Garrity GM, Boone DR, De Vos P, Goodfellow M, Rainey FA, Schleifer KH. Bergey's Manual® of Systematic Bacteriology, Volume Two The Proteobacteria, Part B The Gammaproteobacteria Online: http://www.springerlink.com/content/978-0-387-24144-9#section=682029&page=170&locus=30 (28. 3. 2012).

[33] Ulger F, Esen S, Dilek A, Yanik K, Gunaydin M, Lebleicioglu H. Are we aware how contaminated our mobile phones with nosocomial pathogens? ACMA. 2009; 8: 7-10.

[34] Kluytmans J, van Belkum A, Verbrugh H. "Nasal carriage of Staphylococcus aureus: epidemiology, underlying mechanisms, and associated risks". Clin Microbiol Rev. 1997; 10 (3): 505-520.

[35] Marolt-Gomišček M, Radšel-Medvešček A. Infekcijske bolezni. Ljubljana: Tangram. 2002; 136: 267.

[36] Queck SY, Otto M. "Staphylococcus epidermidis and other Coagulase-Negative Staphylococci". V: Staphylococcus: Molecular Genetics. Caister Academic Press. Norfolk, UK: Caister Academic Press. 2008; 227-230.

[37] Lundov MD, Moesby L, Zachariae C, Johansen JD. Contamination versus preservation of cosmetics: a review on legislation, usage, infections, and contact allergy. Contact Dermatitis. 2009; 60: 70-78.

[38] Wendt C, Wiesenthal B, Dietz E, Rüden H. Survival of Vancomycin-Resistant and Vancomycin-Susceptible. J Clin Microbiol. 1998; 36(12): 3734-3736.

[39] Nokia 9300 (2005). Users Guide: http://nds1.nokia.com/phones/files/guides/Nokia_9300_UG_sl.pdf (25. 8. 2011).

[40] Samsung Galaxy. Users Guide: http://admin.gsmaparati.com/upload/documents/7456241734325886.pdf (25. 8. 2011).

[41] Yusha"u M, Bello M, Sule H. Isolation of bacteria and fungi from personal and public mobile cellphones: A case study of Bayero University, Kano. IJBHS. 2010; 6 (1): 97-102.

[42] The Co-operative Group. Mobile phone hygiene risk to millions of people in the UK: http://www.co-operative.coop/corporate/Press/Press-releases/Pharmacy/Mobile-phone-hygiene-risk-to-millions-of-people-in-the-UK/ (15. 8. 2011).

[43] Larson EL, Morton HE. Alcohols. In: Block SS, ed. Disinfection, sterilization and preservation, 4th ed. Philadelphia, Lea & Febiger. 1991; 191-203.

[44] Kampf G., Jarosch R., Rüden H. Limited effectiveness of chlorhexidine-based hand disinfectants against methicillin-resistant Staphylococcus aureus (MRSA). J Hosp Infect. 1998; 38: 297-303.

© Inštitut za sanitarno inženirstvo, 2012.