COLIFORM BACTERIA CONTAMINATION MEASUREMENT OF CELL PHONES AND USERS' HANDS

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Abstract

Several environmental problem and diseases should be faced by mankind nowadays. Some of them are consequences of our high-speed social life. Recently handwashing has got highlight and several diseases could be avoided by it. This study aims to examine the presence of *coliform* bacteria on the surface of cell phones and the users' hands, as these devices are essential part of human life now. Association was supposed between the contamination level of the telephone parts and owners' hands. More than 90% of the samples from the right and left hands were

infected by *coliform* bacteria and 76.1% of the samples from the screen and back mobile phone were infected by *coliform* bacteria.

The percentage of negative cultures from mobile phone was 20.5% (average percent). The negative samples of the right and left hands were only 12% (average percent). It should be emphasized that the present study is only a case study to highlight the problem and to draw attention to the necessity and accuracy of handwashing, but it is not a representative survey.

Keywords: mobile phone; hands; bacteria contamination

Összefoglalás

Napjainkban számos környezeti problémával és betegséggel kell szembenéznünk. Némelyik igen nagy jelentőséggel bír életünkre. A kézmosásra és higiéniára, szerencsénkre egyre nagyobb hangsúly kerül hazánkban is. Jelen kutatásunkban, célul tűztük ki a *koliform* baktérium kimutatását mobiltelefonokon és használóik kezén egyaránt. A jobb és bal kézből származó minták több, mint 90%-a *koliform* baktérium által fertőzött volt, és kevesebb, mint 10%-a volt csak negatív a mintáknak. A mobiltelefonok 76,1%-a volt pozitív - amelyek esetében *koliform* baktériumot mutattunk ki. Szeretnénk hangsúlyozni, hogy kutatásunk a probléma feltárására, valamint a kézmosás szükségességére és annak pontosságára kívánja felhívni a figyelmet, de nem reprezentatív elemzés.

Kulcsszavak: mobiltelefon, kéz, baktérium szennyeződés

Introduction

Mobile phones (smart phone) have become one of the essential devices used for communication in daily life and are being used almost everywhere (Al-Abdalall and Amira, 2010). Brady et al. (2006) have been reported that mobile phones can harbor more microorganisms than a man's lavatory seat, the sole of a shoe or the door handle. Microorganisms can be transferred from a person to another or from inanimate objects to hand, and vice versa (Brady et al., 2007). Cell phones can be contaminated through various sources, such as human skin or hand, bags, pockets food particles. Mobile phone can spread infectious diseases by frequent contact with hands (Kilic et al., 2009;Tagoe et al, 2011). These sources are links, through which microorganisms can colonize the phone, thus causing diseases that could range from mild to chronic. According to studies, the most common type of microorganism that occupies the hand phones are the coagulase negative *Staphylococcus*, followed by *Staphylococcus aureus*, *Escerichia coli* and *Enterococcus fecalis*, followed by other microorganisms like *Klebsiella pneumonia*, *Bacillus* spp. and *P. aeruginosa* (Sichani and Karbasizadeh, 2011; Al-Abdalall and Amira, 2010). Another study to determine the transfer efficiency of microorganisms by formites suggests that the Gram-positive bacteria are transmitted most readily followed by virus and Gram-negative bacteria (Rusin et al., 2002).

Coliform bacteria are defined as facultatively anaerobic, Gram-negative, non-spore-forming rods that ferment lactose vigorously to acid and gas at 35 ± 2 °C within 24 or 48 h. Coliform bacteria generally belong to four genera of the *Enterobacteriaceae*: *Citrobacter freundii, Enterobacter cloacae, Enterobacter aerogenes, E. coli*, and *Klebsiella pneumoniae* (Eckner, 1998). Coliform bacteria have been used for many years to determine the quality and safety of water for human consumption. Escherichia coli and other groups of coliforms may be present

where there has been faecal contamination originating from warm- blooded animals (Choa et al, 2003)

There are different types of *E. coli* bacteria, from which some strains are way more pathogenic than other ones and it has the potential to cause serious food poisoning and even death. Infections spread through the fecal-oral route, for example by touching contaminated hands with the mouth after using the bathroom or touching fecal matter. In such situations, hand washing is the simplest and also the most effective measure to prevent the spread of agents responsible for communicable diseases (Brandl et al., 2006). Researchers at the London School of Hygiene & Tropical Medicine found fecal matter on one out of every six smartphones in a 2011 study (Hafner, 2017).

Ustun and Cihangiroglu (2012) reported that 97.8% of culture-positive specimens isolated from mobile phones from which 9.5% of phones had MRSA, (Methicillin-rezisztens Staphylococcus aureus) 11.2% had ESBL-producing *Escherichia coli*, which can cause nosocomial infections. According to Cuttler et al. (2018), in the general population, one of six mobile phones in Britain is contaminated with fecal matter. The study reported, that 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 (Cuttler et al., 2018). Another study found that the microbial contamination frequency of mobile phones of college students was 98%: Gram-positive bacilli (30%), Gram-negative bacilli (8%), *Staphylococcus* spp. (14%), *Escheria coli* (16%), *Enterococcus* (18%), coliforms (8%), *Micrococcus* spp. (1%) (Jagadeesan et al., 2013). Study of Reynolds et al. (2005) reported that more than 90% of health care workers' cell phones were contaminated with microorganisms and more than 14% of them carried pathogenic bacteria that commonly cause nosocomial infection. A study examining the phones of 20 hospital staff members found that 94.5% of the phones were contaminated with

some kind of bacteria and many of which were resistant to multiple antibiotics (Ulger et al., 2009). 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* (Singh et al.,2010).

Recently handwashing has got highlight and several diseases could be avoided by it. This study aims to examine the presence of *Escherichia coli* bacteria on the surface of cell phones and the users' hands, as these devices are essential part of human life now. It should be emphasized that the present study is only a case study to highlight the problem and to draw attention to the necessity and accuracy of handwashing, but it is not a representative survey.

Materials and methods

In this case study, 201 mobile phones and 201 pair of hands were examined with standard microbiology methods. Sampling was carried out at Budapest Business School. Samples were taken from the students of the School, aged between 19 and 25. Therefore the results of this study are not representative, only a case study.

The laboratory study was conducted at Budapest Business School, between October 2017 and June 2018 by the Department of Catering.

Microbiological methods

Samples were obtained from cell phones of all participants using sterile cotton swabs. Prior to sample collection swab were moistened in sterile water and were rotated over the front screen and back of the cell phones, and after repeated their right and left hand also. Swab are then

inoculated onto Lactose broth tubes (formula in g/l: pepton 5 g; meat extract 3 g; lactose 5 g; final pH 6.9±0.2 /25 °C/) containing Durham tubes and incubated 48 hours at 37°C. 4 different tubes were used by every student. The color of the samples in the tubes containing *coliform* bacteria after the incubation period changed to yellow, with presence of gas. The negative samples – not containing *Escherichia coli* nor c*oliform* bacteria – kept their green color (Fig.1.). If bacteria utilize carbohydrates as energy source from the nutrient solution, there may be two end products, a gas and acid. The substrate formed from the metabolism of carbohydrate is either glucose or lactose. Even if bacteria releases enzymes that enable to use carbohydrates through fermentation and oxidation, gas may or may not be produced. Fermentation is noted by acid production which can be observed by a color change in Durham tubes aka carbohydrate fermentation tube.

Figure 1. Positive (yellow with gas) and negative samples (green without gas) of Coliform bacteria (source: own picture)

Statistical methods

Data of 201 telephone owners was examined as a pilot experiment. Telephone owners are the graduate students of the Budapest Business School, therefore this research is not representative. The results must be considered as results of a case study. Association was supposed between the contamination level of the telephone parts and owners' hands. Cross tables were generated and the χ^2 independency test was applied to detect the relationship between the variables: telephone screen, telephone back, right hand and left hand, respectively. In case of each variable two levels of contamination was examined as variations: negative and coliform contamination, respectively. The χ^2 independency test is a non-parametric hypothesis test to decide whether two variables are independent (null-hypothesis H_0) or not (alternative hypothesis H_a). If the empirical significance level (p-value) of the test is lower than the chosen significance level (α) H_a should be accepted, and the variables are not independent, there is significant association between the variables. The chosen significance level was 5%. Cramer's V is an indicator of the tightness of the relationship, and its value should be higher than 0 and less than 1 (0 means independency, 1 means complete functional dependency). Computations were made by SPSS v.24 of IBM. Dataset was divided in two parts according to the owners' gender, as it was supposed that there should be some differences in case of then association of the contamination level of the telephone parts and owners' hands. χ^2 independency test was applied from the separated dataset. The ratios of the genders in the sample are 38.8% of male and 61.2% of female.

Results

201 samples were obtained from both the right and left hands. 92.5% of the right samples and 90% of the other hands were infected by *coliform* bacteria and only 7.5% and 10% of the samples were negative (*Fig. 2.*).

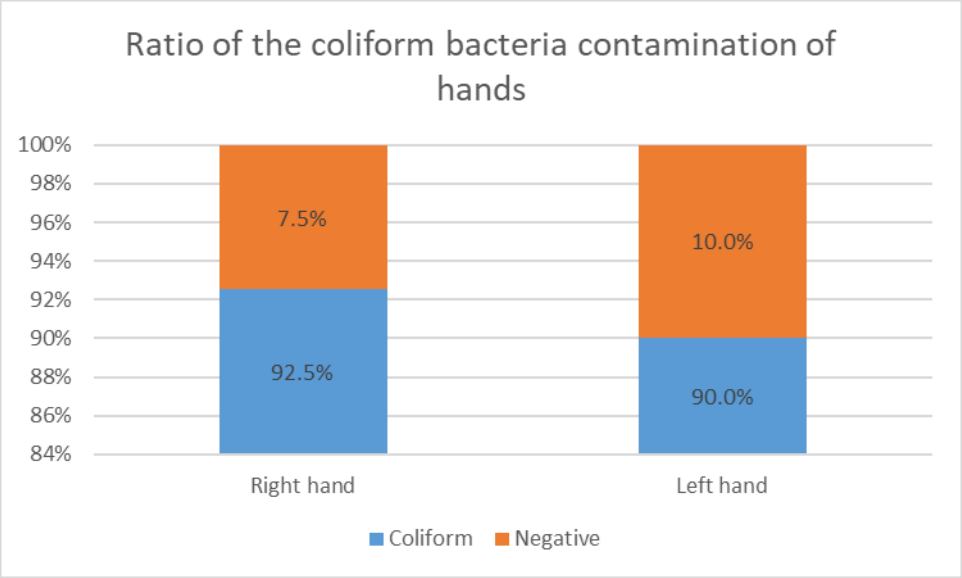

Figure 2. Ratio of the coliform bacteria contamination of hands

201 samples were obtained from both the screen and back of mobile phones.78.1% of the screen and 81.1% of back were infected with *coliform* bacteria and 21.9% of the screen and 18.9% of back samples were negative (*Fig. 3.).*

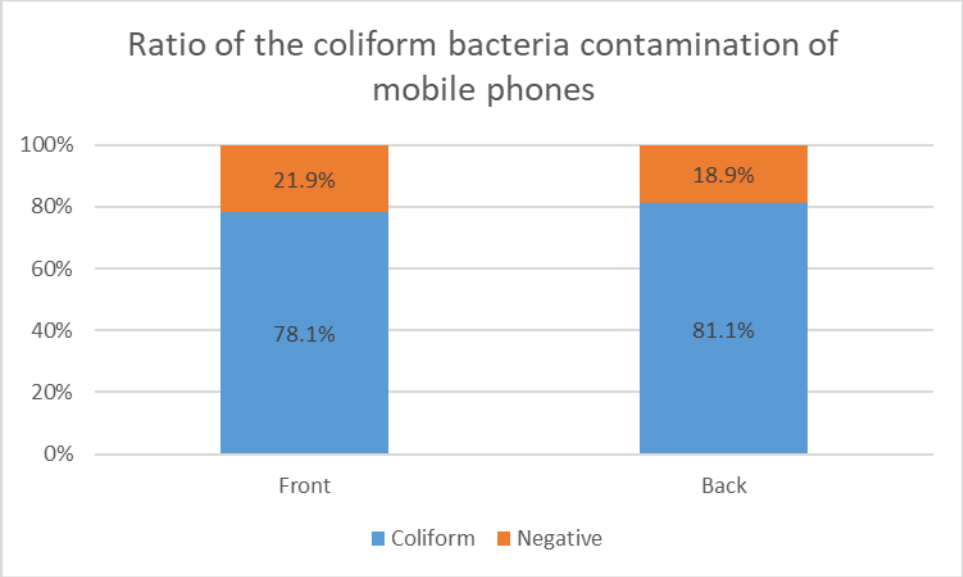

Figure 3. Ratio of the coliform bacteria contamination of mobile phones

We assessed the results of the samples from the mobile phones and hands by gender as well. Female's right and left hand samples included more negative samples (right hand 7.5% - left hand 5.5% negative), than samples from male (right hand 2.5% - left hand 2% negative), however samples of female's left hands had slightly higher *coliform* bacteria contamination level, and right hands had more *coliform* bacteria than the samples from male (female: 55.7%, male: 36.8%).(*Table 1.)*

Table 1. Ratio of the hand contamination by genders (*source: own data)*

	Right hand		**Left hand**	
	negative (%)	**Coliform (%)**	**negative (%)**	**Coliform (%)**
male	2.5%	36.8%	2.0%	36.3%
female	7.5%	55.7%	5.5%	53.7%

The female's mobile phones were cleaner than male's, but interestingly, female's samples had more coliform bacteria (screen: 45.8%; back: 48.3%) (*Table 2*.).

Table 2. Mobile phone contamination by genders

	Screen of mobile phone		**Back of mobile phone**	
	negative (%)	**coliform (%)**	**negative (%)**	**coliform (%)**
male	6.5%	32.3%	6.0%	32.8%
female	15.4%	45.8%	12.9%	48.3%

No association can be demonstrated between the gender and the contamination level of the front of the cellphone, the back of the cell phone, neither of the left and right hand, respectively (*Table 3.)* Gender and the level of contamination are significantly independent, no significant relationship can be found at 5% significance level.

Table 3. P-values of the χ^2 independency test

	Front of the mobile phone	**Back of the mobile phone**	**Right hand**	**Left hand**
Gender	0.154	0.310	0.316	0.182

Table 4. and *5.* summarizes all the p-values of the χ^2 independency tests performed separated by genders. In *Table 6.* and. *7.* the Cramer's V value are given separately for male and female, and where significant association can be demonstrated the values are typed in bold. Cramer's V indicate association in most cases, but differences can be seen between the genders.

The separated dataset of the male owners was analyzed and according to the matrix of p-values in *Table 4.* significant relationship can be shown in almost all cases, except two ones. There is

no significant association according to the hypothesis test between the contamination of the screen of the telephone and the contamination of male owners' left hand, and between the two hands. Significant values of Cramer's V in *Table 6.* rages between 0.32 and 0.47. These values suggest weak and medium level of association between infection of the examined surfaces in case of the male owners.

It can be concluded that in the separated dataset of the female owners, significant association can be found between the telephone parts (screen and back side, respectively) and the level of contamination of the owners' hands (right and left hand, respectively). The matrix of the p-values in *Table 5.* shows that significant relationship can be found between all examined variables. Cramer's V in *Table 7.* explains that there is significant relationship between the contamination of the front and back of the phones and of the hands. The range of the value is 0.18-0.29. These values suggest weak association between infection of the examined surfaces in case of the female owners.

Table 4. P-values of the χ^2 independency test in case of males (significant values are in bold)

	Front of the mobile phone	**Back of the mobile phone**	**Right hand**	**Left hand**
Front of the mobile phone	-			
Back of the mobile phone	**0.000**	-		
Right hand	**0.001**	**0.001**	-	
Left hand	0.148	**0.004**	0.119	-

Table 5. P-values of the χ^2 independency test in case of females (significant values are in bold)

	Front of the mobile phone	**Back of the mobile phone**	**Right hand**	**Left hand**
Front of the mobile phone	-			
Back of the mobile phone	**0.024**	-		
Right hand	**0.019**	**0.041**	-	
Left hand	**0.005**	**0.001**	**0.010**	-

Table 6. The values of Cramer's V in case of males (significant values of relationship are in bold)

	Front of the mobile phone	**Back of the mobile phone**	**Right hand**	**Left hand**
Front of the mobile phone	-			
Back of the mobile phone	**0.477**	-		
Right hand	**0.364**	**0.384**	-	
Left hand	0.164	**0.324**	0.177	-

Table 7. The values of Cramer's V in case of females (significant values of relationship are in bold)

	Front of the mobile phone	**Back of the mobile phone**	**Right hand**	**Left hand**

Front of the mobile phone	-			
Back of the mobile phone	**0.204**	-		
Right hand	**0.212**	**0.184**	-	
Left hand	**0.256**	**0.294**	**0.232**	-

There is stronger association between the contamination of the right hand and the front and the back side of the telephone and the contamination of the two sides of the cell phone in case of male owners compared to the female owners. The association between the infection of the left hand and of the cell phone's front side is significant only in case of the females. This can be concluded also for the pollution of the two hands. Another study found that 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 mobile from female users were highly colonized with bacteria compared with those mobiles from male students (Nwanko et al., 2014).

Discussion

The results show that mobile phone and users' hands were relatively higher contaminated with *coliform* bacteria.

The coliform group, as defined above, includes species of the genera *Citrobacter, Enterobacter, Escherichia, Hafnia, Klebsiella, Serratia* and *Yersinia*. They are a commonly used indicator of sanitary quality of foods and water. *Coliforms* can be found in the aquatic environment, in soil

and on vegetation; they are universally present in large numbers in the feces of warm-blooded animals. While coliforms themselves are not normally causes of serious illness, they are easy to culture, and their presence is used to indicate that other pathogenic organisms of fecal origin may be present.

The overall percentage of positive cultures (*coliform bacteria*) from mobile phone was 79.5% (average percent), compared with 20.5% (average percent) for negative cultures.

The overall percentage of positive cultures (*coliform bacteria*) from right and left hands was more than 90% (average percent), compared with 8.5% (average percent) for negative cultures. This is somewhat higher than the figures reached by studies conducted in Nigeria (14.3%) (Andrej et al., 2012), India (16) %) (Tankhiwale et al., 2012), but lower than the findings of another study from Iraq with 25% (Husam, 2013) and Morocoo with 33.3% of positive samples (Abdellatif et al., 2017).

Our opinion is that keeping hands clean is one of the most important steps we can take to avoid infections and spreading germs. Many diseases and conditions are spread due to improper washing of hands with or without soap and clean, running water. A single gram of human feces — which is about the weight of a paper clip — can contain one trillion germs (Franks et al.,1998). Germs can also get onto hands by people touching any object that has germs on it as a result of being coughed or sneezed on it, or being touched by other contaminated object.

Maxine and colleagues (2011) found that bacteria of potential fecal origin (mostly *Enterococcus* and *Enterobacter spp*.) were found in 44% of samples took without handwashing. Handwashing with water alone reduced the presence of bacteria to 23% (p-value < 0.001). Handwashing with plain soap and water reduced the presence of bacteria to 8 % (Burton et al.,2011).

Hoque and Briend (1995) found that a wide variety of hand cleaning means in poor settings (soap, ash, mud) are effective in reducing the contamination with coliform bacteria on hands. The same author reported that soap may be more effective than water in reducing the presence of coliform bacteria on hands.

Conclusions

Based on our opinion that the education of handwashing and phone disinfection is indispensable, and we believe that this education should be started at childhood. Smart phones are being extremely broadly, but their purity is rarely taken into consideration. We have to accept smart tools will dominate our future; therefore, lot of new surface will present further risk of catching variety of bacteria, and only one of these will be the smart phones (Soto et al., 2006). It will be important to pay attention to the cleaning and disinfection of these tools, surfaces. In parallel the good personal hygiene and handwashing will remain critical, because mobile phones are primarily being infected from hands. These bacteria can cause reinfection from the mobile tools.

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