CONTAMINATION RATES BETWEEN SMART CELL PHONES AND NON-SMART CELL PHONES OF HEALTHCARE WORKERS

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BACKGROUND: Healthcare workers’ mobile phones are easily contaminated with pathogenic bacteria and could be vehicles of transmission. Smart phones are increasingly used in the hospital. The objective of this study was to compare the contamination rate of bacteria with pathogenic potential between smart phones and non-smart phones.

METHODS: We screened mobile phones of healthcare workers in three teaching hospitals in South Korea. The identification of cultivated micro-organisms and assessment of antibiotic susceptibility were performed.

RESULTS: One hundred fifteen (56.7%) participants used smart phones, and 88 (43.3%) used non-smart phones. Bacteria with pathogenic potential were isolated from 58 (28.6%) mobile phones, more often from smart phones than from non-smart phones (34.8% vs 20.5%, P=0.03). Multivariate analysis including various characteristics to determine risk factors revealed that only smart phones (vs non-smart phones) were a significant risk factor for contamination by bacteria with pathogenic potential (adjusted odds ratio [OR], 4.12; 95% confidence interval [CI], 1.07-16.31). Also, in a multivariate model including phone size, the smart phone was still a significant risk factor for the pathogen contamination (OR, 4.17; 95% CI, 1.07-16.33; P=0.04).

CONCLUSION: The smart phones of healthcare workers were contaminated with bacteria with pathogenic potential to a greater extent than were non-smart phones. Journal of Hospital Medicine 2013;8:144–147. © 2013 Society of Hospital Medicine

Mobile phones are now widely used. Healthcare workers, in particular, use them for rapid communication in many hospital settings. As mobile phones increase in popularity, a number of concerns have been raised, including noise and distraction in the clinical environment, confidentiality of patient information, and data security among others.1,2

Of the various concerns regarding mobile phone use in hospitals, one of the most important is that mobile phones may serve as vehicles for nosocomial transmission of micro-organisms.2,3 One report showed that over 90% of healthcare workers’ cell phones were contaminated with micro-organisms, and 14.3% of cell phones were contaminated with bacteria that can cause nosocomial infection.2

Smart phones, which are rapidly flooding the mobile phone market, are useful in the hospital setting, as they could provide rapid access to medical information, quicker consultation and responding, feedback of results to the patient, and ongoing monitoring of chronic diseases (eg, asthma and diabetes).4–8

However, as most smart phones have wide, full, touch screens and are used more often by their owners than non-smart phones are, bacterial contamination rates may be higher than those of non-smart phones. The aim of this study was to compare the contamination rates by bacteria with pathogenic potential in smart phones versus non-smart phones.

MATERIALS AND METHODS
Study Design and Participants
This cross-sectional study was conducted from March 1, 2011 to June 30, 2011, in 3 teaching hospitals affiliated with Seoul National University School of Medicine, namely Seoul National University Hospital, Bundang Seoul National University Hospital, and Seoul National University Boramae Medical Center. Hospital staff working in general wards as well as in intensive care units of the 3 hospitals were invited to participate in this study. The study protocol was approved by the institutional review board of each of the 3 participating hospitals. Informed consent was obtained from all participants.

Questionnaire
We designed a questionnaire inquiring about demographics (age, gender, occupation) as well as behavior...
Regarding cell phone use (type of cell phone, frequency and reasons for use, cleaning of cell phones).

**Bacterial Culture, Identification, and Drug Susceptibility Testing**

Both the anterior and posterior surfaces of each participant’s mobile phone were touched onto blood agar plates. The sampled culture plates were subsequently incubated aerobically at 36°C for 48 hours. To identify cultivated micro-organisms and for the assessment of antibiotic susceptibility, VITEK2 (bioMérieux, Inc., Durham, NC) systems were used.

**Classification of Isolated Micro-organisms**

We classified the micro-organisms isolated from healthcare workers’ mobile phones as bacteria with pathogenic potential (probable pathogens) or non-pathogens. Among probable pathogenic micro-organisms, representative drug-resistant strains such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), and imipenem-resistant *Acinetobacter baumannii* (IRAB) were categorized as drug-resistant pathogens.

**Classification of Smart Phones Versus Non-Smart Phones**

Mobile phones that ran complete mobile operating systems and software that provided a standardized interface and a platform for application developers, were classified as smart phones. All others were classified as non-smart phones.

**Statistical Analysis**

The participants’ clinical variables were analyzed using descriptive statistics. The results are expressed as mean±standard deviation or median value with range. Variables were compared between the smart phone and non-smart phone users. Categorical variables were compared by χ² analysis, and continuous variables were compared using Student t test or the Mann-Whitney test. Variables with P<0.20 after univariate analysis or clinically significant variables were subjected to multiple logistic regression to determine the risk factors for contamination of cell phones with potentially pathogenic bacteria. For all analyses, P values <0.05 were considered significant. Homer-Lemeshow goodness of fit (GOF) test was performed to confirm the fitness of the final model. The Statistical Package for the Social Sciences version 17.0 (IBM SPSS, Armonk, NY) was used for all statistical analysis.

**RESULTS**

**Participants and Their Behaviors Regarding Cell Phone Use**

In total, 203 healthcare workers participated in this study; 80 (39.4%) were physicians, 106 (52.2%) were nurses, and 17 (8.4%) were assistants. The median age of the participants was 29 years, 43 (21.2%) were males, 115 (56.7%) participants used smart phones, and 88 (43.3%) were non-smart phone users (Table 1).

Smart phone users were slightly younger than non-smart phone users. The distribution of occupations did not differ between the two groups. The frequency of use, reasons for using cell phones, the proportion of participants who routinely cleaned their phone, and the frequency of hand washing were also similar (Table 1).

**Bacteria Isolated From Cell Phones**

Bacteria were isolated from all 203 mobile phones; 3 or more different types of bacteria were isolated from 155 (76.4%) phones, 2 types from 39 (19.2%) phones, and 1 type from 9 (4.4%) phones. The most commonly cultured micro-organism was coagulase-negative *Staphylococcus*, which was isolated from 194 (95.6%) cell phones. The isolation of Gram-positive bacilli and *Micrococcus* species was also frequent.

Probable pathogenic bacteria were isolated from 58 (28.6%) mobile phones. Among probable pathogens,
Staphylococcus aureus (S. aureus) was the most commonly isolated. Of the 50 mobile phones that were contaminated with S. aureus, 8 were contaminated with a methicillin-resistant strain. Five (2.4%) phones yielded Acinetobacter baumannii (Table 2).

Although all mobile phones were contaminated with bacteria, probable pathogens were isolated more often from smart phones (34.8% vs 20.5% of non-smart phones, $P=0.03$). The total colony count of probable pathogens from smart phones was also higher (average, 5.5 vs 5.0 from non-smart phones, $P=0.01$). The isolation rate of drug-resistant pathogens appeared to be higher from smart phones (7.0% vs 2.3% from non-smart phones), but this difference did not reach statistical significance ($P=0.19$).

### Risk Factors for Contamination With Probable Pathogens

In the final model constructed to determine the risk factors for contamination with probable pathogenic bacteria, data regarding cell phone users’ age, gender, occupation (ie, physician or not), duration of working in the same place, daily work hours, whether the phone was a smart phone, and frequency of cell phone use during working hours were included. Among these factors, only the phone’s being a smart phone was found to be a risk factor for contamination by bacteria with pathogenic potential (adjusted odds ratio (OR), 4.02; 95% CI, 1.43-11.31; $P=0.01$). The fitness of this model was confirmed with the Hosmer-Lemeshow GOF test ($P=0.94$). Using the cell phone more than 10 times during working hours appeared to be associated with pathogen contamination; however, this correlation failed to reach statistical significance (OR, 2.9; 95% CI, 0.9-9.3; $P=0.07$).

### DISCUSSION

Our study showed that smart phones were more frequently contaminated with bacteria than were non-smart phones. In addition, total colony count of probable pathogens from smart phones was also higher. The colony count as well as contamination rate of pathogens are clinically relevant, because both factors can attribute to increased transmission of pathogens.1

Previous studies have attempted to identify user risk factors associated with bacterial contamination of cell phones.12–14 Many variables, including gender, frequency of use, type of phone, work time, and the medical specialty of the user were considered; however, none of these factors was associated with an increased risk of bacterial contamination.2,14,15

In our study, none of the above-mentioned factors was associated with contamination of cell phones by potentially pathogenic bacteria. Smart phones were the sole predictor of contamination by such bacteria. The reason that smart phones were more frequently contaminated with bacteria with pathogenic potential than were non-smart phones is not clear. We propose two hypotheses to explain this observation. First, smart phones generally have wide screens, whereas non-smart phones have relatively small screens with keypads. Larger screens may afford more opportunity for contamination by micro-organisms. The mean size of a monitor in the smart phone group was 663.2 ± 340.1 cm² and 572.9 ± 564.7 cm² in the non-smart phone group ($P<0.01$). However, in a multivariate model including size with other variables above, the smart phone remained a significant risk factor for the pathogen contamination (odds ratio [OR], 4.17; 95% CI, 1.06-16.33; $P=0.04$). Cell phones are manufactured in a standardized form and the size cannot be changed or controlled. Therefore, we did not include the size in the final model of logistic regression in the main result. Our second explanation is in regard to the pattern of use of smart phones. Considering a single use, smart phones are used for longer periods and require a higher number of finger touches compared with non-smart phones. The intensive use of phones with large screens could facilitate contamination of smart phones by pathogens from the healthcare workers’ fingers or palms.

A recent study showed that cleaning cell phones on a daily basis decreased contamination rates. However, it did not decrease contamination by potentially pathogenic bacteria.12 The role of the hospital environment as a reservoir of nosocomial pathogens and the effect of sanitization on decreasing clinical infection are still controversial.16–19 Thus, further studies are needed to recommend routine cell phone sanitizing and to declare that it is relevant in terms of reduction of hospital-acquired infections potentially associated with the mobile phones of healthcare workers.

Our study is subject to limitation. Lack of association between hand washing and pathogen contamination might be a result of false reporting on hand washing behavior as well as the small number of participants. The bacterial contamination rate of the folding type of non-smart phones may have been underestimated, as their keypads could not contact agar plates because they would not open flatly (we

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### Table 2. Types of Bacteria with pathogenic potential isolated from cell phones of healthcare workers

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Total, N=203</th>
<th>No. of Drug Resistant Strains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probable pathogen</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram-positive bacteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>50 (24.6%)</td>
<td>8 (16%)</td>
</tr>
<tr>
<td>Streptococcus agalactiae</td>
<td>1 (0.5%)</td>
<td>0</td>
</tr>
<tr>
<td>Enterococcus faecium</td>
<td>1 (0.5%)</td>
<td>1 (100%)</td>
</tr>
<tr>
<td><strong>Gram-negative bacteria</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acinetobacter baumannii</td>
<td>5 (2.4%)</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>1 (0.5%)</td>
<td>0</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>2 (1.0%)</td>
<td>0</td>
</tr>
</tbody>
</table>

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touched the exterior surface of the folding type phones, which did not harbor the keypad, to the agar plate). However, given that folding phones are usually stored in their folded position, bacteria on the outside of the phones are likely more relevant than those within keypads insofar as transmission is concerned.

In summary, our data showed that over one-fourth of the mobile phones examined in this study were found to harbor potentially pathogenic microorganisms. In particular, smartphones of healthcare workers were more frequently contaminated with potentially pathogenic bacteria than were non-smart phones even after adjusting for the phone size. Preventive measures to minimize the possibility of bacterial transmission via cell phones should be devised.

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References