



Dissemination of Pathogens by Mobile Phones in a Single Hospital

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Abstract

Background: Superficial wound complications are among the most prevalent problems associated with any surgical procedures. Infection rates of the primary hip and knee joint arthroplasty have been reduced with modern aseptic techniques but this rate may reach 20% in some revision procedures. Mobile phones are frequently used in the hospital and operating room settings, regardless of their microbial load. This study aimed to: 1) determine the level of bacterial contamination of mobile phones from resident physicians at Saint Vincent Charity Medical Center (SVCMC) in Cleveland, Ohio; 2) determine the effectiveness of quaternary ammonium compound (QAC) wipes; and 3) heighten awareness of potential dissemination of pathogens by mobile phones in the hospital setting.

Materials & Methods: A total of fifty mobile phones were randomly sampled from podiatric surgical resident physicians and internal medicine resident physicians at SVCMC. For each mobile phone, a swab was collected from the touch screen prior to use of QAC wipes and following use of QAC wipes.

Results: The results demonstrated that 82% (41/50) of mobile phone touch screens possessed polymicrobial organisms and 30% (15/50) of mobile phones possessed pathogenic organisms. The vast majority of residents, 98% (49/50) used their phones within the hospital and 37% (18/49) used their phones inside patients' room. Most of the residents, 86% (43/50), did not clean their phones on a daily basis and of the residents who did, a majority of them, 71% (5/7) used either dry wipes or alcohol wipes.

Discussion: Sanitizing mobile phones with QAC dis-

posable wipes was shown to be an effective infection control intervention as mobile phone touch screens showed no growth after two minutes of sanitization. QAC could potentially decrease the transmission of microorganisms that cause diseases and reduce the risk of cross contamination infections from mobile phones.

Background

Today mobile phones have become one of the most essential accessories to both personal and professional life. Mobile phones are frequently handled throughout the day and are held close to the face and mouth. They are placed on various surfaces in a variety of rooms (i.e. bedroom, bathroom, floor, and kitchen) and are used during various activities (i.e. driving, showering, breastfeeding, bathroom use, and cooking) [1-6] (Figure 1). Mobile phones are a health hazard and have been identified as one of the carriers of bacterial pathogens [7]. Research has demonstrated that a square inch of a mobile phone contains ten thousand microbes, which is significantly more than the sole of a shoe or a door handle [8]. The consistent heat generated by phones creates a breeding ground for colonization of microorganisms. The regular use of mobile phones makes them a potential source for transmission of microorganisms that cause disease [9,10].

Keywords: Mobile Phones, Cell Phones, Hospital Infections, Prosthetic Joint Infection, Total Knee Arthroplasty
Level of Evidence: AAOS Therapeutic Level III
Educational Value & Significance: JISRF Level A

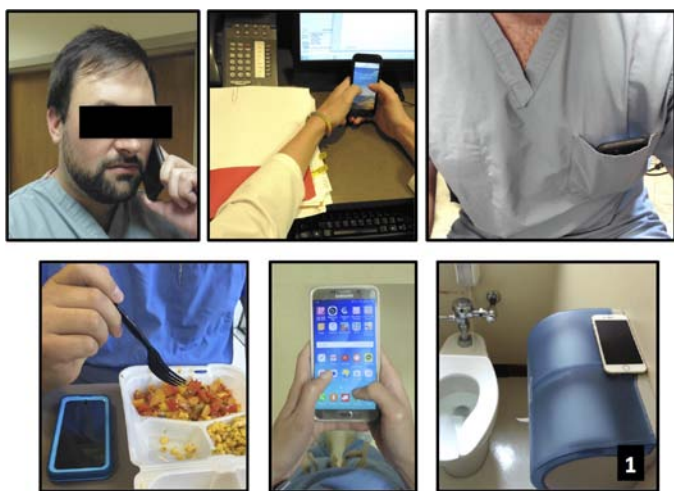


Figure 1: Various locations of mobile phone use in the hospital setting.

Hospital-acquired infections in United State (U.S.) hospitals cause 1.7 million infections per year and are associated with approximately 100,000 deaths each year. It is estimated that one third of these infections could be prevented by adhering to standard infection control guidelines [11]. The Center for Disease Control and Prevention (CDC) and World Health Organization (WHO) guidelines on hand hygiene in health care require decontamination of hands with preferentially alcohol-based hand rub or alternatively soap and water before and after direct patient contact, after removing gloves, and after contact with inanimate objects in the patients' immediate environment [12]. Rusin, et al. documented both gram-positive and gram-negative bacteria in hand-to-mouth transfer during casual activities. This implies that mobile phones may serve as vehicle of transmission for diseases such as diarrhea, pneumonia, boils, and abscesses [13]. Mobile phones are often used in hospitals by patients, visitors, and health care workers. Unlike hands, which are more readily sterilized with hand sanitizers, mobile phones are cumbersome to clean and users rarely make the effort to sanitize them.

Superficial wound complications are among of the most prevalent problems associated with any surgical procedure [14]. Such complications following total knee arthroplasty have been reported to occur in 10% of cases [15]. Literature has correlated superficial wound complications following total knee arthroplasty (TKA) to the eventual development of periprosthetic joint infection (PJI) [16-18]. Infection rates of primary hip and knee joint arthroplasty have been reduced to 0.3% to 2% with modern aseptic techniques, but this rate may reach 20% in some revision procedures [19,20]. Mobile phones are commonly used in the operating room by staff, vendors, residents, and physicians and have been found to possess a high rate of pathogenic bacterial contamination and organic material such as

food, human secretions, and excretions [21].

The first study of bacterial load on mobile phones was conducted in a teaching hospital in Turkey with a bed capacity of 200 and one intensive care unit. One-fifth of the mobile phones examined in a study conducted in New York were found to harbor pathogenic microorganisms. Health care workers' mobile phones provided a reservoir of bacteria known to cause nosocomial infection [22]. Cleaning of mobile phones throughout the day has been shown to decrease the bacterial load, but it requires effort from health-care workers [23]. Other studies have shown that health-care workers do not often comply with cleaning protocols [24-26].

The CDC guidelines for cleaning and disinfecting environmental surfaces in healthcare facilities suggests to disinfect noncritical medical devices such as bedpans, blood pressure cuffs, crutches, and computers with an Environmental Protection Agency (EPA)-registered hospital disinfectant [27]. High-touch environmental surfaces (HTES) (i.e. bed rails, bedside tables, call buttons, telephones, chairs, wall-mounted vital signs equipment, intravenous medication stands, door knobs and handles, bathroom hand rails, and toilet seats) require appropriate decontamination to reduce the risk of contamination of hands of healthcare personal [28]. Disinfectant pre-soaked wipe (DPW) utilize the microbicidal action of disinfectant coupled with physical removal by way of wiping the HTES [29].

Touchscreen phones have been found to harbor fewer microbes than equivalent keypad devices due to the irregular surfaces of keypad phones, but data are limited regarding effective disinfecting protocols [30]. Apple, Inc. forbids the use of wet cleaning wipes citing possible screen damage as the reason [31]. However, in order for mobile phones to be successfully used in a clinical setting, appropriate and effective cleaning must be demonstrated. Disinfectants with quaternary ammonium compounds are commonly used in hospitals for surface decontamination. Sani-Cloth® has not only shown that a single disinfection prevents further contamination, it has also shown it could be effective for up to 12 hours despite the opportunity for repeated contamination [32]. The active ingredient in Sani-Cloth® (Professional Disposables International Ltd, Flint, UK) wipes are quaternary ammonium compounds (QAC) [33,34] which chemically consist of nitrogen cations covalently bonded to alkyl groups some of which contain long carbon chains.

In this study, investigation was performed to determine 1) the microbiological flora (qualitative and quantitative) of Saint Vincent Charity Medical Center (SVC MC) residents' mobile phones, 2) the effectiveness of QAC disposable wipes on disinfecting mobile phones, and 3) increase

awareness and concern of mobile phones as potential vehicle of transmission of pathogenic microorganisms among hospital settings.

Materials and Methods

Samples Collection

The study was conducted at Saint Vincent Charity Medical Center in Cleveland, Ohio. SVCMC has 450 inpatient beds, 20 intensive care unit beds, and 24 emergency department beds. A total of fifty mobile phones were randomly selected from internal medicine and podiatric medicine and surgery residents during the hours of 8 o'clock a.m. to 4 o'clock p.m. After cleaning of hands with an alcohol based instant hand sanitizer, powder-free disposable nitrile gloves were worn. A moistened sterile cotton swab with normal sterile saline was used to swab the touch screen surface across an approximate 28cm² area (Figure 2) after which the swab was immediately placed into a sterile container and sealed with the cotton end soaked in 1 milliliter of sterile normal saline. The phone surface was then cleaned thoroughly with QAC wipes (Figure 3) and remained wet for two minutes and air-dried as recommended by the manufacturer's technique. After the surface was allowed to dry for five minutes, the phone was re-swabbed in the same fashion. The same technique was employed for each of the fifty samples.

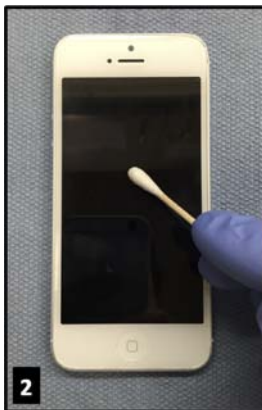


Figure 2: Moistened sterile cotton swab used to culture the touch screens of fifty mobile phones.

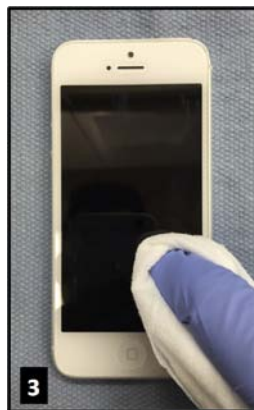


Figure 3: Surface of mobile phones cleaned post culture with QAC wipes.

Questionnaire

A questionnaire was distributed and completed by all participants pertaining to mobile phone use (Table 1).

Organisms Identification

Swabs collected from mobile phones were vortexed for

Table 1: Questionnaire for each participate at time of swab

Question	Results	
1. Do you use your mobile phone within the hospital?		
Yes	98%	49
No	2%	1
2. How many hours per day do you use your mobile phone?		
>12h	18%	9
8-12h	26%	13
4-8h	26%	13
1-4h	30%	15
3. Which locations do you use your phone?		
Hospital	98%	49
Patient’s Room	37%	18
Restroom	40%	20
Home	90%	45
4. How frequently do you clean your phone?		
1x/day	14%	7
Occasionally	38%	19
Rarely	36%	18
Never	10%	5
5. What cleaning agent do you use? (Check all that apply)		
Dry Wipe	42%	21
Alcohol	34%	17
Purple Sani-Cloth	10%	5
Orange Sani-Cloth	2%	1
Other (Clorox, Lens Cleaning Solution, Soap Water)	16%	8
6. How long ago did you last clean your phone?		19.74 days
7. Do you wash your hands		
a. Before using your phone		
Yes	10%	5
No	90%	45
b. After using your phone		
Yes	6%	3
No	94%	47
8. Do you use your phone to check the time?		
Yes	82%	41
No	18%	9

60 seconds to elute the microbes. Samples were then plated onto 5% TrypticaseTM Soy Agar and incubated in a CO₂ incubator for 48 hours. Identification was performed by standard microbiological methods.

Results

Of the fifty mobile phones sampled, only 18% (9/50) revealed no growth. Polymicrobial growth was detected in 88% (44/50) of the mobile phones. Pathogens isolated from the phone samples included: coagulase negative staphylococcus (CoNS), *Staphylococcus aureus* (*S. aureus*), *Bacillus* species (*sp.*), *Diphtheroides*, *Micrococcus* *sp.*, *Proteus* *sp.*, *Pseudomonas* *sp.*, *Alpha Streptococcus* (*Strep*) *sp.*, *Enterobacter* *sp.*, *Strep* *sp.*, *Aspergillus*, *Penicillium*, *Mold* *sp.*, and *Dematiaceous* (Table 2). After cleaning the mobile phones with QAC wipes, mobile phones were swabbed in an identical fashion and all phones revealed no growth.

Among the organisms isolated, CoNS was most prevalent and harvested from thirty-two phones with an average of 12 colony-forming units (CFU)/ml. Microorganisms known to be pathogenic (*S. aureus*, *Proteus* *sp.*, *Pseudomonas* *sp.*, *Enterobacter* *sp.*, *Strep* *sp.*) were isolated from 30% (15/50) of mobile phones.

The vast majority of residents, 98% (49/50) used their phone within the hospital and 37% (18/49) used their phones inside patients' rooms. 40% (20/50) of residents used their phones in the restroom. 82% (41/50) of residents used their phone regularly to check the time (Table 2).

10% (5/50) of residents never cleaned their phones and 74% (37/50) occasionally or rarely cleaned their phones. On average, residents had not cleaned their phones for 19.74 days at the time of the initial random swab. Only 14% (7/50) of the residents cleaned their phones daily; however, a majority of the residents

71% (5/7) used either dry wipes or alcohol and all residents had organisms isolated from their mobile phones. A total of 42% (21/50) of residents used dry wipes to clean their phone and only 10% (5/50) of the residents used QAC disposable wipes. Only 10% (5/50) of the residents washed their hands before using their phones and

6% (3/50) washed their hands after using their mobile phones. None of the residents washed their hands before and after using their mobile phones.

Discussion

Mobile phones are multipurpose, non-medical devices used in health care facilities. Health care facilities have few restrictions on mobile phone use even in sensitive areas such as intensive care units and operating rooms.

Greater than five CFU/cm² of microorganisms is considered unacceptable in health care environments [35]. This study demonstrated 88% of mobile phones had polymicrobial

Table 2: Number of isolates and types of microorganisms from touch screen mobile phone devices of residents

Total number of cultivated swab samples	50		
Positive Culture	41 (82%)		
Type of Microorganisms	Total Colonies (CFU/ml)	Average Total Colonies (CFU/ml)	# of Phones with Isolate
Non-Pathogenic			
CoNS	385	12	32
<i>Diphtheroides</i> <i>sp.</i>	163	6	26
<i>Dematiaceous</i>	1	1	1
<i>Penicillium</i>	4	1	4
<i>Bacillus</i> <i>sp.</i>	89	11	8
<i>Micrococcus</i> <i>sp.</i>	21	5	4
<i>Alpha Strep</i> <i>sp.</i>	63	6	10
<i>Aspergillus</i> <i>sp.</i>	5	3	2
<i>Mold</i> <i>sp.</i>	11	6	2
Pathogenic			
<i>S. aureus</i>	312	31	10
<i>Proteus</i> <i>sp.</i>	6	3	2
<i>Pseudomonas</i> <i>sp.</i>	5	3	2
<i>Enterobacter</i> <i>sp.</i>	2	2	1
<i>Strep</i> <i>sp.</i>	8	8	1

microbial organisms isolated from residents' mobile phones and 30% of the mobile phones had pathogenic organisms. Of the pathogenic organisms isolated on mobile phones in this study, all had ≤ 1 CFU/cm², which is still considered acceptable in health care environments; however, the vast majority of residents (98%) used their phones within the hospital, and 37% used their phones inside patients' rooms. This raises concern for potential spread of pathogenic bacteria to patients from microorganisms on the mobile phones.

Many of the residents 86% did not clean their phones on a daily basis and of the ones who did, a majority of them used either dry wipes or alcohol wipes. When wiping with 70% isopropanol, it has been shown to not adequately disinfect surfaces with high titers of pathogenic microorganisms [36]. A few of the residents (6%) used Clorox® Disinfecting Wipes (Clorox, Oakland, CA, USA) to clean their mobile phones. Although Clorox® reduced pathogenic counts, it has been shown to have a short-lived effect and immediate repeat contamination resulted in microbial growth when swabbed. In a clinical environment, repeated cleaning with Clorox® would be required after every potential contamination [32].

QAC wipes have shown that a single disinfection prevents further contamination and could be effective for up to 12 hours in spite of repeated opportunistic contamination [32]. Ammonium compounds within QAC is well known to have a wide spectrum of antimicrobial activity including some antifungal and antiviral properties, although it is ineffective against norovirus and *Clostridium difficile* (C. Difficile) [37]. In this study, QAC wipes were an effective method of disinfecting mobile phones with no microorganism growth approximately five minutes after cleaning mobile phones with them.

QAC wipes have demonstrated that repeated usage does not have long-term damaging effects on the Apple iPad®. Both the appearance and functionality of the touch screen on the iPad® are not affected [32]. One of the downsides of QAC wipes is the ‘residual effect’ causing a white residue on the touch screen (Figure 4), which would require users to polish the device to remove the residue which would consequently reduce the efficacy of the QAC wipes [32].



Figure 4: Post QAC wipe mobile phone was left wet for two minutes and air dried per manufactures instructions. Post wipe residue present.

None of the dry wipes, alcohol wipes, Clorox® wipes, or QAC wipes have the ability to eradicate *C. difficile*. Tristel (Tristel Solutions Ltd., Snailwell CB8 7NY) wipes system has been shown to be effective in reducing *C. difficile* colony counts. Tristel is a chlorine-based cleaning wipe system, which includes a sporicidal component. There is evidence that sodium hypochlorite may be effective against *C. difficile*, but its safety for use on iPads® has yet to be established [38].

The use of mobile phones is a concern within the operating room setting. Mobile phones are commonly used in the operating room by staff, vendors, residents, and physicians and have been found to possess a high rate of pathogenic bacterial contamination and organic material such as food, human secretions, and excretions [29]. The bacterial and organic material load was decreased after a single disinfecting process with commercially available cleaning wipes safe for mobile phone use.

The use of mobile phones by inpatients is also a concern. 1) Demographics, 2) characteristics of mobile phones, and 3) phone surface microbial contamination used by inpatients were examined by Brady, et al [39]. A majority of

the inpatients (70.3%) completed a questionnaire about the utilization of mobile phones and also provided their mobile phones for bacteriological analysis and comparative bacteriological swabs from their nasal cavities. The majority of the patients, 94% supported utilization of mobile phones by inpatients and 24.5% of patients stated that mobile phones were vital to their inpatient stay.

In addition to mobile phones as potential vehicles of pathogenic bacterial dissemination, multiple studies have shown that white coats, neckties, keyboards, and stethoscopes [40-43] are also potential vectors. White coats' sides, collars, and pockets were the most highly contaminated areas [40]. Neckties are ‘poor practice’ (other than bowties) when in contact with patients as they ‘serve no beneficial function’ in patient care, they are rarely laundered, and they have colonized pathogens in healthcare settings [41]. More than half of the keyboards in hospitals had isolated pathogens [42]. Lastly, stethoscopes have been shown to have significant bacterial contamination resistant to multiple classes of antibiotics [43]. Disinfections before and after each patient contact of any potential vector is recommended to avoid the spread of pathogenic microorganisms.

Creating a Policy

The results of this study and others suggest a feasible policy of mobile phone usage among patients, visitors, and health care workers could be formulated for hospital settings. Mobile phones are essential devices for professional and social lives of users and restrictions on the use of mobile phones is difficult and not a practical solution.

Mobile phone users need to be regularly advised on the use of effective sanitizer wipes in order to decrease the bacterial load of mobile phones. Sanitizing mobile phones regularly will reduce the risk of recontamination while allowing the use of mobile phones in the hospital setting. Specific software applications have been developed to remind users to regularly disinfect their devices. Using the wipes is economical and not time consuming [44].

In addition, a standard infection guideline should be implemented for before and after mobile phone use such as hand washing and sound hygienic practice in order to prevent mobile phones as vehicles of transmission of both hospital and community acquired diseases. Furthermore, possible abstinence from use of mobile phones within a patient's room and operating room or use of a protective sleeve (Figure 5) could be helpful in preventing the transmission of pathogens.



Figure 5: Protective sleeves for use in operating room setting with no interference of talk and touch function. The principle drawback is the cumbersome nature of the sleeve.

Conclusion

Mobile phones have become a part of personal and professional life and accompany patients and healthcare providers everywhere. Furthermore, they are a principle source of communication among health care providers within the hospital. The regular use of mobile phones within the hospital setting may serve as a vehicle of transmission of microorganisms that can cause disease in human beings. Consequently, it is important to regularly disinfect mobile phones, especially health care professionals whose hygiene can directly impact patients' wellbeing.

Further research including phenotyping and genotyping organisms may discover a direct link between mobile phones and hospital acquired infections. Awareness and concern among health care providers of mobile phones use can help control infection and avoid transmission of diseases. Possible solutions include guidelines for curtailing mobile phone use among patients and health care providers.

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SUBMISSION HISTORY

Submitted August 21, 2017
 Reviewed September 12, 2017
 Revised September 21, 2017
 Accepted September 22, 2017
 Published September 30, 2017

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AUTHOR DISCLOSURES

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