Case Study

Mobile Phones as a Potential Vehicle of Infection in a Hospital Setting

The objective of this article is to investigate the potential role of mobile phones as a reservoir for bacterial colonization and the risk factors for bacterial colonization in a hospital setting. We screened 226 staff members at a regional Australian hospital (146 doctors and 80 medical students) between January 2013 and March 2014. The main outcomes of interest were the types of microorganisms and the amount of contamination of the mobile phones. This study found a high level of bacterial contamination ($n = 168/226$, 74%) on the mobile phones of staff members in a tertiary hospital, with similar organisms isolated from the staff member's dominant hand and mobile phones. While most of the isolated organisms were normal skin flora, a small percentage were potentially pathogenic ($n = 12/226$, 5%). Being a junior medical staff was found to be a risk factor for heavy microbial growth (OR 4.00, 95% CI 1.54, 10.37). Only 31% (70/226) of our participants reported cleaning their phones routinely, and only 21% (47/226) reported using alcohol containing wipes on their phones. This study demonstrates that mobile phones are potentially vehicles for pathogenic bacteria in a hospital setting. Only a minority of our participants reported cleaning their phones routinely. Disinfection guidelines utilizing alcohol wipes should be developed and implemented.

Keywords hospital, infection, mobile phones, vehicle

INTRODUCTION

Nosocomial infections pose a serious threat to hospitals all over the world.^(1,2) Healthcare workers (HCW) play a crucial role in the transmission of bacteria to hospitalized patients, and as early as 1861 Semmelweis showed that contaminated hands of healthcare workers transmitted bacteria to patients.⁽³⁾ Strict hygiene standards to prevent nosocomial infection are of paramount importance in a hospital setting.⁽⁴⁾

Mobile phone use in hospitals has been discouraged until recently due to concerns over potential interference with medical equipment.⁽⁵⁾ However, these concerns have now been shown to be largely unfounded,⁽⁶⁾ and mobile phones have become an essential part of the hospital environment. Most doctors and students in hospitals across the world now rely on mobile phones as their main means of communication and as a source of information.⁽⁷⁾

As with other environmental surfaces, prior studies have suggested that mobile phones may serve as a reservoir for pathogenic bacteria.^(8,9) They come into close contact with various parts of the body and at the moment no cleaning guidelines exist in most hospitals. In our pilot study conducted in a pediatric unit, we found that 95% of phones were colonized with bacteria, and 5% contained pathogenic bacteria.⁽¹⁰⁾ We also found that being a medical student was an independent risk factor for heavy microbial growth. The hygiene risk involved in using mobile phones in a hospital setting has not yet been determined in an Australian setting.

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The purpose of this study was to investigate the potential role of mobile phones as a reservoir for bacterial colonization and the level of microbacterial growth. We also wanted to identify any potential risk factors for bacterial colonization, heavy bacterial growth, and the presence of pathogenic bacteria.

METHODS

Study Design and Participants

The study was conducted at a regional hospital in Australia. A total of 226 staff—146 doctors and 80 medical students—were screened between January 2013 and March 2014. The decision was made to only include doctors and medical students, as other staff did not use their personal mobile phones in our hospital. After gaining written informed consent, cultures were obtained from the dominant hand of participants and from their mobile phones.

Questionnaire

Data regarding gender, profession, seniority, years of experience, hand dominance, frequency of mobile phone use, model of mobile phone, an presence of a cover and cleaning behavior were recorded. In terms of cleaning behavior, we recorded the frequency of cleaning, as well as the instrument used to clean the phone. In particular, we consider the use of alcohol wipes to be the gold standard in cleaning environmental surfaces such as phones.⁽¹¹⁾ With regards to seniority, participants were categorized into 5 groups—medical students, interns (first year post graduation), resident medical officers (RMO), registrars, and consultants. RMOs are junior medical officers who have finished their first year of hospital internship, whilst registrars are doctors undergoing training as a specialist.

Bacterial Culture, Identification, and Susceptibility Testing

The samples were collected aseptically using cotton swabs. The first swab was taken from the entire ventral surface of the dominant hand, and the second from both sides of the mobile phone.

Swabs were inoculated onto a split horse blood/MacConkey agar (Oxoid) and incubated in 5% CO₂ at 35°C for 24 hr. Plates were observed for growth and colony counts were performed, with those having >100 colonies classified as having heavy growth. The isolates were identified or grouped using colony morphology, pigmentation, gram stain, oxidase, catalase, Staphytest Plus (Oxoid), DNA plates, Streptex* (Remel), and 2 Compact (Biomérieux). *Staphylococcus aureus*, *Enterococcus* sp. and Gram Negative Coliforms were further investigated for antibiotic resistance using disc diffusion according to the CDS antibiotic susceptibility testing method (Australia). Methicillin Resistant *Staphylococcus aureus* (MRSA), Vancomycin Resistant *Enterococcus* (VRE), and drug-resistant Gram Negative Bacteria (e.g., Extended Spectrum Beta-Lactamase producers) were identified.

Statistical Analysis

Participant characteristics are expressed as percentages with raw values. We then performed univariable logistic regression to assess the presence of bacteria, the presence of heavy bacterial colonization (defined as >100 colonies) and the presence of pathogenic bacteria. We then performed multivariable logistic regression adjusting for gender, cleaning patterns, phone type, phone use frequency, and the presence of a phone cover.

A p-value less than 0.05 was considered statistically significant. All statistical analyses were performed on Intercooled Stata 12.0 for Windows (StataCorp LP).

The investigation was approved by the Tasmanian Human Research Ethics Committee, and written informed consent was gained from all study participants.

RESULTS

Samples from 226 mobile phones were taken from a regional hospital over a twelve month period. These were taken from medical students (n = 80), interns (n = 28), resident medical officers (n = 24), registrars (n = 48), and consultants (n = 46). Smartphones comprised 94% (213/226) of the samples and 73% (165/226) had phone covers. In terms of where the phone was carried, 158 participants (70%) carried them in their pockets, followed by 54 (25%) in their hand bags and 11 (5%) in their belt pouches. Of those that kept the phone in their pockets, 16 carried handkerchiefs as well. In terms of cleaning routine, 6.6% (15/226) reported cleaning their phones in the past 48 hr, and 31.0% (70/226) cleaned them regularly. Among those that reported cleaning their phones regularly, 67% (47/70) used an alcohol-based wipe. Self-reported frequency of mobile phone use averaged at once every 64.5+/-63.3 (SD) minutes. Of the 226 samples taken from mobile phones, 168 (74%) were contaminated with bacteria (Table II); 130 (58%) had one bacterial species, 35 (16%) had two species, and only 3 (1%) had three bacterial species (Table I), IIM.

Table II shows the bacterial organisms isolated from the samples. The types of microorganisms isolated from mobile phones and dominant hands were similar. Most of the bacteria isolated were skin flora (such as *coagulase negative staphylococci*, *Bacillus* spp, *Diphtheroid* spp, and *Non-hemolytic streptococcus*). No MRSA, VRE, or drug-resistant gram negative bacteria were isolated. Twelve (5%) mobile phones were contaminated with potentially pathogenic bacteria (Table II).

We categorized those with >100 colonies as having “heavy growth,” and performed logistic regression to explore the relationship between heavy growth and phone user characteristics. We found that interns had greater odds of having heavy growth on their phones (OR = 4.00, CI 1.54–10.37, p-value = <0.01). Adjusting for gender, phone use frequency, routine cleaning, cleaning in the past 48 hr, type of phone, and presence of a phone cover did not significantly affect the OR (less than 10% change). Gender, hand dominance, other levels of seniority (medical student, RMO, registrar, or consultant),

TABLE I. Participant Characteristics (n = 226)

Females (%)	60.6% (137/226)
R hand dominant	91.2%(206/226)
Smartphones	94.2%(213/226)
Phone cover	73.0%(165/226)
Seniority	
Medical Students	35.4%(80/226)
Interns	12.4%(28/226)
RMOs	10.6(24/226)
Registrars	21.2(48/226)
Consultants	20.4(46/226)
Phone usage	
Less than once in 1 hr	13.3%(30/226)
Once every 31–60 min	30.5%(69/226)
Once every 16–30 min	39.4%(89/226)
Once every 0–15 min	10.2%(23/226)
Location of phones	
Pocket	70.0%(158/226)
Handbag	23.9%(54/226)
Belt pouch	4.9%(11/226)
Others	1.3%(3/226)
Handkerchief	7.1%(16/226)
Cleaning patterns	
Routine cleaning	31.0%(70/226)
Last 48 hr	6.6%(15/226)
Daily	4.0%(9/226)
2–3 times/week	5.3%(12/226)
Weekly	12.8%(29/226)
Fortnightly	4.4%(10/226)
Monthly	4.4%(10/226)
Cleaning equipment	
Alcohol-containing wipes	67.1%(47/70)
Tissue	22.9%(16/70)
Cloth	10.0%(7/70)
Colonization rates	
Bacterial colonization rates	74%(168/226)
1 organism	58%(130/226)
2 organisms	16%(35/226)
3 organisms	1%(3/226)

presence of a phone cover, type of phone, cleaning in the past 48 hr, routine cleaning, and cleaning with alcohol-based wipes showed no significant associations with the presence of growth, heavy growth, or the presence of pathogenic bacteria (data not shown). Those who cleaned their phones daily with alcohol wipes (n = 11) had no growth of pathogenic bacteria.

DISCUSSION

In our study, the mobile phones of doctors and medical students working in the hospital environment demonstrated

TABLE II. Bacterial Agents Isolated from Study

	Phones n (%)	Hands n (%)
Non-pathogenic organisms		
<i>Coagulase negative Staphylococci</i>	133(58.8)	117(51.8)
<i>Bacillus spp.</i>	14(6.2)	27(11.9)
<i>Diphtheroid spp.</i>	26(11.5)	20(8.8)
<i>Non-Hemolytic Streptococcus</i>	24(10.6)	41(18.1)
<i>Alpha hemolytic Strep</i>	0(0)	3(1.3)
Pathogenic organisms		
Coliforms	11(4.9)	9(4.0)
<i>Methicillin-sensitive</i>	1(0.4)	1(0.4)
<i>Staphylococcus aureus</i>		
<i>Enterococcus</i>	0 (0)	0 (0)
<i>Acinetobacter</i>	0 (0)	0 (0)

a high contamination rate with bacteria. Furthermore, there was a 5% rate of contamination with potential pathogenic bacteria (*Staphylococcus aureus* and coliforms). We also found that interns were more likely to have heavy growth of bacteria on their mobile phones. There were no other risk factors for the presence of bacterial growth, heavy bacterial growth or growth of pathogens. Among those that cleaned their phones with alcohol daily, there was no growth of pathogens on their phone.

We believe that our study is the first to suggest that there may be greater contamination of mobile phones used by junior medical staff, specifically interns. This association remained significant even after adjustment for other variables. In our pilot study in a pediatric setting,⁽¹⁰⁾ we found that medical students had greater odds of heavy growth. In both settings the association remained significant after adjustment for other variables. Other potential risk factors (gender, phone use frequency, phone type, cleaning patterns) were not associated with the presence of bacteria, heavy bacterial growth, or the growth of pathogenic bacteria. This is consistent with the results of most studies in this area.^(12,13) Lee et al.⁽¹⁴⁾ reported that smartphones had greater odds compared to non-smartphones for harbouring pathogenic bacteria, while Ustun et al.⁽¹⁵⁾ reported that ICU staff had greater odds of contamination with *E.coli*. This was not seen in our study.

Interestingly, routine cleaning, cleaning in the past 48 hr and cleaning with alcohol was not associated with the absence of bacterial growth, lighter levels of bacterial growth or the absence of pathogenic bacteria. However, we found that of those that cleaned their phones daily with alcohol, there was no growth of pathogenic bacteria. This raises the possibility that while phones may become quickly colonized with non-pathogenic bacteria such as skin flora, daily alcohol cleaning may reduce the chances of harboring pathogenic bacteria. However, given the small number of participants who cleaned their phones daily with alcohol, this result warrants further examination.

Currently, there are no evidence-based guidelines for the use of mobile phones in hospitals.⁽¹⁶⁾ This study adds to the growing body of evidence that suggests that phones act as a vehicle for pathogenic organisms.^(17–20) Furthermore, the rate of regular cleaning was only 31% among our participants, a figure consistent with other studies in this area.^(21,22) Of these, only roughly two-thirds utilized alcohol wipes, which has been shown to be effective in the decontamination of mobile phones in a hospital setting.⁽¹¹⁾ Given that mobile phones are now an integral part of most modern hospitals, guidelines for decontamination of mobile phones with alcohol wipes alongside adherence to other infection control procedures (i.e., hand hygiene) should be developed.

Our study has several limitations. There is a potential that viable but non-cultivable organisms would have been present on the phones, such as viruses or fungi. Therefore, this study might have underestimated the potential of phones as a vehicle for infective organisms. Particularly, viruses such as noroviruses are known to colonize surfaces and only needs a small dose to cause symptomatic infections. Future studies could consider looking at non-bacterial organisms as well.

This study suggests that whilst pathogenic bacteria are an uncommon finding on mobile phones, they remain a possible source of bacteria in a hospital setting. It also suggests that mobile phones belonging to junior medical staff are at greater risk of harboring heavy bacterial growth. Given their widespread usage in hospitals worldwide, a further interventional study looking at the effectiveness of a cleaning regime and its possible impact on hospital infection rates should be considered.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Emily Mauldon and Dr. Mhisti Rele for their assistance.

FUNDING

This work was supported by the School of Medicine, University of Tasmania and Clifford Craig Medical Research Trust. The study sponsor had no role in the design of the study, the collection, analysis, and interpretation of the data; or the writing of the article and the decision to submit it for publication. The researchers work independently of their funders.

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