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Original Article

Bacterial contamination of cellular phones at a veterinary school and veterinary teaching hospital

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Summary

Cellular phones have become an integral part of not only modern-day life but also Veterinary Medicine. They provide clinicians with quick access to reference material, laboratory results, and patient side consults. However, these phones may also act as fomites and be a source of Hospital-acquired infections. The purpose of this study was to determine the role of cellular phones in the dissemination of foodborne pathogens and other pathogenic organisms. Using *Escherichia coli* and coagulase-positive *Staphylococcus aureus* as indicator organisms for pathogenic bacteria, cellular phones belonging to students and staff at a Veterinary School and a Veterinary Teaching Hospital were assessed. Overall less than 1% (1/115) of cellular phones tested positive for *E. coli.* However, 21% (24/115) of the phones were contaminated with the highly pathogenic coagulase-positive *Staphylococcus aureus.* The majority of phones testing for positive for of coagulase-positive *Staphylococcus aureus* (15/24) belonged to persons working in a clinical environment. The low contamination rate of phones with *E. coli* indicates phones are not a major vehicle for the dissemination of foodborne pathogens. However, the higher incidence of *Staphylococcus aureus* contamination should of critical concern since these phones may be acting as fomites for the dissemination of other pathogens. These results highlight the need for proper cellular phone use and disinfection protocols to be implemented in hospital settings to reduce potential transmission pathogens.
***Keywords*:** Cellular phones, *Escherichia coli*, *Staphylococcus aureus*

Introduction

Hospital-associated infections (HAIs) are a major concern in both human and veterinary medicine. While the actual prevalence of hospital-associated infections (HAI) in Veterinary hospitals is unknown, the Centre for Disease Control and Prevention in the USA reports that in 2011 there were over 700,000 human cases of HAIs in the USA (Lax and Gilbert, 2015). In the United Kingdom, it is estimated that there are over 10,000 deaths annually attributed to pathogens associated

with HAIs (Pearson, 2009). While some HAIs may be transmitted directly from person to person, others may be transmitted via fomites such as staff clothing, stethoscopes, computer keyboards, and cellular phones.

The number of cellular phone users has been increasing exponentially and in 2014 there over 7 billion users (Yang et al., 2017). Cellular phones have now become an essential accessory to many persons and their use has infiltrated all aspects of our daily lives. Their value within the medical field is without doubt since they can provide quick and convenient access to reference material, laboratory results, and life-saving consultations in emergencies (Olsen et al., 2020). Such is their importance, that it can be assumed that almost every practitioner owns a cellular phone and a ban on their use in a clinical environment may be impractical (Imhoff, 2006). Given the intimate contact between cellular phones and their users it is not surprising that bacterial contamination of these devices have been reported to be as high as 100% (Srikanth et al., 2010, Tagoe et al., 2011). While the majority of the bacterial flora on these cellular phones may be non-pathogenic, some bacteria may contain virulence genes capable of causing disease or possess antimicrobial genes. Cellular phone users thus have to be wary of the potential for cellular phones acting as fomites in the dissemination of these organisms. This risk was highlighted by Ulger et al. (2009) who reported that 25%of cellular phones sampled from ICU staff were contaminated with *Staphylococcus aureus*, and 10% with coliforms (Ulger et al., 2009). Other studies have also identified foodborne pathogens amongst the microbial flora of cellular phones with *Salmonell*a and *Shigella spp.* being among some of the bacterial isolates recovered. (Tagoe et al., 2011)

The increasing integration of cellular phone use in all facets of our lives potentially makes them an excellent mechanism for the dissemination of pathogens. Increasing use of cellular phones among medical personnel is of particular concern since these persons are exposed to a variety of situations which can result in their hands becoming contaminated with high concentrations of bacteria that can then transmitted onto their cellular phones. As such, the role of cellular phones as a fomite for the dissemination of pathogens warrants further investigation. From the literature cited above, it is clear the role of cellular phones in the dissemination of pathogens in human healthcare settings has been well described; however, this is not the case for Veterinary medicine and especially so for the Caribbean. This study seeks to partially fill this critical void by determining the frequency of contamination of cellular phones with *Escherichia coli* and coagulase-positive *Staphylococcus aureus* (CoPS) on cellular phones at a Veterinary School and Veterinary Teaching Hospital in Trinidad and Tobago as well as evaluate their cellular phone hygiene practices.

Materials and methods

Sample collection and study population

A cross-sectional study was conducted targeting 120 veterinary students, technicians, and clinical faculty at a Veterinary School in Trinidad and Tobago. Using a stratified sampling method, participants from each category were approached and asked to participate in the study. Upon consenting to participate in the study, all surfaces of their cellular phone were aseptically swabbed using sterile gauze, moistened with sterile phosphate-buffered saline (Brady et al., 2011). The gauze was then placed in a Ziploc ® bag and kept in a cooler at 4ºC and transported back to the laboratory for microbial analysis within 4 hours. The participant was also asked to complete a questionnaire which characterized their frequency of contact with animals as well as their cellular phone cleaning habits.

Microbiological analysis

At the laboratory, the bags containing the sterile gauze were weighed on an electronic balance (Scout Pro SP202, Ohaus Corporation, USA) and sterile Buffered Peptone Water (Acumedia, MI) was added at a volume equivalent to nine times that

of the sterile gauze. The contents of the bag were then manually agitated for two minutes to ensure adequate mixing of contents. The bags were then incubated for 24 hours are 37°C. Following incubation, one loopful, approximately 10 µL, of enriched broth solution was then streaked onto Mannitol Salt Agar, MSA, (Oxoid, UK) and Eosin Methylene Blue agar, EMB (Oxoid, UK) and incubated for 24 hours at 37°C.

The next day, MSA plates were examined for isolates with similar colony morphology to *Staphylococcus aureus* (yellow colonies) and these colonies were then subcultured onto 5% blood agar plates and incubated for 24 hours at 37°C for isolation. The next day, individual colonies were subjected to gram stain, coagulase, and catalase tests as described by Tallent et al. (Tallent et al., 2016). The EMB plates were also examined for blue-black colonies with a green metallic sheen and these suspected *E. coli* colonies were streaked onto 5% blood agar plates and incubated for 24 hours for isolation. The following day, the recovered isolates were then subjected to standard biochemical assays including Triple sugar iron, Simmons citrate, Urease, and Indole tests to confirm their identity as *E. coli* (Feng et al., 2002).

Statistical analysis

Data was tabulated using Microsoft Excel. Categorical associations were analysed using Fischer Exact Test and Chi-squared analysis. Differences were considered to be statistically significant at $p < 0.05$. Statistical analyses were done using SPSS® Statistics 22.0 (IBM®, Somer, NY, USA).

Results

Overall a total of 115 cellular phones were sampled, representing 95 students and 20 clinical faculty members of staff (Table 1). The study population was also categorised as being clinical or pre-clinical based on their progression in the academic programme. Students in year 5 and staff were classified as being clinical since they would have spent the majority of their time within the veterinary hospital or attending to ambulatory cases. Students enrolled in years 1 – 4 would have limited access to clinical settings and were thus classified as pre-clinical.

Table 1. Frequency of cellular phone contamination with coagulase-positive *Staphylococcus aureus*. Values represent the percentage of cellular phones contaminated in each category. (n) represents the number of cellular phones tested in each category. (x) represents the number of phones testing positive in each category.

Classification Group	Category (n)	Contamination frequency (%) (x)
Pre-clinical	Year 1 (20)	0.00
	Year 2 (20)	0.00
	Year 3 (15)	26.67 (4)
	Year 4 (20)	25.00 (5)
Clinical	Year 5 (20)	40.00 (8)
	Support staff (6)	33.33 (2)
	Veterinarian (14)	35.71 (5)

Cellular phone contamination: Of the 115 cellular phones sampled, only one cellular phone tested positive for *Escherichia coli.* In contrast, the frequency of contamination of phones with coagulase-positive *Staphylococcus aureus* (CoPS) was much higher, with 21% (24/115) testing positive for CoPS. The CoPS contamination on staff phones was higher than that of students (35% (7/20) vs 18% (17/95) but there was no statistical association between cellular phone contamination and whether the person was a student or staff ($p = 0.16$). (Table 2)

When categorised according to academic year enrolment, students enrolled in year 5 had the

highest CoPS contamination rate with 40% (8/20) of phones being contaminated compared to the phones belonging to students enrolled in year 1 and year 2 who had the lowest (0%) ($p < 0.001$). Among the staff population, the contamination frequency among Veterinarian phones was higher than Veterinary Technicians (35.7% (5/14) vs. 33.3% (2/6), however, this difference was not statistically significant ($p = 0.441$).

Table 2. Frequency of cellular phone contamination with coagulase-positive *Staphylococcus aureus*. Users are stratified according to their (a) academic status or (b) clinical status. Values represent the percentage of cellular phones contaminated with coagulase-positive *Staphylococcus aureus* in each category. (n) represents the number of cellular phones in each category. (x) represents the number of phones testing positive in each category.

Category		Contamination Frequency (%) (x)	*P*
a) Status	Student (95)	17.89 (17)	0.09
	Staff (20)	35.00 (7)	
b) Clinical setting	Preclinical (75)	12.00 (9)	0.001
	Clinical (40)	37.50 (15)	

When the data was further stratified according to persons in a clinical setting (Staff and year 5) versus those in a pre-clinical setting (years 1 – 4), the CoPS contamination in the clinical group was higher than the pre-clinical group (37.5% (15/40) vs. 12% (9/75; $p = 0.001$) (Table 2)

Cellular Phone sanitation practices: Overall there was no statistical association between the frequency of sanitizing cellular phones and contamination with CoPS ($p = 0.266$). The frequency of sanitizing the cellular phone surfaces among the participants varied quite greatly with some respondents cleaning their phones as little as once per month (30%) while some users claimed that they never have never sanitized their phones (21%). When data was stratified into a clinical versus non-clinical setting, there was a statistically significant association between frequency of cleaning and the contamination rates ($p = 0.016$), with contamination rates being higher in groups which never cleaned their cellular phones, and quite surprisingly those who reported they cleaned their phones daily. There was no such association in the pre-clinical group. Of particular concern is that 25% (10/40) of the respondents from the clinical group indicated they had never cleaned the surface of their cellular phones. The cellular CoPS contamination within this group was 60% (6/10) (Table 3).

Discussion

In our study, we determined that 21% of cellular phones tested were contaminated with coagulase-positive *Staphylococcus aureus* (CoPS) and less than 1% were contaminated with *Escherichia coli*. Infection with CoPS can result in a range of localised and systemic infections in both humans and animals. CoPs has also been identified as one of the main causes of catheter infections in hospitals (Morubagal et al., 2017). These organisms are of particular concern since they can be part of the normal skin microflora of both humans and animals but can be pathogenic in the host immuno-compromised (Hanselman et al., 2009, Saputra et al., 2017). In this study, 21% of all cellular phones tested were positive for CoPS. The highest contamination rate was amongst clinical staff and students, with this group accounting for 62.5% (15/24) of all positive cases. One possible reason for this high contamination is these persons would have been exposed to more animals and their environment thus increasing the potential for a contamination event occur. This hypothesis is further supported by the fact that year 1 and 2

students who were primarily exclusively in the classroom with little or no exposure to animals in the Veterinary Teaching Hospital had a 0% contamination rate. Similarly, Goldblatt et al. (2007) in a study evaluating cellular phone contamination in four human hospitals also identified that the hospital environment was a risk factor for cellular phone contamination. In that study, cellular phones which were never carried into the hospital were not contaminated, while 25% of those which were carried into the hospital tested positive for contamination (Goldblatt et al., 2007). Another study at a University Teaching Hospital in Zambia also found approximately 20% of phones sampled were positive for *Staphylococcus aureus* (Mushabati et al., 2021).

Table 3. Frequency of cellular phone contamination with coagulase-positive *Staphylococcus aureus* according to cleaning frequency. Respondents are sorted according to their status: (a) Pre-clinical and (b) Clinical. Values represent the percentage of cellular phones contaminated with coagulase-positive *Staphylococcus aureus* contamination rate. (n) represents the number of cellular phones tested in that category. (x) represents the number of phones positive in each category.

Category	Cleaning Frequency (n)	Cellular phone contamination (%) (x)	*P*
Pre-clinical	Daily (9)	0.00 (0)	0.102
	Weekly (18)	27.78 (5)	
	Monthly (27)	7.41 (2)	
	Yearly (6)	0.00 (0)	
	Never (15)	13.33 (2)	
Clinical	Daily (7)	71.43 (5)	0.016
	Weekly (15)	13.33 (2)	
	Monthly (8)	25.00 (2)	
	Yearly (0)	0.00 (0)	
	Never (10)	60.00 (6)	

Another interesting finding was that although persons reported cleaning their phones daily, they still had a high CoPS contamination rate. One plausible reason for this high contamination rate may be that sampling of the phones was done prior to the daily disinfecting routine. Another plausible reason is that the daily cleaning routine was not sufficient for disinfecting the surface of the cellular phones. The method of cleaning the phones was not recorded or evaluated in this study. Other decontamination studies have reported that cleaning of cellular phones with 0.5% chlorhexidine (+/- triclosan), 70% isopropyl alcohol or ethyl alcohol wipes are effective in reducing the microbial load by 60 – 98% (Basol et al., 2013, Arora et al., 2009, Koscova et al., 2018). Ideally, phones will need to be cleaned multiple times throughout the day in order to prevent them from acting as fomites since they are susceptible to recontamination when used. Clinical staff should also be encouraged not to use cellular phones in between clinical procedures or patients. They should also be encouraged to thoroughly wash their hands using soap and water before and after using their phones while in a clinical setting.

Escherichia coli is a commensal in the gastrointestinal tract of many animals and its presence in the environment is an indicator of recent faecal contamination (Martin et al., 2016, Fonseca et al., 2011). Similar to *E. coli*, many foodborne pathogens are also resident in the gastrointestinal tract of animals and are shed in faeces when the animals defecate (Swartz, 2002). In this study, we used *E. coli* as an indicator of

faecal contamination and thus its presence would indicate the likelihood of other foodborne pathogens being present. Previously published studies have reported that *E. coli* cellular phone contamination rates ranged from 1 – 12 % (Goldblatt et al., 2007, Srikanth et al., 2010, Tagoe et al., 2011, Mushabati et al., 2021, Kakade et al., 2020). Our study revealed a low *E. coli* contamination rate, with less than 1% (1/115) of the cellular phones testing positive. This low contamination rate indicates that the cellular phones in this study are not a method for the dissemination of foodborne pathogens.

This study has certain limitations which we need to be cognizant of. Firstly, we enriched our samples thus the actual number (colony forming units) of bacteria on the cellular phones was not determined. Furthermore, we also relied on individuals' recollection of the frequency of cleaning their cellular phones. This may have potentially resulted in inaccurate data being reported.

Conclusion

The low *E. coli* contamination rate indicates that cellular phones are not a method for the dissemination of foodborne pathogens. However, the high contamination rates of cellular phones with CoPs *s*upports the hypothesis that cellular phones can act as fomites for the transmission of pathogenic bacteria. The phones may thus act as "Trojan horses" allowing for dissemination of other pathogenic agents within the veterinary hospital setting. Given the high contamination with CoPS, the potential of these phones to disseminate antimicrobial resistant organisms such as Methicillin-resistant *Staphylococcus aureus* should not be ignored. This study also highlights the need for the development of proper cellular phone use and disinfecting guidelines for clinical staff and students to be developed and implemented to reduce potential transmission of pathogenic organisms.

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Conflicts of interest statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Ethical approval

Not applicable

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