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ORIGINAL INVESTIGATION

Mobile phones of anesthesiologists as reservoirs of nosocomial bacteria in a quaternary teaching hospital: an observational study

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Abstract

Background: Mobile phones in hospital settings have been identified as an important source of cross-contamination because of the low frequency with which mobile phones are cleaned by health workers and cyclical contamination of the hands and face. The aim of this study was to investigate whether the mobile phones of the anesthesia team at a teaching hospital are potential reservoirs of nosocomial bacteria. In addition, differences in device sanitization and hand hygiene habits between attending and resident anesthesiologists were correlated with mobile phone colonization.

Methods: A prevalence study was conducted over a 6-month period from 2017 to 2018 that involved the collection of samples from the mobile phones of the anesthesiology team and culturing for surveillance. A questionnaire was administered to assess the mobile phone sanitization and hand washing routines of the anesthesia team in specific situations.

Results: Bacterial contamination was detected for 86 of the 128 mobile phones examined (67.2%). A greater presence of *Micrococcus* spp. on devices was correlated with a higher frequency of mobile phone use ($p = 0.003$) and a lower frequency of sanitization ($p = 0.003$). The presence of bacteria was increased on the mobile phones of professionals who did not perform handwashing after tracheal intubation ($p = 0.003$).

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Conclusion: Hand hygiene and device sanitization habits were more important than the use behavior, as a higher presence of bacteria correlated with poorer hygiene habits. Furthermore, handwashing is the best approach to prevent serious colonization of mobile devices and the possible transmission of pathogens to patients under the care of anesthesiologists.

Introduction

Portable electronic devices are increasingly present in the daily lives of individuals and in the medical environment. Positive impacts of these devices among medical professionals with regard to communication, productivity and doctor-patient relationships have been reported.[1] Nonetheless, since the beginning of the 21st century, the use of mobile phones in hospital settings has been considered dangerous due to electromagnetic interference with equipment such as infusion pumps, ventilators, and pacemakers.[2]

Another concern with these devices derives from a pioneering study on the collection of hand and mobile phone swabs that correlated the presence of *Acinetobacter* spp. in these samples with the potential of future patient transmission.[3] Since then, these devices have been identified as potential reservoirs of nosocomial bacteria,[4–7] viruses,[8] and fungi.[9] Indeed, a review published in 2009 indicated that the rate of mobile phone contamination with pathogenic bacteria was between 9 and 25%.[6]

Furthermore, it is believed that mobile phones may be more problematic for cross-contamination than the inanimate objects of hospital settings. The reasons for this include the low frequency with which mobile phones are cleaned by health workers and the cyclical contamination of the hands and face, as well as the close contact with areas of the body that exhibit a high incidence of bacterial colonization, such as the ears, nose, and mouth.[5,7,8,10–12]

Although it has been established that the use of mobile phones by anesthesiologists can result in hand contamination,[12] few studies on this population related to this issue have been specifically conducted.

Given the above information, the aim of this study was to investigate whether the mobile phones of anesthesia teams at a teaching hospital are potential reservoirs of nosocomial bacteria. Additionally, differences in device sanitization and hand hygiene habits between the attending and resident anesthesiologists were investigated and correlated with mobile phone colonization.

Methods

After approval by the institutional Research Ethics Committee, this cross-sectional study was conducted over a 6-month period from 2017 to 2018. This study was based on the collection of samples from the mobile phones of the anesthesiology team of the surgical centers of the Hospital Central da Santa Casa de Misericórdia de São Paulo and microbial culturing for surveillance purposes.

The time spent in data collection should not influence the result of the collected data, as the colonization of mobile phones would be hypothetically related to the habits of hand hygiene and sanitization of devices. For example, the possibility of response bias due to change in behavior (such as more frequent and thorough cleaning of mobile phones), from the perspective of the Hawthorne Effect,[13] would be more likely in a short period (such as 1 month) for a person to attempt to reduce the amount of bacteria cultured from their sample. Ideally, collection on a single day would be the best option for such surveillance, but not all anesthesiologists work on the same day.

Therefore, 10–15 mobile phones belonging to the anesthesiologists were analyzed every two weeks, excluding those who refused to participate, those who did not carry mobile phones in the surgical center, those who were absent on their working days when the samples were collected and those with mobile phones in use for less than three months. Each device was only analyzed once by the investigators. As the surveillance involved convenience sampling, the sample size was determined by based on the population of attending and resident anesthesiologists.

Two trained investigators performed swab sample collections using the appropriate aseptic technique. For each mobile phone, swabbing of the entire screen, back portion, and side buttons was performed for approximately 30 seconds. The swab technique was chosen, which is the most commonly used technique.[5] Unique samples from different anesthetists were transported to the laboratory in Amies medium within 4 hours. A non-validated questionnaire adapted from Ulger et al.,[10] Sadat-Ali et al.,[11] Mark et al.,[14] and Cavari et al.[8] was given to the participants to identify their device sanitization and hand hygiene behaviors, and signed informed consent was obtained.

In the laboratory, the samples were spread onto blood agar plates and incubated at $35 \pm 2\,^{\circ}C$ for up to 48 hours. Colonies that grew on the plates were identified according to conventional biochemical laboratory techniques, and the antimicrobial resistance profiles of the isolates were determined according to the criteria of the Clinical and Laboratory Standards Institute.[15]

An external collaborator was responsible for correlating the questionnaire data with the microbiological results, maintaining confidentiality. All samples were paired with the questionnaires using identification codes such that only individual mobile phone owners could identify their culture analysis results using their personal codes at the end of the study, if interested. This study adhered to the applicable STROBE guidelines.[16]

Quantitative variables were analyzed using Student's *t*-test, and the results are expressed as the mean and standard

Table 1 Distribution of participants according to mobile phone usage habits in the surgical center. Values are reported as the number (percentage).

		Overall n = 126	Attendings n = 78	Residents n = 48	p[c]
Frequency of mobile phone use in a single day[a]	1–5 times	17 (13.5)	13 (16.6)	4 (8,3)	**0.173**
	6–10 times	34 (27)	24 (30.8)	10 (20.8)	
	11–20 times	25 (19.8)	12 (15.4)	13 (27.1)	
	> 20 times	50 (39.7)	29 (37.2)	21 (43.8)	
Types of activities performed with mobile phones[b]	Communication	110 (87.3)	72 (92.3)	38 (79.2)	**<0.001***
	Medical practice	103 (81.7)	59 (75.6)	44 (91.7)	**0.036***
	News	87 (69.0)	50 (64.1)	37 (77.1)	0.15
	Social networks	77 (61.1)	34 (43.6)	40 (83.3)	**<0.001***
	Games	27 (21.4)	13 (16.7)	14 (29.2)	0.102

[a] Only one answer was allowed for this habit. A chi-square test was performed on a 4×2 contingency table.
[b] Participants could choose more than one activity.
[c] A chi-square test was performed between the groups, yielding the p values listed in the table.

deviation. Qualitative variables were analyzed using the chi-square test, and the results are expressed as absolute and relative frequencies. All analyses were performed with the help of the Statistics Service of Santa Casa de São Paulo School of Medical Sciences using SPSS 13.0. The significance level adopted was $p < 0.05$.

For missing data analysis, missing completely at random (MCAR) assumptions were applied. We used pairwise deletion for one participant in sex analysis, one participant in mobile phone brand compilation and two participants in protective cover analysis.

Results

Of 163 potential participants among the attending and resident members of the anesthesia team, 129 met the inclusion criteria for study participation. Of these, only one refused to participate in the study. A total of 128 participants (69 males and 59 females) who carried their mobile phones in the surgical center were selected for participation in this study. The mean age (MA) of the participants was 37.5 (11.2) years, and the mean number of years of anesthesiology experience (MNYAE) was 10.8 (11). Of these 128 participants, 49 were anesthesiology residents (25 males and 24 females; MA: 28.3 [2.2] years; MNYAE: 1.8 [0.83] year) and 79 attending anesthesiologists (44 males and 35 females; MA: 43.4 [10.7] years; MNYAE: 16.1 [10.8] years).

Of 128 participants, one attending and one resident reported that despite carrying the device they did not use their mobile phone inside the surgical center. Of the 126 respondents who responded about their frequency of mobile phone use, only 13.5% reporting minimal use (1–5 times/day) of the device. Protective cases were used on the mobile phones of 115 anesthesiologists (91.3%). When asked about the types of activity performed on their mobile phone, Communication and Medical Practice were the most frequently mentioned activities. When comparing attendings and residents, there was greater use of mobile phones among the latter for Medical Practice ($p = 0.036$) and for Social Networks ($p < 0.001$). The results are summarized in Table 1.

Sanitization habits

We observed that the frequency of reported device cleaning differed between attendings and residents: only 2% of the residents reported cleaning their device every day (vs. 32.9% of the attendings). The results are summarized in Table 2.

Although only 59.4% of the participants performed routine mobile phone cleaning (daily or weekly), 93.8% believed that their mobile phones could be contaminated with bacteria when asked about the subject.

Among the participants who performed mobile phone cleaning, 70% ethanol was the most frequently mentioned agent used, at 88 responses (68.8% of the total). Alcoholic chlorhexidine was stated by 13 participants (10.2%). More than one response was allowed per participant.

Bacterial contamination

Of 128 mobile phones analyzed, 86 (67.2%) showed the presence of bacteria based on culturing. Coagulase-negative staphylococci (CoNS) were the most common bacteria detected, present in 67 samples of which 19 strains were found to be oxacillin-resistant to antimicrobials. *Staphylococcus aureus* was detected in 6 samples (4.7%), with one yielding a methicillin-resistant (MRSA) isolate. Three sample with *Streptococcus* spp. and a single sample with vancomycin-resistant *Enterococcus* (VRE) were also detected, as shown in Fig. 1.

No significant associations were observed when evaluating the presence of bacteria related to the use of protective covers ($p = 0.777$) and the sex ($p = 0.169$) and resident status ($p = 0.976$) of the participants.

Considering the sum of all bacteria in the analysis of the frequency of use and cleaning of mobile phones, no differences were observed in contamination related to better hygiene habits ($p = 0.148$) or higher frequency of use ($p = 0.722$). However, in the analysis of the presence of each bacterium, we observed that *Micrococcus* spp. correlated with both a higher frequency of use and a lower frequency of device sanitization, as illustrated in Table 3.

Table 2 Distribution of participants according to sanitization habits of mobile phones. Values are reported as the number (percentage).

		Overall n = 128	Attendings n = 79	Residents n = 49	*p*
Frequency of mobile phone cleaning[a]	Daily	27 (21.1)	26 (32.9)	1 (2)	**<0.001**
	Weekly	49 (38.3)	30 (38)	19 (38.8)	
	Monthly	21 (16.4)	10 (12.7)	11 (22.5)	
	Never	31 (24.2)	13 (16.4)	18 (36.7)	
		n = 97[c]	n = 66	n = 31	
Motivation for cleaning[b]	Patient contamination	40 (41.2)	26 (39.4)	14 (45.2)	0.591
	Children	21 (21.6)	20 (30.3)	1 (3.2)	**0.003***
	Personal hygiene	81 (83.5)	55 (83.3)	26 (83.9)	0.947
	Fear of disease	7 (7.2)	7 (10.6)	0	0.060

A chi-squared test was performed, yielding the *p* values listed in the table.
[a] Only one answer was allowed for this question. A chi-square test was performed on a 4 × 2 contingency table.
[b] Participants could choose more than one motivation.
[c] Participants who never sanitized their devices were excluded.

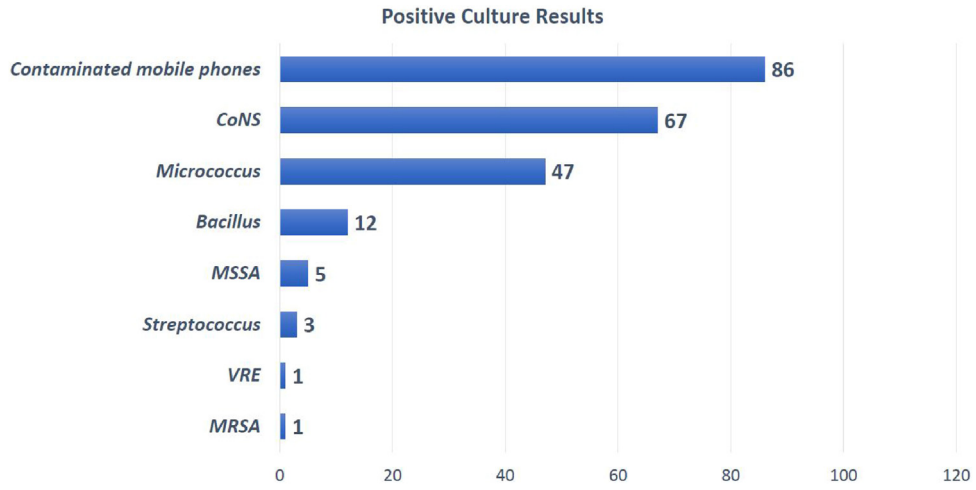

Figure 1 Positive culture results of swab samples from the mobile phones of anesthesiologists in absolute numbers. CoNS, coagulase-negative *Staphylococcus*; MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *S. aureus*; VRE, vancomycin-resistant *Enterococcus*.

Regarding contamination of the devices sanitized with cleaning products compared to that of the devices not cleaned with these products, no significant differences in device contamination were observed when using 70% ethanol (65.9% vs. 70.0%, respectively; $p = 0.648$) or Alcoholic Chlorhexidine (53.8% vs. 68.7% contamination, $p = 0.28$). When examining the presence of each bacterial group with respect to the use of each cleaning product, we observed lower contamination of *Micrococcus* spp. on devices cleaned with 70% ethanol compared to other sanitation methods or unsanitized devices (29.5% vs. 52.5% with $p = 0.013$).

Hand hygiene

Each anesthesiologist was asked to indicate when they washed their hands at the surgical center during determined situations of their routine practice. Before central venous line placement and after contact with biological material were the moments in which the most hand washing occurred. For peripheral venipuncture, prior hand washing was not performed by most of the professionals as shown in Fig. 2.

The presence of bacteria was analyzed for each of the situations in which the anesthesiologist performed hand washing, and the results showed a lower percentage of bacteria for almost all situations. Except for the situation of tracheal intubation (TI) ($p = 0.003$), this reduction was not significant as shown in Table 4.

A deeper analysis of handwashing after TI revealed a greater prevalence of *Micrococcus* spp. ($p = 0.003$; 50.7% [95% CI 38.5–63.0%] vs. 21.3% [95% CI 10.7–31.9%]) and CoNS ($p = 0.005$; 64.2% [95% CI 52.4–76.0%] vs. 39.3% [95% CI 26.7–52.0%]) in the device sample cultures for those who did not perform hand washing in this situation.

Table 3 Relationship between the presence of bacteria in swab sample cultures from devices and a) the frequency of mobile phone use in the surgical center in a single day and b) frequency of mobile phone cleaning. Values are reported as the percentage (95% confidence interval).

		Micrococcus	CoNS	*Bacillus*	*Streptococcus*	*S. aureus*	*Enterococcus*	Bacteria
a) Daily usage	1 to 5	5.9 (0–18.4)	58.8 (32.7–84.9)	5.9 (0–18.4)	11.8 (0–28.8)	11.8 (0–28.8)	0	70.6 (46.4–94.7)
	6 to 10	24 (8.5–38.6)	47.1 (29.4–64.7)	11.8 (0.4–23.2)	0	2.9 (0–8.9)	0	58.8 (41.4–76.3)
	11 to 20	48 (27.0–69.0)	60 (39.4–80.6)	8.0 (0–19.4)	0	4.0 (0–12.3)	0	68.0 (48.3–87.7)
	> 20 times	48 (33.7–62.3)	48 (33.7–62.3)	10.0 (1.4–18.6)	2.0 (0–6)	4.0 (0–9.6)	2.0 (0–6)	70.0 (56.8–83.2)
	p	**0.003***	0.659	0.93	0.549	0.228	0.369	0.722
b) Cleaning frequency	Daily	18.5 (2.9–34.2)	63.0 (43.5–82.4)	11.1 (0–23.8)	3.7 (0–11.3)	7.4 (0–18.0)	0	77.8 (61–95)
	Weekly	28.6 (15.5–41.7)	42.9 (28.5–57.2)	10.2 (1.4–19.0)	4.1 (0–9.8)	8.2 (0.2–16.1)	0	57.1 (43–72)
	Monthly	42.9 (19.8–65.9)	42.9 (19.8–65.9)	9.5 (0–23.2)	0	0	0	61.9 (39–85)
	Never	61.3 (43.1–79.5)	64.5 (46.7–82.4)	6.5 (0–15.6)	0	0	3.2 (0–9.8)	77.4 (62–93)
	p	**0.003***	0.134	0.93	0.549	0.228	0.369	0.148

A chi-square test was performed, with $p < 0.05$ indicating significance.

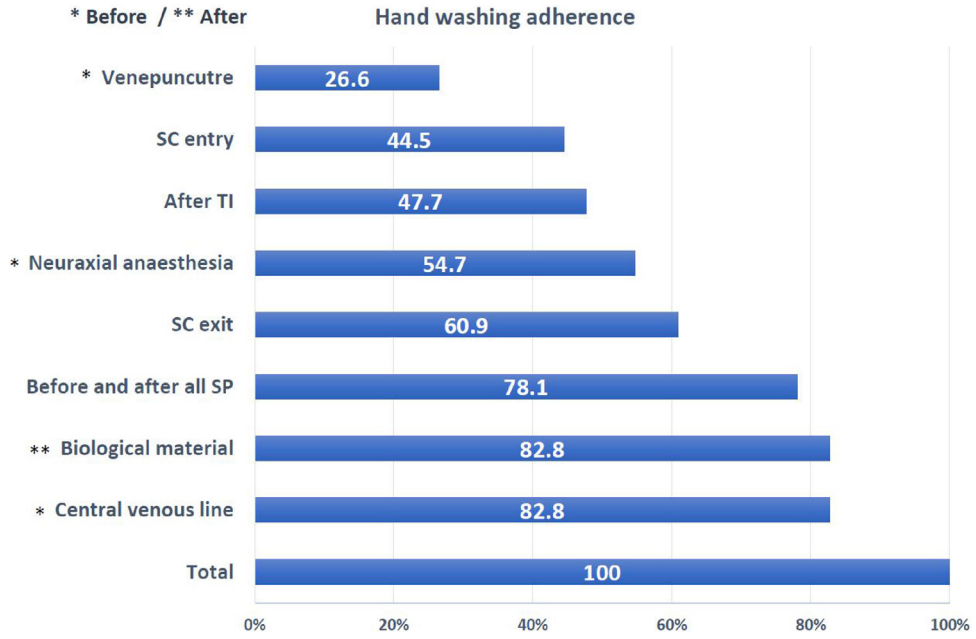

Figure 2 Occurrences of hand washing during routine practices by anesthesiologists, reported in percentages. TI, tracheal intubation; SC, surgical center; SP, surgical procedures.

Table 4 Analysis of the presence of bacteria on mobile phones related to the habit of washing hands or not in specific situations of the routine practice of anesthesiologists. Values are reported as the percentage (95% confidence interval).

Situation	Washes hands	Does not wash hands	*p*
After TI	54.1 (41.2–67.0)	79.1 (69.1–89.1)	**0.003**
SC exit	61.5 (50.5–72.6)	76.0 (63.7–88.3)	0.089
SC entry	59.6 (46.5–72.8)	73.2 (62.7–83.8)	0.104
Central venous line	64.2 (54.9–73.4)	81.8 (64.3–99.3)	0.108
Venipuncture	58.8 (41.4–76.3)	70.2 (60.8–79.6)	0.225
Before and after all SP	65.0 (55.5–74.5)	75.0 (57.9–92.1)	0.319
Neuraxial anesthesia	64.3 (52.8–75.8)	70.7 (58.6–82.8)	0.442
Biological material	67.0 (57.9–76.1)	68.2 (47.0–89.3)	0.913

*A chi-square test was performed, with $p < 0.05$ indicating significance.
TI, tracheal intubation; SC, surgical center; SP, surgical procedures.

Discussion

The present study evaluated the extent to which anesthesiologists' mobile phones can be reservoirs of pathogenic, potentially pathogenic and antibiotic-resistant bacteria. We decided not to divide the bacteria into groups according to their pathogenicity due to the imprecision of the terms "pathogenic" and "non-pathogenic". All bacteria found in the study may cause diseases in humans, varying only in their pathogenic potential.[17] Despite our knowledge of the possible major impact pathogenic bacteria would have on a patient's condition, we preferred not to use this classification in order not to mitigate the anesthesiologists' responsibility with respect to their hygiene habits.

A bacterial contamination rate of 67.2% was observed on mobile phones, which is lower than that described in other studies.[4,10] A review from 2015 indicates that the prevalence of bacteria can vary from 10–100%, with *S. aureus* being the most frequently isolated bacterium.[5] However, our bacterial profile indicated that CoNS was predominant relative to other bacteria, which is similar to the results of a study conducted by Tekerekoğlu et al.[4] This difference might be explained by the progressive decrease in the presence of keyboards and grooves in mobile phones over the years, which previously allowed for bacterial storage and hindered cleaning.[14,18] Furthermore, contamination rates vary according to the country of origin and the hospital setting studied,[6] as well as by the habit of using the devices in specific places, such as restrooms.[19]

In a study that evaluated adherence of anesthesiologists to hand washing, procedures such as peripheral venipuncture and TI were associated with the lowest rate of hygienic adherence, below 25% (vs. 26.6% for venipuncture and 47.7% for TI in our study). In contrast, central venous line placement and neuraxial anesthesia showed the highest rates of hygienic adherence.[20] Therefore, detection of a greater presence of *Micrococcus* spp. and CoNS on the mobile phones of the participants who do not wash their hands after TI is

not surprising, as this practice is recommended by the WHO in its primary hand washing guidelines.[21] A minority of anesthesia professionals are well aware of these guidelines, and the low handwashing adherence observed may be justified by a failure by these professionals to recognize potential contamination situations.[22]

We did not detect any complex dynamics related to the microbiomes of mobile phones with respect to different cleaning strategies, identifying only reduced contamination by *Micrococcus* spp. when 70% ethanol was used and when the mobile phone was frequently sanitized. This lack of impact may reflect the limitations of using self-declared questionnaires and their response biases, which might restrict the extent of the conclusions on which they are based. In addition, the heterogeneity of cleaning methods in terms of scrubbing time, pressure, and area covered among the different participants may have contributed to these results. Thus, the need for studies focused on cleaning techniques and the elimination of bacteria may be of great value to guide these practices and identify the most appropriate technique to lower the bacterial colonization of mobile phones.

From the perspective of the patients, the exploration of possible alterations of patients' flora, to investigate the link between the lack of hand hygiene after intubation and increase of *Micrococcus*, could be the subject of future research to better understand this relationship.

Conclusions

Although device microbiomes are local specific and vary according to the cleaning habits of the owners of the devices, our findings regarding the importance of hand washing to limit potential contamination are likely replicable because the hygiene habits of physicians tend to be precarious. More important than the use profile were the device sanitization and hand hygiene habits, with a higher presence of bacteria correlating to poorer hygiene habits. Limiting the use of mobile phones is not an appropriate strategy, as their benefit in intrahospital or emergency situations would be lost if their use is prohibited. Therefore, hand washing remains the best approach to prevent serious colonization of mobile devices and the possible transmission of pathogens to patients under the care of anesthesiologists.

Conflicts of interest

The authors declare no conflicts of interest.

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