BJGH Brazilian Journal of Global Health
Revista Brasileira de Saúde Global

The use of cell phones as a potential transmission route of microorganisms by health professionals in hospitals: an integrative review

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ABSTRACT

OBJECTIVE

Nosocomial infections are considered a public health issue. Such infections can originate from a range of microorganisms and many of these microorganisms can be resistant to antibiotics. The use of cellular devices can contribute considerably to the transmission and maintenance of these microorganisms in hospital environments, which represents an additional risk to hospitalized patients and to the health professionals. Thus, the aim of this study was to carry out an integrative review to observe the frequency of contamination from cell phones, as well as the frequency of the main agents found.

METHODS

For that, a validated instrument from URSI was used to analyze the main articles used in the study, the articles were collected from the VHL, PubMed, LILACS, BDENF and Medline databases. After applying the inclusion and exclusion criteria, we used 16 articles.

RESULTS

A high frequency of the presence of bacteria, fungi and viruses has been identified. Among the most frequently found agents were *Staphylococcus sp.*, *Streptococcus sp.*, *Bacilus sp.*, *Acinetobacter sp.*, *Klebsiella sp.*, *Candida sp.* Norovirus, among others.

CONCLUSIONS

Most of the health professionals' cell phones were positive for at least one of these microorganisms, such frequent findings highlight the need to establish control measures and protocols in order to reduce the risk of nosocomial infection.

DESCRIPTORS

Cell phones. Nosocomial Infections

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DOI: https://doi.org/10.56242/globalhealth;2020;1;1;42

INTRODUCTION

Nosocomial infections (NI) are those acquired after admission to a health institution or related to care procedures, which can manifest themselves during hospitalization / procedure or after discharge, including the occupational infection of the various health professionals[1].

The World Health Organization (WHO), according to data collected from different countries, estimates that currently, millions of people are affected by NI every year, and with higher incidences found in low to medium income countries. In addition, Nis results in longer hospital stays, greater disabilities, pharmacological resistance (such as antimicrobial resistance), increased financial expenses, both personal and institutional, and deaths that could be avoided [2].

WHO also points out that at least one out of ten patients who are under care or health care get some kind of infection. Due to all this scenario, WHO has as one of its strands, the control and prevention of infection in a global scope, through literature review and / or conduction of studies[2].

In Brazil, since 1997 with Law # 9431 and through Ordinance #. 2,616 May 12, 1998, the Hospital Infection Control Program (HICP) was established, which aims to reduce the incidence and severity of NI, this through the execution of a Hospital Infection Control Commission (HICC), mandatory, since then, in all hospitals nationwide[3].

In the hospital environment the most frequent microorganism related to NI are *Acinetobacter baumanii, Clostridium difficile, Enterobacter sp, Enterococcus sp, Escherichia coli, Klebsiella sp, Pseudomonas aeruginosa, Serratia marcescens, Candida sp. Staphylococcus aureus and coagulase negative Staphylococcus aureus*(CoNS). Also, the emergence of resistant strains are usually described, and severe systemic clinical manifestations are related to each of these agents [4-6].

Interestingly, bacteria have been acquiring multiple resistance to antibiotics due to the overuse of the antibiotics inside and outside of the hospitals, which impacts directly in the therapeutic options and the prognosis of each patient. This scenario gets worse by the multiple ways of transmission on these bacteria inside the hospital, that can be transmitted by direct contact by health workers during performing invasive procedures, and fomites due to poor hand hygiene and/or lack/failure in the aseptic technique of the various procedures related to therapy and care[7,8].

Smartphones represent an additional issue for this situation. Today these devices are essential to maintain the social life and for work. Unfortunately, most of the Healthcare professionals' smartphones are contaminated by bacteria, probably due to poor hygiene and disinfection of the hands and the device, resulting in the microbiota of these devices to resemble those of the hands of these same professionals, offering an feasible condition to transmission to both personal and patients[9,10]. Therefore, the aim of this study was to verify which are the main pathogenic microorganisms present in the cell phones of health professionals inside hospitals.

METHODS

This was an integrative literature review study, whose research object was the use of a cell phone and the subject the health professionals. For the analysis of the results, a validated structured form was used (Ursi, 2005)[11], which was adapted to the issues raised in the present study and the discussion of the findings. For the selection of articles, the "Virtual Health Library" (VHL) and PubMed "National Library of Medicine (NLM)" were used, using the databases "Latin American and Caribbean Literature in Health Sciences" (LILACS), "Nursing Database" (BDENF) and "Medical Literature Analysis and Retrieval System Online" (Medline). The descriptors selected for the search, together with the chosen Boolean operator, were: cell phone "AND" health professionals "AND" hospital infection "AND" pathogens "AND" fomites. To search for articles in international databases, the same Boolean descriptors and operators translated into English and were used: We preferred to use the combination of three descriptors in each search, two of which were fixed (cell phone "AND" health professionals) and the other variables.

In the initial search, 26 articles were found through the VHL portal, 98 through Pubmed and 32 directly through the Medline database. Articles in Portuguese and English were included. It was decided not to limit the limitation to the year of publication.

After inclusion, the titles and abstracts of the articles were read to identify which fit the theme of the work and were excluded from the articles; non-English and non-Portuguese papers were excluded; and those who did not meet the criteria of the topic addressed and/or the study subjects such as: students, patients, veterinary environment, dental clinic, computer equipment, clinical engineering landlines.

RESULT AND DISCUSSION

After reading the titles, abstracts and applying the exclusion criteria, nine articles were selected from the VHL portal because they fit the search profile, four were repeated. By Medline, of the 34 articles found, four were selected for the research, and of these two were repeated. By Pubmed, among the 20 selected articles, six were repeated, resulting in 14 articles for use. After excluding duplicate articles from all databases, the total search resulted 16 articles eligible for the analysis (Figure 1).

The year of 2016 presented the highest number of publications with three articles (18.75%), followed by the years 2013, 2015, 2017 and 2019 that had the publication of two articles each (12.5%). Finally, the years 2005, 2009, 2012, 2014 and 2018 had one publication each (6.25%). 87.5% of publications were made in the last decade, which corroborates the growth in the number and use of smartphones in the daily life of the world, due to the change in the pattern of smartphones[12].

Regarding the country of publication, France was the only one that had two publications (12.5%), the remaining 87.5% were made in different countries with one publication each (6.25%): Saudi Arabia, Australia , Brazil, South Korea, Croatia, United States of America, India, Northern Ireland, Israel, Nigeria, Peru, Poland, Taiwan and Turkey. Regarding the origin of the publications' journal, half were in multidisciplinary and epidemiology and infectiology journals, 37.5% were from medical journals, a nursing journal (6.25%) and one (6.25%) from biomedicine. Table 1 shows the synthesis of the articles included in the review, considering the following criteria: authors, year, method, main findings.

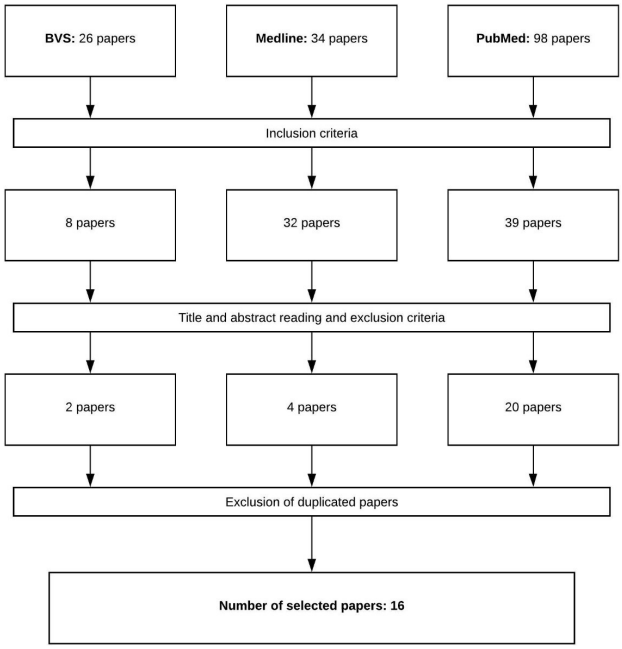

Figure 1. Flowchart of the methodological search.

Table 1. Details of the methods and main findings of the studies included in the review.

Author Date	Methods	Main findings
	Observational study with a quantitative approach. Sampling of 144 swabs collected from the entire surface of Health professionals' smartphones	The data suggests that smartphones represent an important source of bacteria in ICUs, and that poor hygiene may facilitate the transmission of multiresistant bacteria. Smartphones represent a key role for maintenance of the resistant strains in the ICU and outside of the hospital. Health professionals use their smartphones excessively in the ICU and dot not regularly disinfect them
Lee et al., 2013(14)	Observational study with a quantitative approach. Sampling of 204 swabs from health professionals' smartphones on ICUs and three university hospitals	Potentially pathogenic microorganisms were found in more than a quarter of the smartphones
Pillet et al., 2015(15)	Observational study with a quantitative convenience selection approach of 114 health professionals from adult and pediatric emergency rooms, general department of pediatrics and infectious diseases	RNA of viruses were detected in 38,5% of the devices
Stuchi et al., 2013(16)	Observational study of a quantitative approach with the convenience selection of 60 health professionals with the samples collected by means of swabs from the keyboards, sides and microphone of cellular devices, cheek mucosa of the oral cavity and nasal mucosa.	High prevalences of Staphyloccocus aureus and Streptococcus sp are found in nasal swab samples. In addition, these bacteria were also found in lower indicences in the smartphones
Borer et al., 2005(17)	Quasi-experimental study with a quantitative approach, with a random selection of 124 health professionals s, sampling collection was through dominant hand culture with Broth-bag technique and swabs on the back and sides of cell phones.	Twenty percent of the smartphones were positive for Acinetobacter sp. And around 3% of these were multiresistant strains
Volkoff et al., 2020(18)	*Quasi-experimental study with a quantitative approach with random selection of 31 nurses in the ICU and operating room. Samples were collected from the palms and fingers and front and back of the mobile devices, with previous cleaning using 70% alcohol.*	Multiresistant phenotypes were detected. Also, nine genera were detected, and the most frequent genera were: Cutibacterium, Delftia, Lactococcus, Lawsonella, Micromonospora, Staphylococcus e Streptococcus,
Ulger et al., 2009(19)	Observational study with a quantitative approach, with the convenience selection of 200 health professionals (doctors, nurses, physiotherapists, nursing students) from a surgical center and ICU, in a tertiary hospital, with cultures obtained through a sterile swab moistened with solution sterile saline from the palms and both surfaces of cell phones	Around 90% of the smartphones were positive for at least one microorganism. 34% presented more than 2 species of bacteria. Multiresistant strains were detected in 31,3% of the samples, including the hands and smartphones
Kordecka et al., 2016(21)	Observational study with a quantitative approach, with convenience selection of 175 participants (medical students and teachers) in a teaching hospital, with sample collection taken from the outer surfaces of the cover, in addition to the smartphone screen.	The most frequently species found in the participants' cell and hand samples were C. albicans, C. glabrata and C. krusei. Most of them were aware of the possibility of contamination of the cell surface (especially bacteria) and would like to clean their devices in a professional manner. There was a significant correlation between the occurrence of fungi in samples collected from hands and cell phones.
Murgier et al., 2016(22)	Quasi-experimental study with a quantitative approach, convenience selection of 52 participants (medical, nursing and radiologists), from an orthopedic surgical center in a teaching hospital, with the collection of cell phone samples through the Count Tact contact gel ®, without cleaning the phone in advance. Both sides of the telephone were sampled, before and after decontamination (4 samples per smartphone). The contact with the gel lasted 10 seconds per side.	Smartphones were contaminatedby potentially pathogenic bacteria. Decontamination by Surfanios® wipes was effective. The implication in the spread of nosocomial infection was not observed.
Foong et al., 2015(24)	Observational study with a quantitative approach, convenience selection of 226 participants (doctors and medical students) from a regional hospital, sampling was made aseptically with cotton swabs, where the first smear was removed from the entire ventral surface of the dominant hand and the second hand on both sides of the smartphone.	The bacteria found in smartphones and hands, respectively were: CoNS 58.8% (hand 51.8%), Bacillus spp. 6.2% (hand = 11.9%), Diphtheroid spp. 11.5% (hand = 8.8%), Non-hemolytic streptococci 10.6% (hand = 18.1%), Alpha hemolytic streptococci 1.3%; only in the hands; pathogenic = Coliforms 4.9% (hand = 4.0%) and MSSA 0.4% (hand = 0.4%)
Chang et al., 2017(25)	Quasi-experimental study with a quantitative approach. Convenience selection of 72 participants (nursing staff and doctors), of the operating rooms of a surgical center of a hospital, sampling of anterior nasal nostrils through smear with cotton swab against the 1 cm anterior part of the nasal vestibular wall of both nostrils, all around the smartphones, the dominant hand (dorsally and ventrally) and between the fingers.	The total rate of bacteria found was 98.1%, the nasal one were the highest (100%), followed by the dominant hand (97.2%) and smartphone (97.2%). The isolated microorganisms with pathogenic potential were 27.3%, which were more frequently found in the nostrils (58.3%), followed by smartphones (13.9%) and hands (9.7%). The most common clinical pathogen found was S. aureus (19.9%), 12.5% of which were MSSA and 7.4% MRSA, followed by Enterobacter spp. (5.6%) and Citrobacter koseri (4.6%). 97.2% of cell phones were positive for bacterial culture, and among these 94.6% were also found in the nostrils and / or hands.
Nwankwo et al., 2013(26)	Quasi-experimental study with a quantitative approach. Convenience selection of 112 participants (health professionals - doctors, nurses, pharmacists, laboratory scientists, radiologists; and students), from various departments including operating rooms and ICUs, of a teaching hospital , sampling was conducted by using sterile smears slightly moistened with saline and rubbed over the smartphone surface	The rate of bacterial contamination of health professionals' cell phones was 94.6%. S epidermitis were most frequently found in all groups, followed by S. aureus and K. pneumoniae and P. aureginosa. Multiresistant straisn were also detected in the study

In all studies, at least one species of microorganism was found in health professionals' cell phones before or after duty. Among them, the ones that stood out the most were *Staphylococcus* aureus and coagulase negative *Staphylococcus* (CoNS). However, recently it has been discovered that CoNS, despite its natural microbiota in the skin and oral and nasal mucosa in humans, are emerging as one of the largest microorganisms present in nosocomial infections due to the identification of several factors that influence its virulence[27]. Except for *Serra-*

tia spp. all microorganisms identified as NIs evidenced by Souza ES et. al and Monegro AF *et. al* were found in this study[4,5]. Table 2 shows the main microorganisms found in the study and their amplitude among them.

Table 2. Main microorganisms and their frequency in the papers included in the review.

Bacteria	# of papers that have investigated the following microorganism (n=12)	Frequency of the related microrganism
Staphylococcus sp.	12	1,6 % - 90,5%
Streptococcus sp.	8	0,5% - 56,9%
Bacllus sp.	7	1% - 24%
Acinetobacter sp.	6	1,4% - 25%
Pseudomonas sp.	5	0,5% - 31%
Klebsiella sp.	3	2,1% - 7,1%
Enterobacter sp.	3	1% - 7%
Escherichia sp.	1	14,3%
Serratia sp.	0	-
Clostridium sp.	0	-

The two papers that sought to identify the presence of fungi in smartphones, both looked specifically at the *Candida* genus. However, only the study by Kordecka *et al.*, managed to detect it, and the most prevalent species were C. glabrata (74.9%), *C. albicans* (65.1%) and C. *krusei* (54.3%). The only article that had the detection and presence of viral contamination, the authors chose to identify the RNA viruses, and its incidence was in 38.5%, as follows: Rotavirus (92, 8%), Respiratory Syncytial Virus (7.14%) and Metapneumovirus (2.38%)[15,16,21].

All articles that covered the identification of bacteria, showed the presence of at least one multi-resistant microorganism on the smartphones, which further increases the risk of contamination and spread of these strains specially in immunosuppressed patients. In the study by Stuchi et. al,[10] types of antibiogram were tested for S. *aureus* resistance and only three antibiotics were shown to be the most effective (oxacillin, netilmycin and ciprofloxacin), with total resistance to penicillin G and partial high resistance to trobamycin, which confirms this issue[16].

The study by Ulger F. et al, showed that the professionals who used rings were those who had the highest average count of bacterial colonies on their smartphones. This demonstrates that, in addition to participation in increasing hand contamination in the hospital environment, rings have an important role in the spread of microorganisms from the hands to the cell phone (and vice versa), which confirms the importance and compliance with Regulatory Norm nº 32 (NR-32) as a form of personal and patient protection[19,28].

There is still no official protocol used by the institutions with regard to the use and disinfection of cellular devices, however the studies found in this research reinforce that the disinfection of the cellular device with 70% alcohol-based products, hand hygiene before and after of use and the lowest possible use should be encouraged in order to avoid the spread of microorganisms inside and outside the hospital environment, especially with regard to multidrug-resistant strains.

Recently, due to the SARS-CoV2 pandemic, several smartphones manufacturers have positioned themselves in relation to the cleaning of their products, as in this time there has been an increasing number of searches and contact with institutions on the best way to eliminate the SARS-CoV2 of your devices. The recommendation of the main manufacturers (Apple®, Asus®, LG®, Motorola® and Samsung®) is cleaning with 70% isopropyl alcohol, as the product is the most suitable for disinfecting electronics due to its chemical structure that makes oxidation difficult and destruction of parts. This cleaning must be preceded by hand hygiene with alcohol gel or soap and water, the device must be turned off, unplugged and, obviously without the protective cover that can be cleaned separately with a soft cloth[29].

CONCLUSIONS

The diversity of countries on all the continents listed in this research reveals that the problem and difficulties related to the use of cell phones in hospital settings are not restricted to only some regions or developing countries. It is proven that cell phones, especially Smartphones, due to their ease, technology, and insertion in the modern world, and in the professional sphere, cannot be prevented from being used in the hospital environment. However, its use must be limited through the awareness of its users as a way of preventing the propagation and dissemination, at work and at home, of potentially pathogenic and multi-resistant microorganisms.

Although there are no official protocols or guidelines related to the cleaning, disinfection and use of cell phones in hospitals, institutions, under the coordination and supervision of the CCIH and education, should reinforce hand hygiene before and after its use, and disinfection according to the manufacturers' suggestions may considerably prevent NI.

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