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CELL PHONE USAGE BY HEALTH PERSONNEL: PREVENTIVE STRATEGIES TO DECREASE RISK OF CROSS INFECTION IN CLINICAL CONTEXT

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ABSTRACT

Objective: with the intent of describing the characteristics of cell phone use by Health Personnel and identify strategies to prevent these equipments from acting as vectors of transmission for multiresistant microorganisms.

Method: an integrative review of the literature was carried out following the PICOD Method. An appropriate research strategy was developed at each base/repository EBSCO platform, MEDLINE and CINAHL databases and search engines PubMed, B-on and Google Scholar to identify relevant studies. It was elaborated a formal protocol, including studies published from 2006 to 2016. The titles/abstracts were analyzed, excluding articles that do not meet the criteria defined in the protocol. Data extraction was performed from the remaining included articles.

Results: 13 studies met the defined criteria for this review. After a comprehensive analysis, it can be concluded that healthcare personnel' cell phones constitute a reservoir of pathogenic microorganisms that may affect patient safety.

Conclusion: user hand hygiene, cell phone disinfection and education of health personnel are the main preventive strategies. Technological innovation can be a strong ally for health personnel and organizations by creating new equipment such as antibacterial covers and films or ultraviolet light for sanitary purposes. This review opens the door for further research to be undertaken in this area.

DESCRIPTORS: Health personnel. Cell phones. Strategies. Cross infection.

USO DO TELEFONE CELULAR PELO PESSOAL DA SAÚDE: ESTRATÉGIAS PREVENTIVAS PARA REDUZIR O RISCO DE INFECÇÃO TRANSFRONTEIRA NO CONTEXTO CLÍNICO

RESUMO

Objetivo: descrever as características do uso do telefone celular pelo pessoal de saúde e identificar estratégias para evitar que esses equipamentos atuem como vetores de transmissão para microorganismos multirresistentes.

Método: revisão integrativa da literatura realizada seguindo o Método PICOD. Uma estratégia de pesquisa apropriada foi desenvolvida em cada banco de dados de base/repositório EBSCO, bases de dados MEDLINE e CINAHL e motores de busca PubMed, B-on e Google Scholar para identificar estudos relevantes. Foi elaborado um protocolo formal, incluindo estudos publicados de 2006 a 2016. Os títulos/resumos foram analisados, excluindo artigos que não atendem aos critérios definidos no protocolo. A extração de dados foi realizada a partir dos restantes artigos incluídos.

Resultados: 13 estudos preencheram os critérios definidos para esta revisão. Após uma análise abrangente, pode-se concluir que os telefones celulares do pessoal de saúde constituem um reservatório de microorganismos patogênicos que podem afetar a segurança do paciente.

Conclusão: a higiene das mãos dos usuários, a desinfecção do telefone celular e a educação do pessoal de saúde são as principais estratégias preventivas. A inovação tecnológica pode ser um aliado forte para o pessoal de saúde e as organizações criando novos equipamentos, como tampas antibacterianas e filmes ou luz ultravioleta para fins sanitários. Esta revisão abre a porta para novas pesquisas a serem realizadas nesta área.

DESCRIPTORS: Pessoal da saúde. Telefones celulares. Estratégias. Infecção Hospitalar.

USO DEL TELÉFONO CELULAR POR EL PERSONAL DE SALUD: ESTRATEGIAS PREVENTIVAS PARA REDUCIR EL RIESGO DE INFECCIÓN CRUZADA EN EL CONTEXTO CLÍNICO

RESUMEN

Objetivo: describir las características del uso del teléfono celular por parte del personal de salud e identificar estrategias para evitar que estos equipos actúen como vectores de transmisión de microorganismos multirresistentes.

Método: una revisión integradora de la literatura siguiendo el Método PICOD. Se desarrolló una estrategia de investigación apropiada en cada base / repositorio de la plataforma EBSCO, las bases de datos MEDLINE y CINAHL y los motores de búsqueda PubMed, B-on y Google Scholar para identificar los estudios relevantes. Se elaboró un protocolo formal, que incluye estudios publicados de 2006 a 2016. Se analizaron los títulos / resúmenes, excluyendo los artículos que no cumplen con los criterios definidos en el protocolo. La extracción de datos se realizó a partir de los artículos incluidos restantes.

Resultados: 13 estudios cumplieron los criterios definidos para esta revisión. Después de un análisis exhaustivo, se puede concluir que los teléfonos celulares del personal sanitario constituyen un reservorio de microorganismos patógenos que pueden afectar la seguridad del paciente.

Conclusión: la higiene de manos del usuario, la desinfección del teléfono celular y la educación del personal de salud son las principales estrategias preventivas. La innovación tecnológica puede ser un fuerte aliado para el personal de salud y las organizaciones mediante la creación de nuevos equipos como fundas antibacterianas y películas o luz ultravioleta para fines sanitarios. Esta revisión abre la puerta para futuras investigaciones en esta área.

DESCRIPTORS: Personal de salud. Teléfonos celulares. Estrategias. Infección hospitalaria.

INTRODUCTION

The prevalence of Health Care Associated Infections (HCAI) has increased considerably, hindering patient treatment, which constitutes a serious dilemma for managers and health personnel because it implies prolonged hospital stay, long term disability, increased resistance of microorganisms to antimicrobials, a massive additional financial burden for health systems, high costs for patients and their families, and an excess of deaths.¹ This type of infection develops during the course of health care treatment and it is considered a major obstacle to quality of care.¹

In Europe, a study conducted between 2011 and 2012, coordinated by the European Centre for Disease Prevention and Control shows that the prevalence of HCAI was 5.7% and *Pseudomonas aeruginosa* (15.9%), *Enterobacter* (10.3%) and *Escherichia coli* (10.1%) were the most prevalent bacteria.²

HCAI are a broad concept of infection acquired by users and professionals associated with the provision of care, regardless of where they are provided (acute wards, rehabilitation wards, ambulatory settings and others).³ HCAI are generally associated with invasive techniques, some performed by nursing professionals.⁴ However, the spread of HCAI is complex and multifactorial, and multiple recent studies demonstrate the ability of inanimate objects or surfaces to function as a vector of transmission for multiresistant microorganisms that can cause diseases.⁵

Adverse effects caused by pathogenic microorganisms depend on several factors and their ability to invade the host and multiply themselves in order to trigger signs and symptoms of infection. This dissemination or transmission from the reser-

voir or source, can be direct or indirect.⁶ In direct transmission there is immediate contact between the reservoir and a host. In indirect transmission, the agent can either reach the host through physical contact with an intermediary inanimate vector, for example, contaminated medical equipment, or an animate vector, such as hands, droplets or liquid particles. Indirect transmission can also be carried aerogenically from the use of aerosols, microbial spores from contaminated dust, etc.⁶ By becoming aware of their role as potential agents of infection in a health care environment, health personnel, where nurses play a key role, need to focus their collective efforts in providing quality care to their patients by providing safe practices to help prevent and reduce HCAI.

Since 1980, when it was first launched on the market as a innovative product for telecommunication, the cell phone has grown in popularity around the world. It is estimated that between 2016 and 2017, more than 4.5 billion people (roughly, 60% of the entire world's population) had a cell phone. This number is expected to increase to 67.6% by 2019.⁷ This growth was accentuated around 2012 with the commercialization of smartphones, cell phones with intelligent software able to perform tasks beyond the traditional calls and messages between users, such as navigating through the internet, taking pictures and videos, playing multimedia games, among others. It is estimated that around 2.3 billion people have a this type of equipment.⁷

Given the above, and since patient safety and the quality of care provided are two fundamental pillars in nursing professional practice and conduct,

the following question was formulated: "Regarding Health Personnel, what are the characteristics of cell phone use and what strategies can be adopted in order to prevent these equipments from acting as possible vectors for the transmission of multiresistant microorganisms?". Thus, with this article, we intend to describe the characteristics of cell phone use by health personnel and identify strategies to prevent these equipments from acting as vectors

of transmission for multiresistant microorganisms.

METHOD

In order to point out the pertinence of this paper, the following research question was elaborated: "regarding health personnel, what strategies can they adopted in order to prevent cell phone from acting as possible fomites?". This was possible through the use of the PICOD Method (Table 1).

Table 1 - Formulation of the research question through the PI[C]O[D] method

	PI[C]O[D] Method	Keywords
P (Participants)	Health personnel	Health care workers OR Health professionals AND Hospital infection OR Cross-contamination OR Nosocomial Infection OR Fomite AND Cell phone OR Mobile phone OR phone
I (Interventions)	Preventive strategies	
O (Outcomes)	Cell phone act as possible vector for the transmission of multiresistant microorganisms	

In order to review the published research, a comprehensive search of the EBSCO platform, MEDLINE and CINAHL databases and search engines PubMed, B-on and Google Scholar was performed during April and May 2016, combining the above keywords. Only articles published from 2006 onwards, in Portuguese or English and in full text were accepted for this review. A total of 106 initial articles were found.

The search results were included in endnote file and duplicates were removed (n=12). The remaining studies were assessed for relevance based on title and abstract by two independent reviewers, using the pre-determined inclusion and exclusion criteria: regarding the participants (P), studies that emphasized other related health personnel such as veterinarians and studies based on other types of interventions (I) other than preventive, such as interventional or resolatory, were excluded. In the outcome domain (O), studies focused in other communication devices such as computers, laptops, pagers, tablets, etc. were excluded. Finally, and concerning the study design (D), only articles with quantitative or qualitative method were selected. Out of the remaining studies (n=94), 63 were excluded after confronting the articles title and abstract with the defined inclusion criteria.

Whenever the title and abstract lacked data to make a decision, two reviewers examined the full-text articles independently to check whether they met the inclusion criteria described above. Any disagreements that arose between the reviewers

were resolved through discussion, or with a third reviewer. Of the remaining articles (n=31), 18 were excluded after full-text analyzes (10 due to the type of study, 4 due to type of participants, 2 due to setting and 2 due to full-text unavailability and lack of reply from the authors).

Data was extracted from the included articles by following the Cochrane Method,⁸ and included specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. Any disagreements that occurred between the reviewers were resolved through discussion, or with a third reviewer.

RESULTS

A final number of 13 studies were selected for the purpose of this paper (Table 2). In order to facilitate the analysis of the chosen results for conducting the literature review, brief description of the type of study, main objectives and participants is presented.

In accordance with the results obtained, the prevalence rate for potential infection agents ranged from 10% to 100% of the total samples. It should be noted that the prevalence of 10% was identified in a literature review,⁹ and did not specifically examine which characteristics and conditions of the study were conducted to these results. Almost half of the selected studies presented a microorganism contamination rate among health Personnel' cell phones above 90%.¹⁰⁻¹⁵

Table 2 – Description of type, aim, participants and setting about selected studies

Ref.	Description
9	Type of study: literature review. Aim: analyze different studies on the relationship between cell phone use and cross contamination, reporting findings in common. Participants: 4.876 multidisciplinary health personnel. Setting: general/teaching hospitals and medical schools in several countries such as India, Saudi Arabia, Turkey, United Kingdom, Canada, Korea, Israel, United States of America, Egypt, Singapore, Nigeria and others.
10	Type of study: cross-sectional. Aim: alert health personnel to the need of adopting preventative behavioral measures related to cell phone usage. Participants: 60 members of a multidisciplinary team. Setting: hospital in Brazil.
11	Type of study: observational analytical. Aim: evaluate the microbial load present in the cell phones used by health personnel. Participants: 183 health personnel. Setting: in multiple wards from a secondary referral hospital (including the intensive care unit) in Turkey.
12	Type of study: cross-sectional. Aim: compare microbial contamination rates of cell phones with and without keyboard between health personnel and other professionals in the hospital setting. Participants: 76 multidisciplinary health personnel. Setting: two hospitals in Turkey.
13	Type of study: cross-sectional. Aim: compare the bacterial contamination rates with pathogenic potential of smartphone cell phones and not smartphone. Participants: 203 multidisciplinary health personnel. Setting: general wards and intensive care units from three teaching hospitals in South Korea.
14	Type of study: observational analytical. Aim: determine whether health personnel' phones are contaminated and if cell phones from hospital administrative/clerical staff show similar results. Participants: 51 multidisciplinary health personnel and 36 clerical staff. Setting: hospital and corporate office in India.
15	Type of study: observational analytical. Aim: determine the contamination rate of cell phones belonging to health personnel in the intensive care unit and operating theater. Participants: 200 Health Personnel. Setting: mixed tertiary intensive care unit and 14 operating rooms in Turkey.
16	Type of Study: Cross-sectional. Aim: investigate the level of contamination on cell phones used in the operating theater and identify strategies for safe usage in these clinical settings. Participants: 50 members of a surgical multidisciplinary team. Setting: inpatient wards in Northern Ireland.
17	Type of study: cross-sectional. Aim: assess the impact of basic disinfection and cleaning interventions to combat bacterial contamination in cell phones. Participants: 87 physicians. Setting: general hospital in the United Kingdom.
18	Type of study: cross-sectional. Aim: to analyze the presence of bacteria in cell phones used in orthopedic operative theater and test the effectiveness of recommended cleaning protocols. Participants: 53 orthopaedic surgeons. Setting: operating room from a hospital in the United States of America.
19	Type of study: literature review. Aim: review of existing literature regarding cell phones as reservoirs of pathogens in the clinical setting. Participants: 1.600 multidisciplinary health personnel. Setting: Children's Hospital, Tertiary Care Hospital, Teaching Hospital, Metropolitan Hospital and Medical Centre in the United Kingdom, Canada, Israel, United States of America, Barbados, Turkey and Austria.
20	Type of study: cross-sectional. Aim: documenting the potential risks and benefits associated with the usage of cell phones in the clinical setting. Participants: 110 Physicians. Setting: tertiary care teaching hospital in Barbados.
21	Type of study: observational analytical. Aim: analyze if the bacterial contamination on cell phones with touchscreen technology is lower than in devices with keyboard. Participants: 71 multidisciplinary health personnel Setting: hospital in the United Kingdom.

Prevalence and commonly isolated organisms

When comparing all included studies, the most commonly isolated organisms were the Coagulase-negative *Staphylococcus* spp. (from 48.7% to 95.6% of all samples tested), *Staphylococcus aureus* spp. (from 6.7% to 66.7% of all samples), and *Acinetobacter* spp. (1% to 33% of all samples). These results vary across studies, with special attention to discrepancies relating to methods of study, clinical study contexts and geographical location.

The existence of polymicrobial cultures was mentioned in all analyzed studies, varying between one and more than six colonies per tested sample. According to Srikanth et al.,¹⁴ 74% of the collected

samples showed two to three polymicrobial cultures. Similar results were identified by Koroglu et al.,²¹ although mean values of five bacterial cultures were also isolated.¹⁶

Several of the analyzed authors expressed their concerns regarding the number of colonies that present high levels of microbial resistance: in Stuchi et al.¹⁰ 100% of isolated cultures of *Staphylococcus aureus* were resistant to Penicillin G, while 3.57% to 28.58% had resistance to common antibiotics in clinical settings such as Oxacillin, Erythromycin, Clindamycin, Ciprofloxacin, Gentamicin and Amikacin. These concerns were shared in other studies which found resistance rates of *Staphylococcus aureus* to Methicillin averaging 9.5% to 52% of all held samples.^{11,17} A high

percentage of the Gram negative bacteria isolated in were also resistant to Ceftazidime (31.3%).¹⁵

Influence of setting, health personnel demographics and clinical role in cell phone contamination

As referenced before, the results obtained vary according to the clinical setting involved. Cell phones from health personnel working in intensive care units showed a higher rate of bacterial contamination compared to health personnel working in other clinical areas.¹¹ This relationship was not observed in any other of the studies analyzed, although mention an high contamination rate in cell phones from professionals working in inpatient settings such as intensive care units, operating theaters, dialysis units, burnt centres and others.^{9-10, 18-19}

Regarding health personnel's cell phones, and according to all the studies analyzed, demographic data such as age, gender and education level did not show any impact on bacterial contamination rates. However, cell phones belonging to doctors present a higher infection rate, followed by health technicians and finally nurses (although with no statistical significance)¹⁹. In accordance, one of the studies examined the bacterial contamination rate of cell phones and the hands of the respective holders of such equipment having obtained a higher risk of contamination in doctors' phones, followed by support workers and, finally, nurses.¹⁵

In one study, cell phones from both health personnel phones involved in direct contact with patients and hospital administrative/clerical professionals and managers were analyzed, concluding that cell phones belonging to the latter group had a higher microbial contamination rate (78%) and a greater number of colonies (of which 29% were considered pathogenic specimens).¹⁴ With regard to health personnel, doctors' cell phones showed higher infection rates. In contrast, and according to Koroglu et al,¹² which also analyzed the equipment of these two groups in the hospital context, the infection rate among health personnel directly involved with patients and other professionals in the hospital setting were similar (95% and 91%, respectively).

Health personnel common practices relating to cell phone cleaning and disinfection

Regarding to the professionals' behaviour, most of the authors were consensual on their results: in one study 96.7% of the professionals involved never disinfected their phone.¹¹ Similar results

were obtained,^{14-15,17} in which 88%, 89.5% and 92%, respectively, of the professionals never considered cleaning and disinfect such equipment, and those who do have described techniques and cleaning/disinfection agents labeled as ineffective by the authors (e.g. paper wipes soaked in water). In one study, 24% of the health personnel said to disinfect their phone on a daily basis (24%), although it is not specified which technique and agents are used.¹⁶

Two of the selected studies analyzed the contamination rates before and after a unique moment of disinfection, with both studies showing a drastic decrease in percentage terms: in the first study a decrease of around 87.5% was observed and in the second approximately 79%.¹⁷⁻¹⁸ However, in the first study, new samples were collected from the same equipments analyzed one week later, having obtained a 75% infection rate, which may indicate a failure to adopt preventive strategies by professionals. The adoption of preventive strategies by health personnel has been addressed in one particular study, in which 10% of the participants perceived their phone as a clean equipment and 57% of the professionals only contemplated changing their practices if they witnessed results which would conclusively prove the contamination of their cell phones by microorganisms.¹⁶ This passivity on the part of Health Personnel was also identified in another study,⁹ with all of the health personnel involved in the study thinking that their cell phones could not be considered a vector for multiresistant microorganisms.

Moreover, some of the authors pointed out findings relating to the contamination of health personnel's hands and inappropriate compliance with clinical safety protocols. One study found that 45% of professionals "never" washed their hands before and after using their cell phones, 38% "occasionally" and only 17% said "consistently".¹⁶ Similarly, another study found that 97% of the professionals involved do not wash their hands before and after use the equipment and 47% never disinfected their phones.²⁰ In another study was detecting an equal existing microbial flora in health personnel's cell phones and their hands (equal in average 6.7% to 10%).⁹ In the same sequential line, identical strains of *Staphylococcus aureus* specimens resistant to Methicillin have been identified in 52% of the analyzed cell phones and in the hands of 37.7% health personnel who carried them.¹⁵

Cell phone's characteristics and contamination rate

Some authors analyzed the possible link between physical characteristics (size, width, metal

fixtures, etc.), having touchscreen or keyboard, the type of technology of the different cell phones and the contamination rate by microorganisms. One study,¹² found no statistical significance between the physical characteristics of the equipments and the contamination rate, although it has identified a large number of bacterial colonies on touchscreen equipments. However, some authors found opposite conditions, and phones with keyboard were those who showed higher contamination rates. In addition, the authors found that owners of cell phone with smartphone technology had higher infection rates⁸ in cell phones with keypad displaying higher contamination rates, a bigger number of polymicrobial cultures and antibiotic-resistant colonies.²¹

One study concluded that the type of technology possessed by these devices determines their contamination level, with smartphones presenting larger numbers of colonies and higher probability of these being pathogenic microorganisms (34.8%).¹³ The authors believe that this relationship is due to the usage patterns of these devices, which are used for a longer period of time and require more frequent finger touches. Use of devices with larger screens, commonly associated with this type of technology, seems to play another important factor, since there is a greater contact surface between the equipment and the fingers/palms of health personnel.¹³

Cell phone as a clinical tool of common use

Most authors confirm that the use of cell phones by health personnel in the clinical setting is a current and relevant reality. One of the selected studies reveals that 95% of the professionals consider the cell phone as an extremely important work tool.²⁰ In accordance, 50% to 65% of the respondents confirmed the use of this equipment when in direct interaction with patients.¹⁹ With similar results, one study found that 88% of the professionals use the phone in the clinical setting, 9% of them more than 20 times per shift and 55% of them justified their use by labeling it a "work tool".¹⁶ More regularly, and in study from 2015 the use of cell phones by health personnel ranged from 20 to 50 times per shift. However, 75% of those involved do not consider that banning this equipment from the clinical setting would be a practical or realistic measure to combat HCAI.¹⁸ In a slightly opposite perspective, research from one study showed that 73% of the professionals enquired consider that applying restriction policies on cell phone usage in the clinical setting is an efficient preventive measure to be adopted.¹⁴

The concern shared by some of the authors

regarding the role of cell phones as vectors of microorganism's transmission inside and between health institutions should be noted, since the mobility of professionals between different health institutions is a contemporary reality. However, an added value to this matter given the risk assigned to it in terms of public health.¹¹ Agreeably, some authors emphasize their concerns regarding not only what is due to patient safety in a clinical setting, but also when considering the surrounding community, given the cell nature and easy accessibility of cell phones, which can be a vector of pathogenic transmission between individuals. The authors cite the example of health personnel' families, especially younger children, as secondary users of these same equipments.⁹

DISCUSSION

In order to combat contamination of cell phones by microorganisms, the vast majority of the analyzed authors agree on three preventive strategies of capital importance: washing their hands before and after the use of such equipment, regular and standardized disinfection of cell phones and education of health personnel in relation to this theme.

Hand hygiene

Some authors consider the adoption of strict policies regarding hand hygiene, glove use adapted to the various clinical interventions and adequate waste management policies, which will positively impact and influence contamination rates.^{10-11,16} The hands of health personnel are considered the main source of contamination of cell phones, hence the importance of hand washing in breaking the hands-phone-health professional's face cycle of contamination, given the high risk to the health personnel themselves in the sense that the cell phone usage increases the risk of contact of pathogens with "gateways" to the human body such as the ear canal, nasal cavity, eyes and oral cavity.^{15,19} This finding may explain results obtained in one particular study, which found colonization by *Staphylococcus aureus* and *Streptococcus mitis/salivaris* not only in health personnel' cell phones, but also in their nasal and oral cavity.¹⁰

Cell phone disinfection is understood as the most consensual preventive strategy among authors. Disinfection should meet the specific needs of each equipment, which hinders the diffusion of generalized procedures in this regard, and the manufacturer's recommendations must be respected in order to not jeopardize the orderly functioning and integrity

of the equipment. Some of the authors identified isopropyl alcohol as the most adequate disinfecting agent for such equipments.^{9,11,14,17-18} The allusion to ethyl alcohol 70%, 0.5% chlorhexidine and ammonia solution was referenced by some authors, although the it has been verified that these options did not show similar and as satisfactory results in combating contamination of cell phones by microorganisms.^{11,19}

Continuous education and training has been referred to as the other major preventive strategy, which could be justified by the passive and uninformed attitude demonstrated by various health professional groups involved. Although cell phones are widely used in clinical practice, they are not considered medical equipment, which eliminates the requirement for manufacturers to publish disinfection protocols in several of the countries involved in the studies analyzed.¹⁹ Health institutions, regardless of the specifics of each device should implement guidelines for that express the need for regular disinfection of all professional's cell phones, their restricted use or ban in all units or risk-added services (intensive care units, operating theater, etc.) and strengthening of hands hygiene policies before and after the use of the devices.⁹

In addition to these findings, some authors consider that institutional guidelines for other information and communication devices such as computers (and all its components) and tablets are more in number, given the fact that these equipments belong to the health institutions, but the same position should be taken in respect of health professional's cell phones.¹² In addition to these facts, surveillance and internal legislation developed by health institutions on the impact of cell phone use in the clinical setting is very small, and mostly focused on aspects such as patient confidentiality, clinical information governance, noise in the clinical areas, interference with medical equipment and distraction of professionals that may lead to clinical errors.¹⁹

Some studies consider the restriction or ban of these equipments in the clinical setting as a preventive strategy to be implemented by managers of health facilities.¹⁸⁻¹⁹ A few studies briefly mention other preventive strategies such as the use of bluetooth devices (hands-free), the use of disposable antibacterial cases and protective films or the use of equipment that emits ultraviolet light for health and safety purposes.

Additionally, all authors pointed out that none of the strategies were properly studied, and it is undetermined if they will be effective in reducing cell phones contamination rates, or even if some equip-

ment damage may result from its adoption.^{9,17,19} The future use of nanotechnology based on substances such as titanium dioxide, oxide silver or zinc dioxide could prove useful in creating protective films with possible impact on reducing contamination by microorganisms.⁹

Given its integrative nature, the selection of descriptors, databases and languages for conducting the research may have conditioned the final results. Some authors expressed the need for further epidemiological studies to corroborate the importance of this matter and agree that despite the results, it is uncertain what the true relationship between the contamination of health personnel' cell phones and HCAI due to the lack of studies that show a direct connection between the two.⁹⁻¹⁰ In the same perspective, one study add that the impact of preventive strategies outlined have not been properly investigated, despite the scarce specific results in some studies.¹⁹

CONCLUSION

The use of cell phones by health personnel in the clinical setting is a contemporary practice and a growing factor of concern amongst the scientific community. Initially criticized due to ethical and legal jurisdiction matters, it is now seen as a threat to patient safety, acting as a reservoir and transmission vector of pathogenic microorganisms. Thus, the cell phone may be a means of transmission of pathogens during clinical practice and may result in prolonged hospitalization, extraordinary financial costs, health risks, and ultimately, a patient's death. However, there are no studies that support how these agents present on cell phones affect the patient, stressing the need for further epidemiological and exploratory studies to better understand the problem.

On the other hand, as corroborated by some authors and upon its examination, the safety of the health personnel themselves is threatened with the contamination of their phones by microorganisms. Phone usage promotes a constant cycle that consists of the hands, phone and face of these professionals, which enhances the contact between pathogens and a "gateway" to their body such as the oral and nasal cavity, ear canal and eyes (all involved when using a cell phone). Consequently, the risk of developing diseases increases, which can lead to illness and absenteeism, resulting in extra financial costs for health institutions, for health personnel and their families.

Due to its unique characteristics, cell phones are presented as highly plausible vector for multiresistant microorganisms, representing a risk of infec-

tion at an intra and inter-organizational level, as well as public health risk for the surrounding communities. Currently, and increasingly, these devices have several multimedia and recreation features, and are used in various social contexts, which may expose individuals to different pathogenic specimens, some of which are resistant to common antibiotics in clinical practice. In this sense, the health professional's family members such as children may become ill, leading to absenteeism of said health personnel for the purpose of parental monitoring, lead to new admissions into care units, additional costs associated with health care, among others.

Therefore, it is imperative to adopt preventive strategies by health personnel, recognized and promoted by their own health institutions, given the impact that the subject could lead to a patient, health personnel and the surrounding community. The change in practices and mentalities, emerging or planned, should be based on three fundamental pillars: strengthening optimal hand washing practices before and after the use of such equipment, disseminate continuous cell phone disinfection and cleaning policies and raise awareness campaigns for professionals and patients, so that all parties involved recognize the urgency, and risks associated with cell phone contamination by microorganisms. In addition, with the rapid and promising development of new technologies, the emergence of new tools such as antibacterial films, ultraviolet radiation emitting devices and protective covers developed using nanotechnology could help health institutions and professionals to better their hygiene and disinfection practices, allowing greater control of HCAI. However, these new technological bets require proper assessment by conducting new studies in order to support the impact before its possible implementation.

REFERENCES

1. World Health Organization. Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. Geneva (CH): WHO Document Production Services; 2016 [cited 2017 Jun 17]. Available from: <http://www.who.int/gpsc/core-components.pdf>
2. European Centre for Disease Prevention and Control. Annual Epidemiological Report 2013: reporting on 2011 surveillance data and 2012 epidemic intelligence data. Stockholm (SE): ECDC; 2013 [cited 2017 Jun 17]. Available from: <https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/annual-epidemiological-report-2013.pdf>
3. World Health Organization. Global Guidelines for the Prevention of Surgical Site Infection. Geneva (CH): WHO Document Production Services; 2016 [cited 2017 Jun 17]. Available from: <http://apps.who.int/iris/bitstream/10665/250680/1/9789241549882-eng.pdf?ua=1>
4. Souza E, Belei R, Carrilho C, Matsuo T, Yamada-Ogatta S, Andrade G, et al. Mortality and risks related to healthcare-associated infection. *Texto Contexto Enferm* [Internet]. 2015 [cited 17 Jun 2017]; 24(1):220-8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-07072015000100220
5. Vale B, Dinis A. The role of fomites in the transmission of infectious diseases. *Saúde Infantil* [Internet]. 2011 [cited 17 Jun 2017]; 33(1):23-27. Available from: http://saudeinfantil.asic.pt/download.php?article_id=217
6. Wilson J. *Controlo da infeção na pratica clínica*. 2nd ed. Lisboa (PT): Lusociência; 2003.
7. Statista P. Mobile phone penetration worldwide 2013-2019 [Internet]. Portal Statista. 2017 [cited 17 Jun 2017]. Available from: <https://www.statista.com/statistics/470018/cell-phone-user-penetration-worldwide/>
8. Higgins J, Green S. *Cochrane handbook for systematic reviews of interventions*. 2011 [cited 17 Jun 2017]. Available from: www.handbook.cochrane.org.
9. Ulger F, Dilek A, Esen S, Sunbul M, Leblebicioğlu H. Are healthcare workers' mobile phones a potential source of nosocomial infections? Review of the literature. *J Infect Dev Ctries* [Internet]. 2015 [cited 17 Jun 2017]; 9(10):1046-53. Available from: <https://jicd.org/index.php/journal/article/view/26517478/1391>
10. Stuchi R, Oliveira C, Soares B, Arreguy-Sena C. Contaminação bacteriana e fúngica dos telefones celulares da equipe de saúde num hospital em Minas Gerais. *Cienc Cuid Saude* [Internet]. 2013 [cited 17 Jun 2017]; 12(4):760-7. Available from: http://periodicos.uem.br/ojs/index.php/CiencCuidSaude/article/download/18671/pdf_90
11. Ustun C, Cihangiroğlu M. Health care workers' mobile phones: a potential cause of microbial cross-contamination between hospitals and community. *J Occup Environ Hyg* [Internet]. 2012 [cited 17 Jun 2017]; 9(9):538-42. Available from: <http://www.tandfonline.com/doi/pdf/10.1080/15459624.2012.697419>
12. Koroglu M, Gunal S, Yildiz F, Savas M, Ozer A, Altindis M. Comparison of keypads and touch-screen mobile phones/devices as potential risk for microbial contamination. *J Infect Dev Ctries* [Internet]. 2015 [cited 17 Jun 2017]; 9(12). Available from: <https://jicd.org/index.php/journal/article/view/26719936/1427>
13. Lee Y, Yoo C, Lee C, Chung H, Kim Y, Han S, et al. Contamination rates between smart cell phones and non-smart cell phones of healthcare workers. *J Hosp Med* [Internet]. 2013 [cited 17 Jun 2017]; 8(3):144-7. Available from: <http://onlinelibrary.wiley.com/doi/10.1002/jhm.2011/pdf>
14. Srikanth P, Rajaram E, Sudharsanam S, Lakshmanan A, Mariappan U, Jagannathan K. Mobile phones:

- emerging threat for infection control. *J Infect Prevent* [Internet]. 2010 [cited 17 Jun 2017]; 11(3):87-90. Available from: <http://journals.sagepub.com/doi/pdf/10.1177/1757177410364866>
15. Ulger F, Esen S, Dilek A, Yanik K, Gunaydin M, Leblebicioglu H. Are we aware how contaminated our mobile phones with nosocomial pathogens?. *Ann Clin Microbiol Antimicrob* [Internet]. 2009 Mar 6 [cited 17 Jun 2017]; 8:7. Available from: <https://ann-clinmicrob.biomedcentral.com/track/pdf/10.1186/1476-0711-8-7?site=ann-clinmicrob.biomedcentral.com>
 16. Mark D, Leonard C, Breen H, Graydon R, O'Gorman C, Kirk S. Mobile phones in clinical practice: reducing the risk of bacterial contamination. *Int J Clin Pract* [Internet]. 2014 [cited 17 Jun 2017]; 68(9):1060-4. Available from: <http://onlinelibrary.wiley.com/doi/10.1111/ijcp.12448/epdf>
 17. Brady R, Chitnis S, Stewart R, Graham C, Yalamarathi S, Morris K. NHS Connecting for health: healthcare professionals, mobile technology, and infection control. *Telemed J E Health* [Internet]. 2012 [cited 17 Jun 2017]; 18(4):289-91. Available from: <http://online.liebertpub.com/doi/pdf/10.1089/tmj.2011.0147>
 18. Shakir I, Patel N, Chamberland R, Kaar S. Investigation of cell phones as a potential source of bacterial contamination in the operating room. *J Bone Joint Surg Am* [Internet]. 2015 [cited 17 Jun 2017]; 97(3):225-31. Available from: <https://insights.ovid.com/pubmed?pmid=25653323>
 19. Brady R, Verran J, Damani N, Gibb A. Review of mobile communication devices as potential reservoirs of nosocomial pathogens. *J Hosp Infect* [Internet]. 2009 [cited 17 Jun 2017]; 71(4):295-300. Available from: <http://www.sciencedirect.com/science/article/pii/S0195670108005197?via%3Dihub>
 20. Ramesh J, Carter A, Campbell M, Gibbons N, Powlett C, Moseley Sr H et al. Use of mobile phones by medical staff at Queen Elizabeth Hospital, Barbados: evidence for both benefit and harm. *J Hosp Infect* [Internet]. 2008 [cited 17 Jun 2017]; 70(2):160-5. Available from: <http://www.sciencedirect.com/science/article/pii/S0195670108002430?via%3Dihub>
 21. Pal P, Roy A, Moore G, Muzslay M, Lee E, Alder S, et al. Keypad mobile phones are associated with a significant increased risk of microbial contamination compared to touch screen phones. *J Infect Prevent* [Internet]. 2013 [cited 17 Jun 2017]; 14(2):65-8. Available from: <http://journals.sagepub.com/doi/pdf/10.1177/1757177413475903>