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ORIGINAL ARTICLE

Mobile health applications: characterization of the scientific production of Brazilian nursing

Aplicativos móveis em saúde: caracterização da produção científica da enfermagem brasileira

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ABSTRACT

The use of mobile devices by nurses is increasing in healthcare. This bibliometric study identified the development of mobile health applications in Brazilian *stricto sensu* master's and doctoral scientific production in the area of nursing, by searching the Coordination for the Improvement of Higher Education Personnel's (CAPES) Catalog of Theses and Dissertations. The sample consisted of 24 studies, of which 19 were master's dissertations and five were doctoral theses. The studies addressed a range of topics, with a predominance of studies on intensive care, and adult and elderly healthcare, as well as on topics such as systematization of nursing care. Of these productions, 16 (66.7%) were care-focused, six (25%) were education-focused and two (8.3%) were management-focused. It was possible to identify that Brazilian nursing is advancing scientifically in the field of mobile technology and is adopting this resource to produce applications with outcomes that strengthen healthcare practice, education and management, although these applications remain scarce in relation to the context of international production.

Descriptors: Mobile Applications; Nursing; Information Technology; Biomedical Technology.

RESUMO

O uso de dispositivos móveis por enfermeiros é crescente na área da saúde. Estudo bibliométrico que identificou o desenvolvimento de aplicativos móveis na produção científica brasileira *stricto sensu* na enfermagem por meio de buscas no Catálogo de teses e dissertações da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior. Amostra com 24 estudos, sendo 19 dissertações de mestrado e 5 teses de doutorado. Temas variados, com predominância de estudos em terapia intensiva, saúde do adulto e idoso e ainda sistematização da assistência de enfermagem. Das produções, 16 (66,7%) tiveram foco assistencial, seis (25%) com foco educacional e duas (8,3%) com foco na gestão. Foi possível identificar que a enfermagem brasileira está avançando cientificamente no campo da tecnologia móvel e apropriando-se desse recurso para produzir aplicativos que trazem resultados que fortalecem a prática assistencial, a educação e a gestão em saúde, apesar de escasso em relação ao contexto de produção internacional.

Descritores: Aplicativos Móveis; Enfermagem; Tecnologia da Informação.

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INTRODUCTION

Information Technology has grown rapidly in recent years and is being used across a wide range of different areas of knowledge. An important event in the spread of IT use by nurses was the creation of the Technology Informatics Guiding Education Reform (TIGER) in 2004. This is an initiative formed by a group of leaders in Nursing Informatics that seeks to provide nurses with theoretical and practical IT knowledge, in order to develop evidence-based care, the use of tools that support clinical decision-making and electronic health records, seeking to ensure quality and safety in patient care[1,2].

There has been a noticeable change in the way that the Internet is accessed, as computers (desktops and notebooks) have given way to their mobile versions in the form of tablets and smartphones[3]. According to the results of the latest National Household Sample Survey (PNAD), published in 2016, mobile cell phones are the type of equipment that is most used to access the internet at home and are present in 46.735 million households in the country. The next most common is the microcomputer, which has substantially lower representation, but is still present in more than half of the households with internet access[4].

In this context, there has been a visible increase in the production of new technologies for mobile devices. Initially, the major function of these devices was to make phone calls and send and receive text messages. They have now gained many new uses, however, as their functions have expanded to include services that enable users to watch videos, read eBooks, access maps, browse social networks, share information, etc.[3]. These devices are becoming increasingly popular, leading to the phenomenon known as mobile computing, with widely used devices including Personal Digital Assistants (PDAs), netbooks, tablets and smartphones[5].

The main difference between mobile devices and more traditional ones, such as the computer, is the fact that they are always accessible to their users because they can easily be carried to any location and they are usually connected to the Internet. Portability provides access to a wide range of information, including in the area of health, such as supporting disease treatment at any time and in any context[6,7].

Historically, the first mobile device that incorporated communication and computing features was the Blackberry, launched in 2002. Later other devices also came onto the market, with Apple launching the iPhone in 2007, and smartphones running Google's Android operating system introduced in October 2008. In 2010 Apple launched the iPad tablet, which due to its ease of use, portability and comparatively large screen represented yet another transformative computing tool[8].

With the growing use of smartphones and access to information and communication technologies, there is visible interest and increasing numbers of downloads on app platforms relating to various areas and subjects. This is mainly due to the ease with which these apps can be accessed in the respective online stores[9].

In the area of health knowledge, more than 165,000 mobile apps have been made available through the iTunes and Android app stores since 2015 and 34% of cell phone users had at least one health-related app on their mobile device[10-12]. These compose the so-called New Information and Communication Technologies (NICT), part of a range of technological tools that can be installed on mobile devices, providing specific features and enabling access to and sharing of a range of information[3].

Researchers in the area of healthcare are developing, evaluating and using apps for many purposes. Some examples include the screening, monitoring and self-management of depression, with promising results for treatment of this illness[13]; improving adherence to treatment by patients who are quitting smoking[14]; and use of mobile technology for recovery in cases of cerebrovascular accidents (CVA)[15].

In addition, another area of focus has been the development of health self-management apps, where patients use this technology for various treatments/interventions[16]. Examples include the identification of 10 mobile applications developed for self-management of care for people who are HIV positive[17] and also the valuing of mHealth as a useful tool to improve the care provided by health professionals to women with gestational diabetes mellitus[18]. It can be observed that the apps developed in the area of health are used to improve access to and recording of information, for communication, treatment and monitoring of patients, decision making, health education and training, among other areas[19].

An integrative review study identified studies involving mobile technology applied to health that are being developed in Brazil[9]. According to the study's findings there was a very small number of publications in the area of nursing related to the use of mobile devices in patient care (only three studies)[9]. Considering that nursing is a profession that involves a presence at the patient's side 24 hours per day, it is worth highlighting the importance of the experience of these professionals and the application of their knowledge regarding mobile technology, with publications and products that can contribute to healthcare practice and safe patient care.

It is important to understand what these researchers are producing in this area and the impact of productions on healthcare. With this in mind, this article aimed to identify the development of mobile health applications in the Brazilian scientific production of nursing dissertations and theses.

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METHOD

This is a bibliometric study, which aims to quantify the scientific studies and analyze their production, as well as explore and investigate the chronological development, productivity of institutions and the dissemination of these publications in sources of scholarly articles[20,21]. The following research question was formulated to guide this study: What is the scientific production of Brazilian nursing related to the development of mobile health applications? To answer the guiding question, a bibliographic search of the Coordination for the Improvement of Higher Education Personnel's (CAPES) Catalog of Theses and Dissertations was carried out, through the following website: http://catalogodeteses.capes.gov.br/catalogo-teses/#!/.

To search the publications, the following keywords were used: "application AND nursing", "mobile device AND nursing" and "mobile applications AND nursing", combined together by Boolean operators. The criteria for inclusion accepted Brazilian studies (dissertations and theses) published after 2007 that were fully available and that addressed the subject proposed for this study,

i.e. the development of mobile applications by Brazilian nurses. The period beginning in 2007 was stipulated because this was the year that smartphones were created. Data was collected independently in March and April 2018 by two researchers, as displayed in the study selection flowchart shown in Figure 1. First, a thorough search was performed using the aforementioned keywords (n=232). After this initial search, the titles and abstracts of the studies were read, with the exclusion of those not related to the development of mobile applications for healthcare (n=187). In this phase, duplicate studies were also excluded (n=21). Therefore, 24 dissertation and thesis studies were selected for inclusion in the final analysis.

RESULTS

The total sample consisted of 24 studies, of which 19 were master's dissertations and five were doctoral theses. Studies were found dating from 2008 to 2017, with dissertations predominating in the years 2009 and 2015 and theses in 2016, as shown in Graph 1.
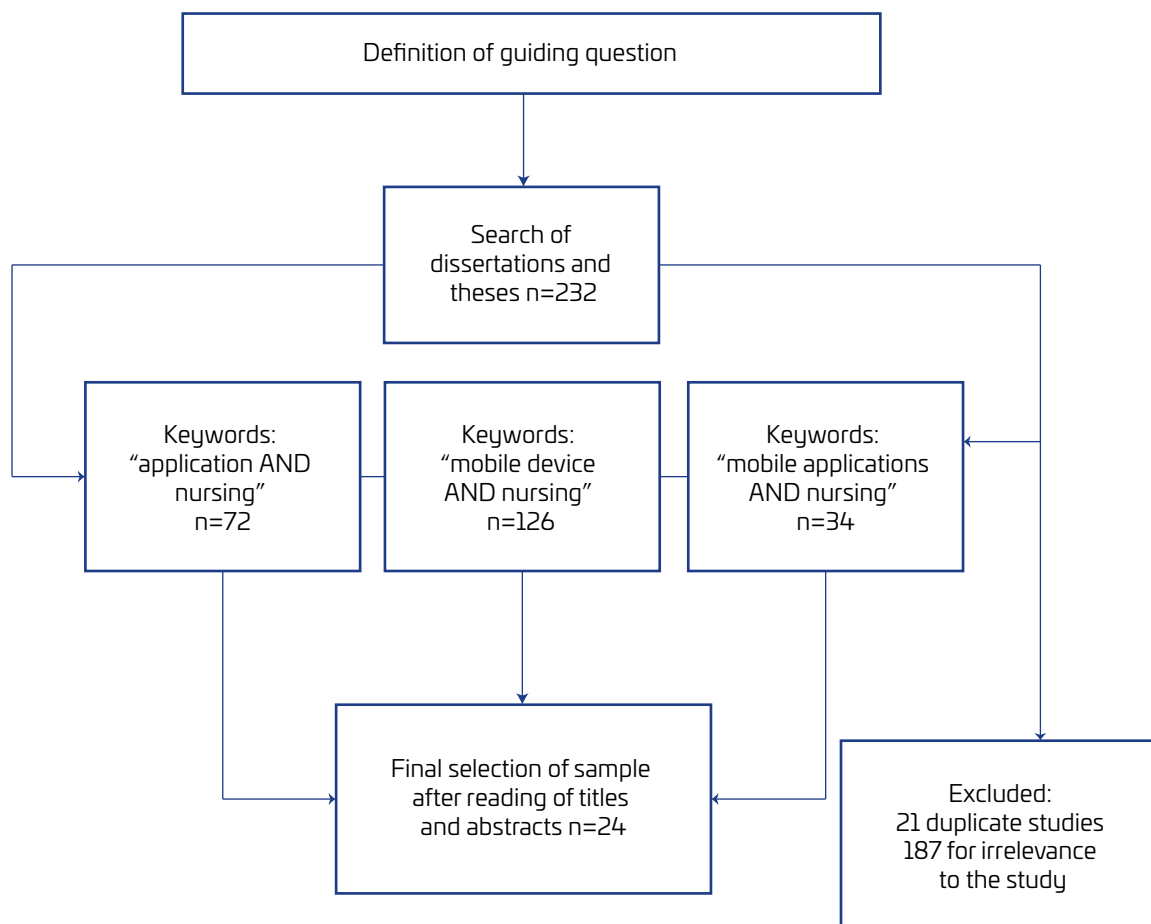

Figure 1. Study selection flowchart. Florianópolis, SC, Brazil, 2018.

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Regarding geographical location, studies originating from postgraduate programs located in the Southeast region were the most numerous with 10 (41.6%), followed by nine (37.4%) from the South region, as shown in Table 1.

Regarding the areas of knowledge, there was a predominance of studies in intensive care, adult and elderly health, and also on topics such as nursing care systematization and educational technologies. The titles of the selected productions are shown in Chart 1:
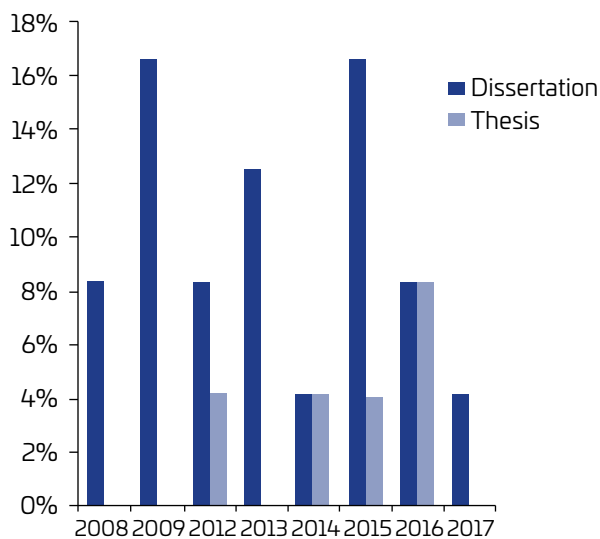
Graph 1. Percentage of dissertations and theses per year. Florianópolis, SC, Brazil, 2018.

The studies were organized according to their different areas of focus to enable evaluation and discussion of the apps developed. The majority of studies, 16 (66.7%), were identified as care-focused, followed by 6 (25%) that were education-focused and 2 (8.3%) that were management-focused.

DISCUSSION

Nursing is a specific area of knowledge that is becoming stronger as a science, technology and innovation, evidencing the increasing number and quality of *sensu stricto* master's and doctorate postgraduate programs across the country[46]. As in other professions, nurses are making use of technological resources, alongside other methods, to improve care practice and patient safety and bring positive results for the patient, family and healthcare team.

Among these resources, we can mention mHealth (mobile health), which according to the World Health Organization (WHO) can be defined as the provision of medical and/or public health services that use the technological support of mobile devices, such as mobile phones, sensors and other equipment directly connected to the user[47]. This enables the provision of reliable clinical information at any time and place[48].

Some of the potential applications of this type of technology are: telephone support for health care; free emergency telephone services; monitoring of adherence to treatment; appointment reminders; health promotion actions; Health education; mobile telemedicine; emergency

Table 1. Number and frequency of academic productions by region and institution. Florianópolis, SC, Brazil, 2018.

Higher education institutions	Region		
	Southeast	South	Northeast
	n (%)	n (%)	n (%)
University of São Paulo	5 (21%)		
São Paulo State University	1 (4.1%)		
Federal University of São Carlos	2 (8.3%)		
Pontifical Catholic University of Minas Gerais	1 (4.1%)		
Federal University of Minas Gerais	1 (4.1%)		
Federal University of Santa Catarina		8 (33.3%)	
University of Passo Fundo		1 (4.1%)	
Federal University of Ceará			1 (4.1%)
Federal University of Paraibá			2 (8.3%)
Higher Education Institute of Piaui			1 (4.1%)
Salvador University			1 (4.1%)
Total	10 (41.6%)	9 (374%)	5 (21%)

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Chart 1. Authorship and title of dissertations and theses. Florianópolis, SC, Brazil, 2018.

Author	Title
Castro, 2008[22]	*Construção de um aplicativo com o nursing activities score: instrumento para gerenciamento da assistência de enfermagem na UTI*
Barra, 2008[23]	*Processo de enfermagem informatizado em terapia intensiva em ambiente PDA (personal digital assistant) a partir da CIPE® versão 1.0*
Alvarez, 2009[24]	*Objeto virtual de aprendizagem simulada em enfermagem para a avaliação da dor aguda em adultos*
Beppler, 2009[25]	*E-PEP: Um framework para prescrição e evolução de enfermagem para dispositivos móveis*
Jesus, 2009[26]	*Aplicações Móveis à Beira Leito*
Vigolo, 2009[27]	*Desenvolvimento de uma Plataforma Wireless para Prescrição Médica e Verificação de Sinais Vitais Baseado em PDA*
Galvão, 2012[28]	*Aplicativo multimídia em plataforma móvel para o ensino da mensuração da pressão venosa central*
Tognoli, 2012[29]	*Medida indireta da pressão arterial: avaliação de programa de educação permanente oferecido em dispositivo móvel*
Nagliate, 2012[30]	*Desenvolvimento de educação permanente com tecnologia móvel: avaliação em um curso sobre higienização das mãos e uso de luvas*
Santos, 2013[31]	*Elaboração e desenvolvimento de aplicativo para dispositivos móveis para prevenção do pé diabético*
Madureira, 2013[32]	*Objeto de aprendizagem digital para ensino de ressuscitação cardiopulmonar*
Palmeiras, 2013[33]	*Uso de equipamentos assistivos em centro de terapia intensiva: comunicação alternativa entre a equipe de cuidados de saúde e paciente*
Grossi, 2014[34]	*Oncoaudit: desenvolvimento e avaliação de um aplicativo em ambiente web e móvel para auditores em saúde*
Alvarez, 2014[35]	*Tecnologia persuasiva na aprendizagem da avaliação da dor aguda em enfermagem*
Cherman, 2015[36]	*Aplicativo móvel para prevenção e classificação de úlceras por pressão*
Pereira, 2015[37]	*Estudo e desenvolvimento do protótipo de aplicativo móvel cateterismo intermitente limpo: guia de apoio para adultos*
Barros, 2015[38]	*Aplicativo móvel para aprendizagem da avaliação do nível de consciência em adultos (OMAC)*
Capote, 2015[39]	*Protótipo de aplicativo para dispositivo móvel para o acompanhamento das famílias pelo enfermeiro na Estratégia de Saúde da Família*
Rezende, 2015[40]	*Sistematização da assistência de enfermagem em unidade de terapia intensiva neonatal: desenvolvimento de um protótipo para utilização em dispositivo móvel*
Lima, 2016[41]	*Aplicativo em plataforma móvel para a sistematização da assistência de enfermagem a gestantes de risco habitual*
Naz, 2016[42]	*Savinglife®: an educational technology for basic and advanced cardiovascular life support in nursing*
Medeiros, 2016[43]	*Uso da tecnologia da informação móvel e sem fio para a sistematização da assistência de enfermagem na área de obstetrícia*
Silva, 2016[44]	*Processo de comunicação para promoção do aleitamento materno exclusivo na concepção de profissionais da estratégia saúde da família*
Domingos, 2017[45]	*SEPSESCARE: aplicativo móvel para o cuidado de enfermagem à pacientes com sepse em unidade de terapia intensiva*

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response; epidemiological surveillance and monitoring; patient monitoring; dissemination of information; development of decision-making support systems; and new ways of storing clinical data[47]. This technology is promising, since it enables a rigorous follow-up so that the subject can manage their own self-care[49].

With the use of mhealth, healthcare professionals currently adopt a range of apps in their daily work, for purposes such as seeking information, enhancing knowledge, and improving care and management, as well as using apps with an educational focus. Mobile health has a positive impact on patient care and results in better decision making, reduced medical errors, and better communication among healthcare staff[50].

The present article identified the development of mobile health apps in dissertations and theses within the postgraduate nursing programs in Brazil and provides evidence of a growing number of productions over the years, especially master's dissertations. It can be argued that this is because there is a larger number of master's courses available and that their establishment largely preceded the implementation of the doctorate courses, in chronological terms[51].

The regions with the largest number of studies were the Southeast and South, where many of the *sensu stricto* master's and doctorate postgraduate nursing courses are located. According to the most recent data from CAPES regarding the distribution of nursing courses, 42.9% (18 doctorate, 21 academic master's and 09 professional degrees) are in the Southeast and 21.4% (08 doctorates, 09 academic master's and 07 professional degrees) in the South. A further 25.9% (09 doctorates, 14 academic master's and 06 professional degrees) are in the Northeast, 8.0% (03 doctorates, 05 academic master's and 01 Professional degree) in the Midwest and 1.8% (02 master's) in the North[46]. The predominance of the Southeast and South regions may also occur due to their pioneering role in offering these *sensu stricto* master's and doctorate courses[51]. It is worth noting that the Brazilian Science, Technology and Innovation system is highly concentrated in these two regions[52].

Regarding the institutions to which the courses are linked, the majority came from the Federal University of Santa Catarina (UFSC) and the University of São Paulo (USP). At UFSC there is the Technological Health Production Laboratory and Clinical Research Group on Technologies and IT in Health and Nursing (LAPETEC/GIATE), which is linked to the same institution's Postgraduate Nursing Program. One of the main aims of this research laboratory is to develop applications in health and education, such as: apps for learning to assess levels of consciousness and learning to assess acute pain in nursing[53].

At USP there are various groups involved with lines of technological research, such as the Study and Research Group

on Information Technology in Nursing Work Processes (GEPETE), which aims to produce and socialize knowledge in the area of information and communication technology in healthcare and nursing, coordinate integration with research groups in this area and promote student participation[54]. Also noteworthy is the Ribeirão Preto School of Nursing at USP's (EERP/USP) Research Group on Nursing in Child and Adolescent Care (GPECCA), which aims to develop knowledge and technologies for nursing care for newborns, children and adolescents and their families[55]. This group developed the e-Baby tool, which displays the environment of a virtual incubator in which the user performs the clinical evaluation of a preterm baby[56].

In addition to this research group, the Study and Research Group on Communication in the Nursing Process (GEPECOPEN) is also part of EERP/USP. This group works with innovations in communication technology in the teaching, research and care sectors, computerization of processes and record, exploration of virtual nursing and advanced communication technology, and fostering of research and the research/teaching/continuing education interface, both for in-person and distance learning[57].

The study was limited in the process of identifying other initiatives in Brazil by its choice of keywords/descriptors, being restricted to the development of mobile apps and therefore possibly not capturing some digital educational technologies that are accessible through mobile devices, and which do not appear in the search and selection of studies. Therefore, at another time the search could be expanded to include other descriptors found in master's dissertations and doctoral theses, such as mhealth and educational technologies.

The apps developed in master's dissertations and doctoral theses were grouped according to their focus, and classified as follows: Care-focused applications; Education-focused applications; and Management-focused applications.

Care-focused applications

Regarding care-focused applications, 16 (66.7%) of the studies were identified as relating to the topic of mobile technology assisting the practice of diverse healthcare professionals. Content was related to bed sores, sepsis, prevention of diabetic foot, breastfeeding, systematization of nursing care, and medical prescriptions. Mobile computing emerges as an innovative technology for nursing care through its application via mobile devices and its use can undoubtedly help considerably in the daily lives of health professionals[58].

Review studies in Brazil and abroad that have aimed to identify research involving mobile technology applied to health also showed results that indicated the predominance of applications aimed at supporting professionals, which corroborated the findings of the present study[9,59]. In this context, the integration of technological skills into the clinical

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practice of nurses can be seen to be positive, as well as for patients, pointing to a significant impact on health outcomes[60].

Gradually, healthcare professionals are incorporating ICTs, and these technologies contribute to the elaboration of reliable diagnoses and qualified therapeutic guidelines/conducts for patients[61-63]. In addition, they enable real-time and remote access to information and contribute to problem solving and health needs in different geographical areas[61]. The use of technology in care facilitates their work, as it is quicker, brings greater precision and speed in actions, and provides more time for the team to dedicate to care, in order to improve the quality of care[64]. When using an app through a mobile device, the professional can have access to information and make a record anywhere without having to move away from the patient, e.g. without having to leave their bedside.

Education-focused applications

The use of digital educational devices has increased in nursing education, with 6 (25%) applications with this purpose identified by this study[65]. The topics covered focused on: measurement of central venous pressure; basic and advanced life support; teaching of cardiopulmonary resuscitation (CPR); indirect measurement of blood pressure; acute pain; and hand hygiene and the use of gloves.

Apps are believed to be beneficial for learning because they support a self-paced learning environment and can be accessed anywhere and at any time[66]. Teaching and computerization must go hand in hand to allow for extracurricular study and to prepare the student for the reality they will encounter in the field of practice, when knowledge and skills are needed to deal with situations analogous to reality[67].

From this perspective, some studies point to apps used for teaching, such as one study conducted in Iran that investigated the use of mobile technologies by medical and nursing students and likely future trends[50]. The most widely used apps among medical students were medical dictionaries, medication apps, medical calculators, and anatomical atlases. Among nursing students, the most widely used were medical dictionaries, anatomical atlases, and nursing care guides[50]. In addition, the study highlights future trends towards the use of support systems for decision-making, remote monitoring, remote diagnostics, patient record documentation, diagnostic guidelines and laboratory testing[50].

One randomized clinical trial aimed to evaluate the effect of an interactive mobile nursing skills app for nursing students. Student-centered mobile applications with systematic content have proved to be an effective method for students to experience practical nursing skills[68].

In this sense, multimedia applications constitute pedagogical support tools for the construction and application of knowledge, and allow for the provision of an environment in which the student exercises cycles of reflection and action[69]. A review study analyzed the contributions of the use of digital educational technologies in the teaching of nursing skills, where the use of different formats of technology were identified, such as videos, virtual environments, apps, hypertext, games and virtual reality simulators[70]. In the analysis of the articles, it was highlighted that digital educational technologies contribute to the teaching of nursing skills, improving the acquisition of theoretical references that support practices[70].

The need for pedagogical actions integrated with the use of technology should be considered, as its use in isolation is not a guarantee of better learning. It is necessary to enable a critical action linked to reality and built on the students' autonomy and cooperation[67].

Management-focused applications

In the management area, two (8.3%) productions were identified, one of which was the development of an application with a Nursing Activities Score and the other was the development of an application for health auditors. Many of the studies developed in the field of mobile technology focus on its applicability to care practice, which also contributes to the management process, favoring communication between professionals, the obtaining of data/records and decision-making, for example.

In this context, one review study aimed to identify useful apps for the clinical care of women and to discuss the best practices for their implementation in clinical care[71]. Apps for evidence-based care guidelines, women's health, pharmacological reference, and laboratory and diagnostic guides were highlighted, as well as apps for storing and managing information and electronic health records[71]. A study conducted in a surgical ward and a medical ward at Geneva university hospitals evaluated the acceptance of a mobile application to support the nurses' workflow[72]. The app provided an integrated view of all daily tasks that nurses need to perform during their shifts[72]. The technology acceptance questionnaires revealed the high usability of the application for nurses[72]. Given the above, it is possible to see the contributions that mobile health apps can bring to the improvement and refinement of the management process.

CONCLUSION

This study enabled the identification of progress in scientific productions in the field of mobile technology and to present what Brazilian nursing has been developing in the area of mHealth, in *sensu stricto* master's and doctorate courses.

Nurses recognize the importance of improving their professional practice and find ways to do so by using mobile technology as an ally at work. Several applications were

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identified that bring positive results for nursing care, as well as educational and managerial support. However, further progress is still needed in this area, which has already shown that it contributes to safe healthcare practice, as well as providing remote access to information and knowledge. It favors the diagnosis and treatment of diseases, as well as care and monitoring of patients, and is potentially significant in stimulating self-care. It is emphasized that the number of studies is still small compared to international research.

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