

MOBILE APPLICATIONS DEVELOPED FOR THE HEALTH SECTOR IN BRAZIL: AN INTEGRATIVE LITERATURE REVIEW

APLICATIVOS MÓVEIS DESENVOLVIDOS PARA A ÁREA DA SAÚDE NO BRASIL: REVISÃO INTEGRATIVA DA LITERATURA

APLICACIONES MÓVILES DESARROLLADAS PARA EL SECTOR DE LA SALUD EN BRASIL: REVISIÓN INTEGRADORA DE LA LITERATURA

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ABSTRACT

The popularization of smartphones has been considered by many the technological revolution of greatest impact in recent years. Considered a pocket computer with access to millions of applications, its main feature is the breaking of the limitations of mobility, following its user 24 hours a day, anywhere. This quality is essential to assisting in healthcare activities, since these professionals constantly move around within the institutions in which they work. This study aimed to identify prior research developed in Brazil which involved mobile technology applied to healthcare. The methodology used in this study was an integrative literature review. The final sample included 27 articles. Analysis of results showed that the most commonly addressed theme in the production of mobile applications for the healthcare field was support for healthcare professionals. Analyzing the focus of mobile applications, it could be found that the category of interdisciplinarity was the most benefited by research in mobile technology. The review concluded that it is of great importance to develop mobile applications linked to scientific research on healthcare, since their content will be analyzed and tested by professionals who know the final users' real needs.

Keywords: Medical Informatics Computing; Nursing; Medical Informatics.

RESUMO

A popularização dos celulares inteligentes, os smartphones, tem sido considerada por muitos a revolução tecnológica de maior impacto nos últimos tempos. Considerado um computador de bolso e com acesso a milhões de aplicativos, sua principal característica é a quebra da limitação da mobilidade, acompanhando o seu usuário 24 horas por dia em qualquer lugar. Essa qualidade é fundamental para auxiliar a assistência em saúde, uma vez que esses profissionais deslocam-se constantemente dentro das instituições em que trabalham. Este estudo objetivou identificar quais as pesquisas envolvendo tecnologia móvel aplicada à saúde que estão sendo desenvolvidas no Brasil. A metodologia empregada é do tipo revisão integrativa da literatura. A amostra final contou com 27 trabalhos. A análise dos resultados trouxe que a temática mais abordada no desenvolvimento de aplicativos móveis para a área de saúde foi a de apoio ao profissional. Quando analisado o foco desses aplicativos, viu-se que a área mais beneficiada pela pesquisa em computação móvel tem sido a multiprofissional. Concluiu-se, com a revisão, que é de suma importância o desenvolvimento de aplicativos móveis vinculados à pesquisa científica em saúde, pois seu conteúdo será analisado e testado por profissionais que conhecem as reais necessidades dos usuários finais.

Palavras-chave: Computação em Informática Médica; Enfermagem; Informática em Saúde.

RESUMEN

La popularización de los teléfonos inteligentes (smartphones) ha sido considerada por muchos como la revolución tecnológica de mayor impacto de los últimos tiempos. Se trata de un ordenador de bolsillo con acceso a millones de aplicaciones cuya principal característica es que la ruptura con los límites de la movilidad: puede seguir al usuario durante las 24 horas desde cualquier lugar. Esta cualidad es esencial para apoyar al sector de la salud ya que los profesionales se desplazan constantemente dentro de las instituciones donde trabajan. El presente estudio ha buscado identificar los estudios que se están llevando a cabo en Brasil con tecnología móvil aplicada a la salud. La metodología utilizada es tipo revisión integradora de la literatura. La muestra final incluyó 27 estudios. El análisis de los resultados indica que el tema que más se desarrolla es el de apoyo profesional. Al analizar el foco de estas aplicaciones se observa que la zona más favorecida por la investigación en informática móvil es la multiprofesional. El artículo concluyó que es de suma importancia desarrollar aplicaciones móviles relacionadas con la investigación científica en salud porque su contenido podrá ser analizado y probado por profesionales que conocen las necesidades reales de los usuarios finales.

Palabras clave: Computación en Informática Médica; Enfermería; Informática en la Salud.

INTRODUCTION

The popularization of smartphones has been considered by many the technological revolution with the greatest impact in recent years, surpassed only by the revolution sparked by the Internet and social networks.¹

Growth in the mobile devices market has generated both commercial and social opportunities in a wide range of areas. These devices are considered pocket computers with access to millions of applications. In 2012 alone, more than 40 billion applications were downloaded on smartphones, and the forecast is that this number will reach 300 billion in 2016.² This is mainly due to the facility with which these applications can be accessed in their respective online stores. In this manner, the development of computer solutions in mobile application formats represents an efficient means through which to make a tool available and reach the desired target public.

The main feature of these mobile applications is the breaking of the limitations of mobility, since smartphones are simply pocket computers and can follow their user 24 hours a day, anywhere. Another important aspect is the personalization that the equipment brings to its users, considering that professionals can use their own devices, which they use regularly on a daily basis.³

The use of computer tools in healthcare is growing, as this type of support can allow the professional to achieve greater precision and agility in their work. As regards nursing care in Brazil, the adoption of technological resources is a fact that has been growing since the 60's, with the scientific foundation of the registered nurse as a profession.⁴

Mobile technology can be applied in many spheres of healthcare. Among these applications, what stand out are remote monitoring, diagnostic support, and assistance in decision-making.^{5,6}

This literature review is part of a larger project aimed at the development of mobile technology for the fields of healthcare and nursing. In addition, this review is also essential to identifying the gaps to be filled by future research on the theme.

In this light, the present study aimed to identify the current state of the art and research tendencies throughout Brazil that use mobile technology in the health sector.

MATERIALS AND METHOD

This study was an integrative literature review aimed at learning about what exists in the Brazilian scientific journals on the theme of technology and mobile applications in the health sector from January 2006 to July 2013.

This method allows one to gather prior research and draw conclusions on this specific technological theme.⁷ As this study is an integrative literature review, it was not necessary to obtain approval from a Research Ethics Committee, as set forth in Resolution 466/12 by the Brazilian Health Ministry.⁸ To per-

form this review, the study followed that proposed by Ganong⁹, which involves the following steps:

- selection of the questions for review;
- defining of the study inclusion criteria and the search for literature;
- presentation of the characteristics of the reviewed studies;
- analysis of the studies using a specific instrument;
- interpretation of the results;
- presentation of the results and a synthesis of the knowledge.

To guide the integrative review, the following question was posed: "what has been developed in Brazil as regards scientific research in the health sector concerning mobile applications?"

The following databases were used to select the articles: the virtual libraries of SCIELO, LILACS, and Google Scholar. The Google Scholar library was consulted in an attempt to expand the scope of this study, encompassing, in addition to indexed articles, theses, dissertations, and final papers of courses not found in the indexed libraries, which minimized the possible routes in this step of the process geared toward the gathering of studies to be reviewed. Any studies found in more than one database were considered only once.

The study inclusion criteria were the following: publications available online, in Portuguese, developed by Brazilian researchers, and published in the period between 2006 and 2013. The exclusion criteria included: articles in which it was not possible to identify any relation to the theme by reading the title or the abstract, research that was not developed by Brazilian researchers, and review articles. The key words used were: application *and* health *and* smartphone. The article selection process is presented in Figure 1.

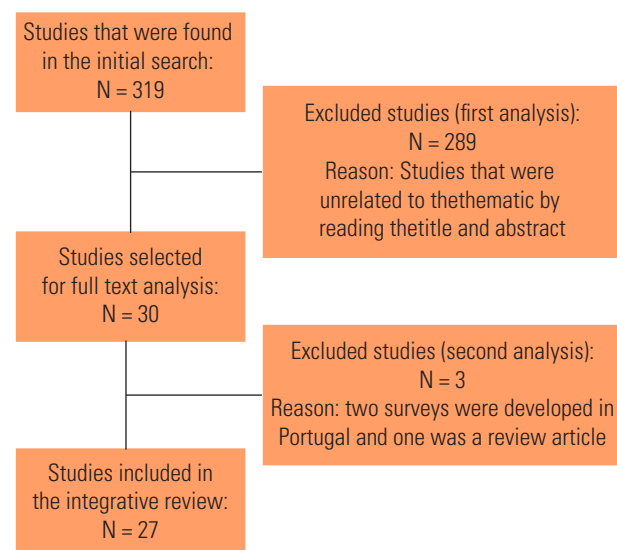


Figure 1 - Synthesis of the article selection process for the integrative literature review.

A specially designed instrument was used to extract and analyze the data from the selected studies. In this instrument, it is necessary to identify the study, its home institution, the type of journal in which the work was published, the methodological characteristics of the study, and the assessment of the methodological accuracy.¹⁰

To classify the evidence level of the works, the categorization established by the Agency for Healthcare Research and Quality (AHRQ) was used.¹¹ The quality of the evidence is classified in six levels, as follows:

- **level 1** – meta-analysis of the controlled studies;
- **level 2** – individual study with experimental framework;
- **level 3** – study with near-experimental framework, such as a study with no randomization, with only one pre and post-test group, temporal or case-control series;
- **level 4** – study with no experimental framework, such as correlational and qualitative descriptive studies or case studies;
- **level 5** – case reports or data obtained in a systematic manner, of verifiable quality or program evaluation data;

- **level 6** – opinion from respected authorities based in clinical competence or opinions from committees of experts, including interpretations of information based on prior research.

RESULTS

Through the searches performed in the chosen databases, 319 studies were found. All of the titles and abstracts were read, respecting the inclusion and exclusion criteria, and 27 studies were selected for more detailed analysis. To better identify each selected study, the articles were organized in an alphanumeric sequence, from A1 to A27 (Table 1)

The selected articles were summarized and classified according to the following criteria: Year of publication, type of publication, thematic approach, and the application's focus on a specific profession. According to the year of publication, the following distribution was employed: 2013 (1), 2012 (10), 2011 (6), 2010 (3), 2009 (3), 2008 (1), 2007 (1), and 2006 (2).

Table 1 - Works selected for analysis

Nº	Article Data	
A1 ¹²	Title	"Medic Mobile" mobile application for remote access of the clinical data of hospitalized patients
	Authors	Tonon US.
	Year	2006
A2 ¹³	Title	Study and development of an application for clinical-hospital environments, considering the use of mobile devices with wireless communication networks
	Authors	Camillo Júnior A.
	Year	2006
A3 ¹⁴	Title	Proposal for a telemetry system for the acquisition of physiological signs
	Authors	Schwarz L.
	Year	2007
A4 ¹⁵	Title	Can mobile technology contribute to the adoption of protocols in emergency rooms?
	Authors	Marques IR, Pisa IT, Marin HF.
	Year	2008
A5 ¹⁶	Title	Stela Project: telemetry system for ambulances
	Authors	Bastos LP, <i>et al.</i>
	Year	2009
A6 ¹⁷	Title	Development of an M-pharmacy system as a support tool in the adherence to medication treatments
	Authors	Yañez YSV.
	Year	2009
A7 ¹⁸	Title	Development of a wireless platform for medical prescriptions and verification of vital signs based on PDAs
	Authors	Vígolo V.
	Year	2009
A8 ¹⁹	Title	Nursing Activities Score System: Stages of development of a mobile system for nursing
	Authors	Silveira DT, <i>et al.</i>
	Year	2010

Continues...

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Table 1 - Works selected for analysis

Nº	Article Data	
A9 ²⁰	Title	An iPhone application to identify melanomas
	Authors	Magalhães GL, Aguiar MS.
	Year	2010
A10 ²¹	Title	Modeling and Assessment of Algorithms for Mobile Platforms designed for automatic diagnoses and the identification of <i>Plasmodium</i> (malaria) parasites on slides with blood samples
	Authors	Albuquerque J, Ferrer-Savalla J, Codina DL.
	Year	2010
A11 ²²	Title	InteliMed: an experience in the development of a mobile system for medical diagnostic support
	Authors	Menezes Júnior JV, <i>et al.</i>
	Year	2011
A12 ²³	Title	Nursing Activities Score System in mobile technology
	Authors	Catalan VM, <i>et al.</i>
	Year	2006
A13 ²⁴	Title	Vital signs monitoring and management system based on mobile devices
	Authors	Fernandes BMV.
	Year	2011
A14 ²⁵	Title	UMED: an architecture for the development of software geared toward ubiquitous Medicine
	Authors	Rodrigues SL.
	Year	2011
A15 ²⁶	Title	HEARTNET: Body area network application for medical monitoring
	Authors	Kodama AJ, Morales EB, Kawai RD.
	Year	2011
A16 ²⁷	Title	Hospital management system using Android, Google Appn Engine, and Google Web Toolkit platforms
	Authors	Ferreira DAM, Rodvalho RAM.
	Year	2011
A17 ²⁸	Title	ADAFARMA – application to assist in the treatment adherence stage
	Authors	Navarro BR, Santos J, Baklizky M, Wagner PK, Araújo LV.
	Year	2012
A18 ²⁹	Title	Development of reference mobile application about vaccinations in Brazil
	Authors	Oliveira TR, Costa FMR.
	Year	2012
A19 ³⁰	Title	Use of mobile devices in healthcare monitoring
	Authors	Araújo MVS, Alves F.
	Year	2012
A20 ³¹	Title	Mobile technologies: allies in education and health
	Authors	Pereira TA, Tarcia RML, Sigulem D.
	Year	2012
A21 ³²	Title	The impact of the use of ICT in healthcare: development and application of a mobile system in the family health strategy program
	Authors	Barone DA, Figueiredo MC, Wink GL.
	Year	2012
A22 ³³	Title	Virtual Caregiver: a system for supporting collaboration in elderly monitoring
	Authors	Ugulino U, Ferreira M, Velloso E, Fuks H.
	Year	2012

Continues...

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Table 1 - Works selected for analysis

Nº	Article Data	
A23 ³⁴	Title	Interactive viewing in real time of medical data on the Web
	Authors	Moraes TF, <i>et al.</i>
	Year	2012
A24 ³⁵	Title	A computer vision system for the monitoring of parameters and respirators of patients with amyotrophic lateral sclerosis
	Authors	Silva GHS.
	Year	2012
A25 ³⁶	Title	Follow-Ups: a ubiquitous healthcare platform
	Authors	Ghizoni MLA.
	Year	2012
A26 ³⁷	Title	Development of a solution in mobile devices in the health sector
	Authors	Wink GL.
	Year	2012
A27 ³⁸	Title	Smart Audio City Guide
	Authors	Valente CF, Orso GH.
	Year	2013

As regards the type of publication, no theses were found; the other types of publications were summarized as: article (13), dissertation (7), and final paper for a course (7). All of the identified studies were classified with an evidence level of 4, based in the AHRQ categorization,¹¹ as it contained a non-experimental framework with a descriptive, applied, or correlational type of research.

To analyze and discuss the mobile application developed for the health sector, the studies were organized in categories by adding the theme to the target public of each study, as follows: "Studies that focus on interdisciplinarity"; "Studies that focus on nurses"; "Studies that focus on doctors"; "Studies that focus on dentists"; "Studies that focus on patients" (Table 2).

Table 2 - Classification of the studies in thematic categories

Categories	Selected articles
Studies that focus on interdisciplinarity	A1, A3, A4, A7, A13, A14, A16, A19,
Studies that focus on nurses	A8, A12, A18.
Studies that focus on doctors	A2, A5, A9, A10, A11, A15, A23.
Studies that focus on dentists	A21, A26.
Studies that focus on patients	A6, A17, A27.

STUDIES THAT FOCUS ON INTERDISCIPLINARITY

As regards the category of "Studies that focus on interdisciplinarity", 12 publications were selected that dealt with the theme of mobile technology geared toward assistance in the

practices of a wide range of healthcare professionals. The great majority of studies developed technologies that used the vital signs of the patients as the core idea, aimed at viewing these data and healthcare professionals' constant follow-up of patients, without the need to remain at the patient's bedside, in turn facilitating access to information in any environment.^{12,14,18,24,25,27,30,33} Among these, one study reported on a differential mechanism used to view a patient's vital signs by using a photoplethysmography¹⁴, while the others used data transmission through a mobile device connection with technological devices attached to the patient. All of the studies showed the importance of facilitating the professionals' access to the patients and optimizing their activities, in turn aiding in the communication among the professionals when the patient was in an unstable condition.

One of the studies proposed the use of mobile technology to help follow the medical protocols for attending to ST-segment elevation acute myocardial infarctions (STAMI)¹⁵; another developed a computer display system to remotely monitor the respiratory parameters of the patients with amyotrophic lateral sclerosis (ALS) in a hospital environment³⁵; another study analyzed the use of mobile technologies with a didactic proposal within a healthcare context³¹; while other authors researched and proposed a ubiquitous healthcare environment through the use of mobile technology.³⁶

STUDIES THAT FOCUS ON NURSES

In the category "Studies that focus on nurses", three studies were selected that contemplated the use of mobile devices geared toward nursing practices.

One mobile application was developed about vaccinations in Brazil, stemming from current data from the Brazilian Health Ministry's National Immunization Program.²⁹ Another mobile application classified patients and evaluated the work load of nurses who work in intensive care units, the *Nursing Activities Score* (NAS).^{19,23} Both applications are in their final development stages and posterior evaluation of the software in clinical practices, aimed at updating the nurses' professional knowledge as well as at a greater insertion of mobile technology in their work environments.

STUDIES THAT FOCUS ON DOCTORS

Eight "Studies that focus on doctors" were selected. This category was the second most commonly found theme, surpassed only by the "Studies that focus on interdisciplinarity."

Among the selected applications were two initiatives that aid doctors in making decision about diagnoses.^{20,21} Both studies, in addition to assisting the doctor in the diagnostic process, also use imagery processing technology in this process of identifying and classifying diseases. A third initiative, in addition to aiding in the diagnostic process, also transmits exam data from remote locations.²⁶

The patient data transmission technology was developed and used in another four works focused on medical professionals.^{13,16,22,34} These applications, with data transmission functions, in addition to helping doctors follow their patients remotely, also encourage evidence-based practices, providing medical consultations of specialized knowledge based on data retrieved through the application.

STUDIES THAT FOCUS ON DENTISTS

In the category of "Studies that focus on dentists", only two studies were selected. Both works presented the development and use of applications as support offered to dentists working in the Brazilian government's Family Health Strategy (FHS) program. These systems are designed to store information about the oral health of patients who receive home care.^{32,37} Both studies reported that the systems were proposed as a means through which to ensure efficiency in home care and in the organization of collected data.

STUDIES THAT FOCUS ON PATIENTS

Finally, three studies were selected according to their main focus on the category of "Studies that focus on the patient". In this category, two applications were developed to aid patients in adhering to both pharmacological and behavioral treatments.^{17,28} The third application of this category sought to aid in the mobility of the visually impaired in urban environments.³⁸ All of the ap-

plications were developed with the purpose of being used directly with the patient, thus representing remote medical support.

DISCUSSION

The analyzed data demonstrated that the publications in the line of research regarding mobile technology applied to healthcare is a new field and is growing. The publications found between 2006 and 2013 had their largest concentration in 2012, with 10 published articles. An increase in publications on the theme could be observed over the years, and it is believed that this number will be even higher in 2013 due mainly to the popularization of smartphones and tablets. One indication that this is a new field of research is the fact that no "thesis" could be found on the theme, which may well be due to the sheer amount of time needed to conclude work in this category.

The analysis of articles showed that the professional category that was most benefitted by the development of mobile applications in the health sector was that of interdisciplinarity, with 12 studies (*interdisciplinarity* is understood as works that involve two or more distinct professional categories in the health sector). The professional categories that were analyzed exclusively included doctors, nurses, and dentists, with seven, three, and two studies, respectively.

Among the works analyzed in this study, it was possible to identify three applications that are geared toward the patient as the end user. The development of applications to provide medical support to the patient stands out as a gap that warrants further examination. This is because the use of mobile devices is becoming more and more common, since these devices are available to the user 24 hours a day and, as a pocket computer, can be taken to any environment. This role played by mobile devices may well represent an important aid in the adherence to behavioral and/or medicinal treatments.

Work developed at the University of Columbia³⁹ identified a total of 83 mobile applications documented in international literature. Of these, 57 were geared toward healthcare professionals, with the most common focus being on assisting in doctor's diagnoses. Another 11 applications were found to be geared toward medical and nursing students and 15 toward patients. Such data are similar to findings from the present integrative review, given that the population that was most benefitted by the mobile applications was that of healthcare professionals, with a special emphasis placed on applications developed to assist doctors.

No integrative review on a similar theme could be found in Brazil. Despite the low number of studies applied and/or developed by healthcare professionals selected in this review, it is still important to highlight the importance of investments in this field of research. Healthcare professionals are in constant

movement throughout the different sectors of the health institutions in which they work, and mobile technology contains the exact main feature that serves to break this limitation of mobility and can thus offer remote support to these professionals. In addition, the use of mobile devices promotes better communication through their multimedia functions and further boosts scientific research in this field of work, thus giving incentive to evidence-based practices.³⁹

It is important to note that the devices and information technology analyzed in this study can only be found in their prototype form and are not yet available for use in daily medical practices. In a recently published study,⁴⁰ the authors assessed and described mobile applications for healthcare uses that are available for download and for use by the end user. However, upon evaluating these applications, what stands out is that the majority of these have no ties to research projects, but rather to private developers. In this light, it can be concluded that, despite the importance and popularization of mobile applications in the healthcare field, research in this field is still in its beginning stages.

FINAL CONSIDERATIONS

This study presented mobile applications for the health sector that could be identified in prior Brazilian scientific literature. The majority of the selected studies had the objective of being used by three or more healthcare professionals concomitantly, which highlights the importance of tools that encourage interdisciplinary integration.

Despite the reduced number of articles developed in Brazil on this theme, a constant growth can be seen over the years analyzed in this study. It is understood that the development of mobile applications for scientific purposes is important, since the content tends to be analyzed and tested by professionals who understand the true needs of end users. Recognizing the needs of these users is essential to planning and implementing new technologies in a coherent and appropriate manner, according to specific demands that have been tested in research and implemented in healthcare practices.

In addition to research on applications that provide support to healthcare professionals, future studies should also develop applications geared toward providing support to patients. In this manner, patients can become more involved in aspects related to their own health, have access to information, and, when necessary, receive remote support for self-care and treatments.

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