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METHODS FOR DEVELOPING MOBILE APPS IN HEALTH: AN INTEGRATIVE REVIEW OF THE LITERATURE

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ABSTRACT

Objective: to identify, in the Brazilian and international publications indexed in the databases, the main methods adopted by researchers for developing mobile apps in health.

Method: integrative review of the literature, of studies published in the following databases: MEDLINE/PubMed, Scopus, Web of Science, CINAHL and SciELO, in 2012 – 2016. A total of 21 articles were selected for analysis.

Results: the main methods for developing mobile apps in the area of health, described in the articles, were: systematic design of instruction, contextualized design of instruction, user-centered design and systems development life cycle.

Conclusion: regardless of the method of development selected, the stages must be well-defined and structured, so that the mobile app developed may be useful to the end-user.

DESCRIPTORS: Mobile applications. Medical informatics applications. Nursing informatics. Medical informatics. Information technology.

MÉTODOS PARA DESENVOLVIMENTO DE APLICATIVOS MÓVEIS EM SAÚDE: REVISÃO INTEGRATIVA DA LITERATURA

RESUMO

Objetivo: identificar nas publicações nacionais e internacionais indexadas nas bases de dados os principais métodos adotados pelos pesquisadores para o desenvolvimento de aplicativos móveis em saúde.

Método: revisão integrativa da literatura de estudos publicados nas bases de dados MEDLINE/PubMed, Scopus, Web of Science, CINAHL e SciELO, no período de 2012 a 2016. Foram selecionados para análise 21 artigos.

Resultados: os principais métodos para desenvolvimento de aplicativos móveis na área da saúde descritos nos artigos foram: design instrucional sistemático, design instrucional contextualizado, design centrado no usuário e ciclo de vida de desenvolvimento de sistemas.

Conclusão: independentemente do método de desenvolvimento escolhido, as etapas devem ser bem definidas e estruturadas, a fim de que o aplicativo móvel desenvolvido seja útil ao usuário final.

DESCRITORES: Aplicativos móveis. Aplicação de informática médica. Informática em enfermagem. Informática médica. Tecnologia da informação.

MÉTODOS PARA DESARROLLO DE APLICACIONES MÓVILES EN SALUD: REVISIÓN INTEGRAL DE LA LITERATURA

RESUMEN

Objetivo: identificar en las publicaciones nacionales e internacionales indexadas en las bases de datos los principales métodos adoptados por los investigadores para el desarrollo de aplicaciones móviles en salud.

Método: revisión integrativa de literatura de estudios publicados en las bases de datos MEDLINE/PubMed, Scopus, Web of Science, CINAHL y Scielo, en el período de 2012 a 2016. Fueron seleccionados para el análisis, 21 artículos.

Resultados: los principales métodos para el desarrollo de aplicaciones móviles en el área de la salud descritos en los artículos fueron: diseño instructivo sistemático, diseño educativo contextual, diseño centrado en el usuario y ciclo de vida de desarrollo de sistemas.

Conclusión: independientemente del método de desarrollo elegido, las etapas deben estar bien definidas y estructuradas, a fin de que la aplicación móvil desarrollada sea útil para el usuario final.

DESCRIPTORES: Aplicaciones móviles, aplicación de informática médica, informática en enfermería, informática médica, tecnología de la información.

INTRODUCTION

In the current context, Information and Communication Technologies (ICT) geared toward the area of health have various tools which support the structuring and organization of the data and information, allowing the storing, processing, accessing in real time and/or remotely, and the sharing of the same - by both a wide variety of professionals involved in the care, and the patients/service users themselves.[1-5] These technologies are considered a global resource, which connects various computers, creating a network of information, and which makes it possible to contribute to the development and improvement of the health professions.[1]

ICT, in addition to making it possible to publicize and spread knowledge in the area of health, besides bringing it constantly up-to-date, can also support professionals' critical decision-making, contributing to the making of reliable diagnoses and qualified therapeutic guidance/conducts, aimed at patients/service users.[1-2,5] It is also emphasized that accessing information in real time and/or remotely contributes to resolving health problems/needs in different geographical regions, promoting broad coverage in terms of specialized healthcare, undertaken in the major urban centers.[1]

In this scenario, emphasis is placed on the phenomenon of the mobile technologies (tablets, smartphones etc.) - in particular, the use of worldwide mobile applications (also known as apps). Apps are conceptualized as a set of tools designed to undertake specific tasks and jobs.[6]

Mobile devices, and mobile apps in particular, aim to enable people to access information and knowledge, unrestricted by time and space. The possibility of breaking barriers of time and space also allows new forms of communication.[7-9] Such characteristics add strategic value to the new society in the Information Era.[10]

It is currently possible to observe a proliferation of mobile technologies and apps (mHealth), which is contributing to the construction of a new mode of healthcare, in which the information referent to people's health is readily available and ubiquitous.[6] Various studies indicate that these apps, including the information that these generate, can be used to optimize results and reduce risks in health; they can also be used for understanding the determinant factors which promote health and/or lead to illness.[11-16]

Specifically in the area of nursing, it is considered that the tools made available by ICT, associated with clinical, educational and management practice, require nurses to make efforts to achieve a definition of their role regarding ICT in nursing. There is evidence of the urgent need for these professionals to undertake reflection on this subject – and also to include themselves in the technological environment of the mobile apps, which are so strongly present in the Brazilian cultural, social and economic contexts.[17]

In the light of these considerations, the following research question arose: what are the main methods adopted by researchers for developing mobile apps in health? As a result, this integrative literature review aims to identify, in the Brazilian and international publications indexed in the databases, the main methods adopted by researchers for developing mobile apps in health.

METHOD

This is an integrative literature review of scientific studies published in 2012 – 2016. The stages of this review were based in a previously-established protocol, the aim being to maintain scientific and

methodological rigor, namely: 1) elaboration of the research question; 2) definition of the inclusion criteria for studies, and selection of the sample (search or sampling in the literature); 3) representation of the study selected in the format of tables, considering all the characteristics in common (data collection); 4) critical analysis of the studies included, identifying differences and conflicts; 5) interpretation/discussion of the results; 6) presentation of the integrative review in a clear and objective way including the evidence/data found.[18]

In order to respond to the review's guiding question, a bibliographic search was undertaken in the publications indexed in the following databases: MEDLINE/PubMed, Scopus, CINAHL, Web of Science and SciELO. The MeSH descriptors adopted were: Mobile applications; Medical informatics; Medical informatics applications; Public health informatics; Nursing informatics; Information technology; Telemedicine; and Technology. Due to the variety of terms used in the area of ICT, the decision was also made to include the following keywords in the search: mobile technology; eHealth; mHealth; telehealth; healthcare application; and cybercare. It is emphasized that the Boolean expressions AND and OR were the resources adopted for the study, with the aim of obtaining the largest number of studies possible regarding the topic to be reviewed.

The inclusion criteria for the studies were: original research, literature reviews (systematic, integrative or narrative) and experience reports, published between January 2012 and December 2016; in English, Portuguese or Spanish; available in full, and which clearly expressed the stages/methods (framework) for the development of the mobile app in the area of health - specifically, nursing, medicine and public health. The exclusion criteria considered were: duplicated articles, editorials, conference proceedings, case studies and reflection articles.

It should be emphasized that the selection of studies was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology.[19] The researchers were divided into 2 groups, each one with 2 members. Group 1 was responsible for carrying out the search in the databases, using the descriptors and keywords selected. In this stage, a total of 1,984 articles were found. After the search, the articles were shared with Group 2, and the researchers proceeded to the remaining stages of the review independently and simultaneously. Figure 1 presents the summary of the results obtained in each stage.

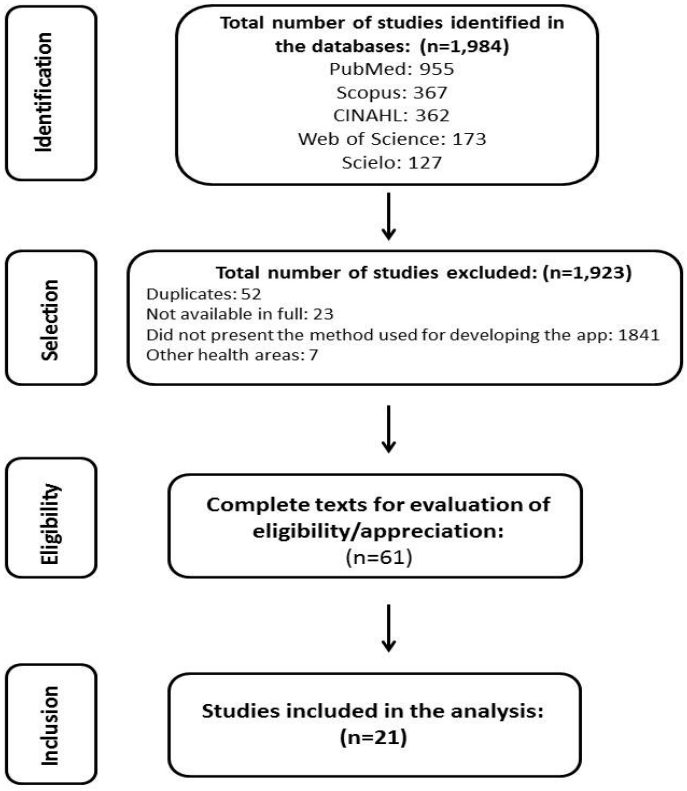

Figure 1 - Flowchart of the process for selecting the studies, based on the PRISMA methodology. Florianópolis, State of Santa Catarina (SC), 2017

The scientific method of reading was adopted for carrying out the data analysis. This method is undertaken in three stages: 1) syncretic vision – reading for general recognition, aiming to familiarize oneself with the topic being studied, and selective reading, seeking information about the study objective; 2) analytical vision: reflexive and critical reading of the articles selected, and choice of the main content related to the topic; and 3) synthetic vision: reading for interpretation of the data/results presented in the studies.[20]

It is highlighted that an instrument was developed for collecting and analyzing the data from the studies included. This instrument contains the following information: authorship, country, language, category of publication, year of publication, journal, study objective, area of health attended by the mobile app, and theoretical framework and method adopted for the development of the mobile app. Grouped by similarity of content, two categories for analysis were formulated: 'Description of the characteristics of the studies', and 'Methods used for developing mobile apps in health'.

RESULTS

Description of the Characteristics of the Studies

The publications selected for the identification of the main methods adopted by the researchers for developing mobile apps in health are described in Table 1.

Table 1 - Descriptions of the publications regarding methods for developing mobile apps in health, by year of publication, journal, method and area of health which the app dealt with. Florianópolis (SC), Brazil, 2017

Year	Journal	Method used	Area of health the app dealt with
2014	Acta Paulista Enfermagem	Systems Development Life Cycle	Oncology[21]
2014	Oncology Nursing Forun	Systematic Design of Instruction	Oncology[22]
2015	European Journal of Oncology Nursing	Systematic Design of Instruction	Oncology[23]
2015	Journal of Medical Internet Research	Systematic Design of Instruction	Oncology[24]
2014	Patient Preference and Adherence	Systematic Design of Instruction	Respiratory disease [25]
2014	JMIR Mhealth and Uhealth	Systematic Design of Instruction	Respiratory disease[26]
2016	Journal of Biomedical Informatics	Systematic Design of Instruction	Respiratory disease[27]
2016	Translational Behavioral Medicine	Systematic Design of Instruction	Primary health care[28]
2013	JMIR Mhealth and Uhealth	User Centered Design	Primary health care[29]
2015	Revista Panamericana de Salud Publica	Systematic Design of Instruction	Primary health care[30]
2014	Online Journal of Nursing Informatics	Systematic Design of Instruction	Geriatrics[31]
2015	Conference IMCOM	User Centered Design	Geriatrics[32]
2014	Computers Informatics Nursing	Systematic Design of Instruction	Pediatrics [33]

Year	Journal	Method used	Area of health the app dealt with
2012	Nursing Informatics	Systematic Design of Instruction	Pediatrics [34]
2012	Revista Escola de Enfermagem da USP	Contextualized design of Instruction	Critical care[35]
2016	Revista Latino Americana de Enfermagem	Systematic Design of Instruction	Critical care[36]
2012	Journal of the American Medical Informatics Association	Systematic Design of Instruction	Kidney disease[37]
2015	Healthcare Informatics Research	Systematic Design of Instruction	Metabolic disease[38]
2015	JAMIA: Journal of the American Medical Informatics Association	Systematic Design of Instruction	Mental health[39]
2015	JMIR Mhealth and Uhealth	Systematic Design of Instruction	Post-anesthetic recovery[40]
2016	JMIR Research Protocols	Systematic Design of Instruction	Parenteral nutrition[41]

In the MEDLINE/PubMed databases, 12 articles were selected for analysis; in Scopus and Web of Science, three studies in each; in CINAHL, two studies; and in SciELO, one study, totaling 21 articles analyzed. It is emphasized that 86% (18) of the studies were published in international periodicals, and 14% (03) in Brazilian periodicals.

In relation to the studies' country of origin, distribution was as follows: United States of America, 33.5% (07); Brazil, 14% (03); Sweden, 9.5% (02); and Argentina, Australia, Chile, South Korea, Spain, Holland, Indonesia, Italy and Taiwan, 43% (09) – one article for each nation. Regarding the languages of the articles analyzed, 86% (18) were published in English, and 14% (03) in Portuguese; no publication in Spanish was selected for analysis.

Figure 2 presents the distribution of the study selected by year of publication.

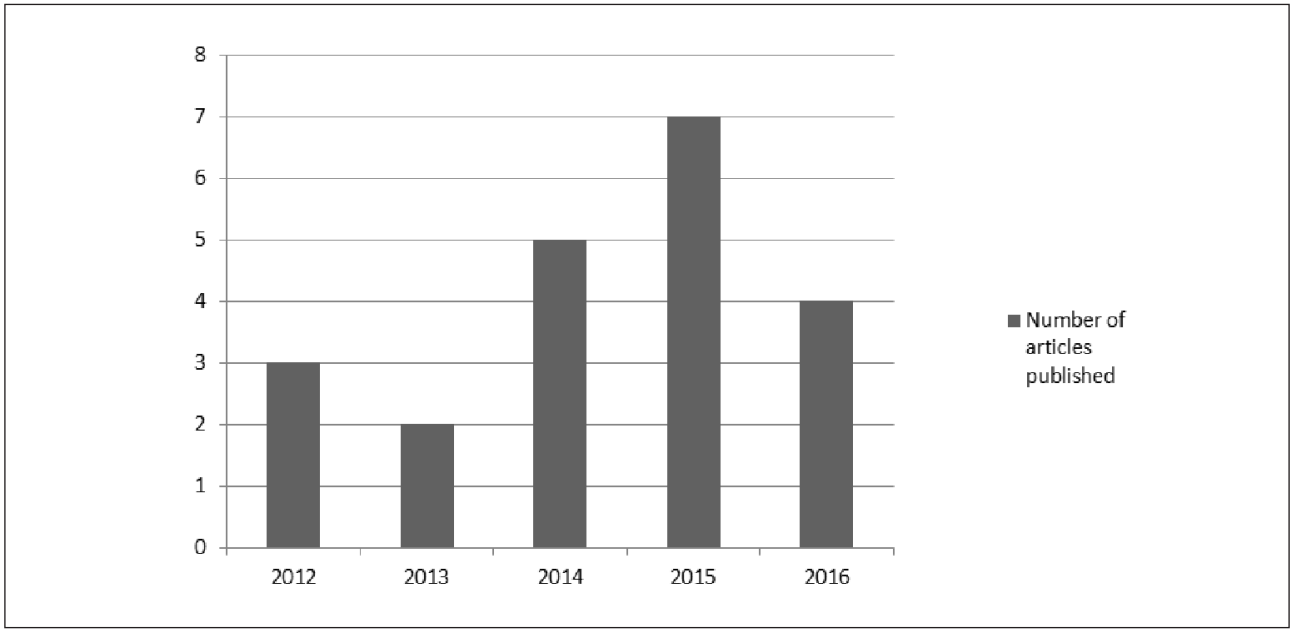

Figure 2 – Distribution of the publications by year. Florianópolis, SC, Brazil, 2017

The articles were classified by their category of publication, as specified by the periodicals: 86% (18) original studies; 9.5% (2) short communiqués and; 4.5% (1) protocol.

In relation to the area of specialty of the mobile apps developed and/or evaluated, the following distribution was evidenced: oncology (hospital-based, home-based and auditing),[21-22] 19% (4); respiratory diseases (asthma/adolescent and home care),[25-27] 14.3% (3); Primary Health Care (health promotion, chronic diseases and cardiovascular diseases),[28-30] 14.3% (3); geriatrics,[31-32] 9.5% (2); pediatrics (palliative care and care for the newborn)[33,34] 9.5% (2); critical-care (adult and neonatal),[35-36] 9.5% (2); kidney disease (hemodialysis),[37] 4.8% (1); metabolic disease (obesity),[38] 4.8% (1); mental health (depression)[39] 4.8% (1); post-operative recovery[40] 4.8% (1) and; nutrition (parenteral) [41] 4.8% (1).

Methods used for developing mobile apps in health

Based on the review undertaken, the following descriptors were evidenced: Mobile applications; Medical informatics; Medical informatics applications; Public health informatics; Nursing informatics; Information technology; Telemedicine; and Technology – as well as the keywords 'mobile technology', 'eHealth', 'mHealth', 'telehealth' and 'healthcare application'. These encompassed studies which addressed the main methods for developing mobile apps in the area of health. The keyword 'cybercare', researched in isolation and/or in association with other descriptors, was not found in studies on the central topic of this integrative literature review.

One of the methods which has spread most worldwide is Systematic Design of Instruction (SDI).[22-28,30-31,33-34,36-41] Developed by Walter Dick and Lou M. Carey[42-43] in 1978, this model considers the stages of analysis, design/development, implementation and evaluation.

Another method used for developing mobile apps in health is Contextualized Design of Instruction (CDI).[35] This method adopts the same stages as Systematic Design of Instruction, except that the stage of implementation takes place simultaneously with the stages of analysis/elaboration, adding stages and adding greater detailing to this technological tool.[44-46]

The method of User Centered Design (UCD) was used to develop apps in the area of Geriatric Nursing[32] and Primary Care (prevention of chronic diseases).[29] This is a method which establishes participation/collaboration between the users and designers/researchers in the phase of conception, so as to develop computer-based systems, namely, the mobile apps.[47-50]

The Systems Development Life Cycle (SDLC) method was adopted in a study which developed an app for consulting on chemotherapy medications, the aim being to assist with the auditing - in nursing - of hospital accounts.[21] This method has three approaches for developing systems: the classic lifecycle, the spiral lifecycle, and the prototyping life cycle. These means seek to help the developer/researcher to identify the users' needs.[51-52]

DISCUSSION

A range of methods/procedures involved in SDI has been developed in recent decades, with a view to constructing new technological tools (namely, the mobile apps), which improve the teaching-learning process and the performance of the users in the most widely-differing of contexts. It is observed that the developer/researchers have adopted a series of instructional means/resources in order to achieve their objectives but that, however, regardless of the method chosen and the different stages which make up each one of these, the majority of the methods include the stages of analysis, conception, development, implementation and evaluation.[42,44,46,53] It is also noted that, in the instructional and technological design, besides the stages mentioned, one can include the stage of management as a whole.[53]

In a general way, SDI covers planning, preparation, production and publication of texts, images, sounds and movements, simulations and activities supported by virtual tools made available by ICT.[45] This method has some contextual characteristics and mechanisms, including: individualization of rhythms of learning; it is adaptable to institutional, national, regional and/or local characteristics; it is possible for it to be constantly updated by users' feedback/opinions; the information can be accessed in real-time and/or remotely; there is the possibility for communication between users and developers/researchers; and it is possible to monitor the individual and collective construction of the users' knowledge.

Different modalities of SDI, which have similar objectives but which differ in their modelling and characteristics, are described in the literature.[44] Accordingly, the SDI model is divided according to how it is presented: Fixed Instructional Design (FID),

Open Instructional Design (OID), CDI and the Integrative Learning Design Framework (ILDF) model.

The CDI method considers human activity to be central, and seeks a balance between the automation of processes of planning, personalization and contextualization of the teaching/content and the technological tools available. That is to say, the term CDI is adopted in order to describe an intentional action of planning, development and specific and contextualized didactic applications, underpinned by the tools made available by ICT, incorporating - in its various phases - mechanisms and processes which promote the contextualization and flexibility of the content/teaching.[44-45]

CDI is made up of the following stages: analysis, design, development, implementation and evaluation. However, while the conventional instructional design models incorporate specific stages in each stage, this model adopts interlacing between its stages throughout the whole of the process of development of the teaching/content. CDI firstly characterizes the users, identifies the needs of the same, and carries out a survey of the limitations, improving and updating these data and information in parallel with the new requirements and participation of the users. As a result, the implementation phase does not take place separately from the conception phase (analysis, design and development); both progress and incorporate a series of stages which complement each other.[44-46]

In order to exemplify the use of the CDI method, one can cite a study which developed and assessed a mobile app for teaching the measuring of central venous pressure, which was designed for students of nursing (end-users). In this study, the researchers considered all the stages described by CDI, specified as following: I) Analysis: "identifying the needs, the characterizing of the target-public, the collection of bibliographic references, the definition of the educational objectives, the definition of the content, the analysis of the technological infrastructure, and the creation of a diagram to guide the construction of the tool";[35:109] II) Design: "planning and production of the didactic content, the definition of the topics and editing of the modules, the selection of the media, and the design of the interface (layout). The decision was made to use images and texts, structured in topics, and connected by links";[35:109] III) Development: [...] "Selection of the tools of the multimedia app, the definition of the navigation structure, and the planning of the configuration of environments";[35:109] IV) Implementation: [...] "Configuration of the tools and educational technological resources, as well as the construction of an environment for downloading the application on the Internet and installing it on the mobile device";[35:109] and V) Evaluation: "evaluation by specialists regarding the content, didactic resources, and the environment's interface".[35:109]

The SDI method, also termed the Dick and Carey model, has a systems approach aiming for effective instruction in order to support the teaching-learning process in a way which has been highly successful. This method encompasses the stages of analysis, design/development, implementation and evaluation, and emphasizes the complete and detailed analysis of the various instructional components which are inter-related, the comprehensive assessment of the materials produced, and the refining/updating of the content/teaching throughout the process of development of the technological tool.[42-43,46,53-54]

In spite of the stages described in this method, the authors indicate that there is no single model for creating and developing instruction/content, and encourage developers/researchers/designers and users to create their own method/process for instructional design, aiming for unique solutions to problems and/or specific needs in their practical situations.[42-43,54]

This method can be used for a variety of instructional systems – in the present study, the mobile apps.[22-23,26-28,34,38-39] It is also highlighted that the Dick and Carey model is based in various perspectives found in the teaching-learning process, namely: Behaviorism (definition of the components of the instructional strategy); Cognitive Theory (formulation of the presentation of the material/instructional content, and processing of the information); and Constructivism (analysis of contexts in order to assist the users in the construction of conceptual structures for learning).[42-43,53-54]

The UCD method has a broadened approach. This is a general term, characterized by a philosophy and by stages which describe the processes of a project, centered on its creation and the users' involvement in the elaboration of computer-based systems.[47] That is, in the UCD, the end-users can directly influence all of the methodological stages, it being fundamental that the researcher/developer/designer should understand the technological tool's context of use, and the requirements provided by the users.[47,55-57]

It is highlighted that in the UCD method, the user's participation can vary in intensity.[47] At one end of the technological tool's construction, the involve-

ment can be relatively low – that is, the users may be consulted and observed regarding their needs, and maybe invited to participate in usability tests with the system being developed. At the other end, the users may be involved intensely, actively participating in all of the stages of the project, including the conception of the technological tool itself.

It is worth emphasizing that the International Organization for Standardization (ISO) regulation 13,407: Human-centered design processes for interactive systems describes three design solutions for the UCD method: I) Cooperative design (users and developers/researchers are involved in all stages); II) Participative design (users occasionally participate in the development process) and; III) Contextual design (based in the current context).[55]

Various mechanisms support the UCD method, including: usability tests, systems usability engineering, heuristic assessment and rapid evaluations/pilot-tests. The rapid evaluations (pilot-tests) are considered important so that the users will be able to give their feedback from the very beginning of the project, as well as to bring the same closer to the developer/researchers and the technological tool itself.[47]

As an example of the application of the UCD method, one can mention the study which developed a mobile app for monitoring and reacting in order to encourage physical activity in people with chronic illnesses in primary care. In that study, the researchers recruited people from national associations of patients who had Chronic Obstructive Pulmonary Disease (COPD) and diabetes, so that they could participate in the research team. These patients described and reflected on the needs, requirements and restrictions of their conditions as persons with chronic diseases. They also provided the researchers with feedback on their understanding of the issues addressed in the interviews and of the content/documents created for the end-users. Through adopting the UCD method, the researchers managed to gather requirements, which were then translated into technical solutions by the project's engineering team, allowing continuous interaction between all those involved.[29]

The SDLC method covers the following stages: analysis (collecting data on the needs, and identifying the needs of the institution/user); project (detailed specifications of the project); development (which includes the development or acquisition of the software); implementation (after undergoing evaluative tests); and maintenance (continuously maintaining and updating the system). SDLC is subdivided into three categories: classic lifecycle, spiral lifecycle, and prototyping life cycle.[51-52]

The classic lifecycle, also termed the Cascade Model, follows all the stages of the SDLC described above. It has a linear structure, is sequential, and there is an absence of revision for each stage, that is, the system's development takes place in a single direction, it being considered to be an inflexible model/method. In adopting this method, the researcher/developer delivers the entire technological system/tool at the end of the project.[51-52]

The spiral lifecycle is based in the concept of the user's greatest need. This method develops and hands over the system/technological tool in versions. It is emphasized that each version follows all the stages of the SDLC, with the following exceptions: I) the implementation stage may be adopted in some or all versions; II) the stage of maintenance will be applied only to the last version made available. In the 'spiral approach' SDLC, the users can monitor the system's development and judge whether the content/instruction material meets their needs satisfactorily, thus making it possible to substitute the existing system (new versions).[51-52]

The prototyping life cycle addresses the gradual and evolving discovery of the system under development by the users and developers/researchers. That is to say, based on a set of the users' needs, the developer/researchers implement the needs rapidly and refine/detail them based on the increase in knowledge regarding the system by the users and by the developers themselves.[51-52]

This model has three categories: I) paper prototyping, or computational prototype (demonstrates the human/machine interaction, and the clear understanding of this interaction which is present; II) working prototypes (implements some functions required by the user which may be improved during the development of the system); and III) functional prototype (which allows the user to store data and undertake operations using the data). It is stressed that the prototypes make it possible to visualize uncertain aspects of the system under development. They also make it possible to check and test hypotheses regarding these aspects. As a result, the prototypes are considered to be typically incomplete, and are not intended to function without tolerable shortcomings.[51-52]

One study developed an app for consulting regarding chemotherapy medications in the auditing of hospital accounts.[21] The researchers adopted the SDLC method – prototyping, covering the following stages: I) communication: "raising the requirements

of the software";[21:180]; II) planning: description of the "resources which will be used and the timeline to be followed";[21:180] III) modeling: "creation of a model which is consistent with the requirements raised";[21:180] IV) construction: "generation of codes and tests to reveal errors";[21:180] and V) implantation: "the final stage, in which the product is analyzed and evaluated".[21:180]

One systematic review study summarized the current knowledge regarding the factors which influence the adoption of mobile health apps (mHealth) by health professionals. Based on the 33 studies selected for analysis, 179 elements recognized as facilitating (54.7%), or as barriers (45.3%) to, the adoption of these technological tools. Among the main elements identified, characterized as individual, organizational and contextual, emphasis is placed on the following: use/purpose and ease of use; design and technical concerns; security, privacy, cost and time; familiarity with the technology; and interaction with colleagues, patients and managers.[16] Stress is placed, therefore, on the relevance of the appropriate choice of method for the development of mobile apps in health, as issues related to ease-of-use, design and technical components of the systems may be either factors directly related to the successful adoption of these technological tools, or may be barriers to this adoption.

CONCLUSION

In this integrative review of the literature, the decision was made to analyze only articles which contained the description of the method used, associated with the detailing of their respective stages, for the development of mobile apps in health. However, it is worth emphasizing that as a result of adopting the "Scientific Reading Method", in the syncretic vision phase, for the analysis of the 1,984 articles, it was possible for the authors to evidence that, in a general way, the researchers/developers/designers used the main methods for developing apps described in the literature, namely: instructional design, systematized design instruction, contextualized instructional design, user-centered design, and systems development lifecycle.

This integrative review made it possible to identify the stages described in each method, highlighting the characteristics of each one and also making it possible to understand that, regardless of the method chosen, the stages must be well defined and appropriately structured, so that the mobile app developed will be useful for the end-user.

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