Original Article

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TEXT & CONTEXT NURSING TEXTO & CONTEXTO ENFERMERÍA

PICCPED® MOBILE APPLICATION: PREVENTION OF ADVERSE EVENTS IN A PERIPHERALLY INSERTED CENTRAL CATHETER IN PEDIATRICS

Sabrina de Souza[1]
Patrícia Kuerten Rocha[1]
Ariane Ferreira Machado Avelar[2]
Andréia Tomazoni[1]
Jane Cristina Anders[3]
Amanda Ullman[4]

[1]Universidade Federal de Santa Catarina, Programa de Pós-Graduação em Enfermagem. Florianópolis, SC, Brasil.
[2]Universidade Federal de São Paulo, Programa de Pós-Graduação da Escola Paulista de Enfermagem. São Paulo, SP, Brasil.
[3]Universidade Federal de Santa Catarina, Programa de Pós-Graduação Gestão do Cuidado em Enfermagem. Florianópolis, SC, Brasil.
[4]Griffith University, School of Nursing and Midwifery and Menzies Health Institute Queensland. Brisbane, Queensland, Australia.

ABSTRACT

Objective: to construct a mobile application in the *mobile-learning* format that favors learning, offering support to the nurse's clinical reasoning and decision-making in the prevention of adverse events related to the peripherally inserted central catheter in pediatrics.
Method: the construction of the *mobile-learning* technological production took place between 2016 and 2020, following seven steps that included the Contextualized Instructional Designer. The content of the application was based on current scientific evidence, with the inclusion of guidelines, international and national directives; and was elaborated grounded on Problem-Based Learning. The project team involved the participation of two content experts, a programmer, and two graphic designers.
Results: the application consists of a pediatric clinical case, which gives rise to six other cases, exploring six catheter maintenance procedure. When presenting the cases, the user is encouraged to perform a clinical evaluation and make a decision about the problem raised. So, when the user correctly chooses the clinical issue, there is a message of congratulations and they are encouraged to continue their learning. In opposition, when the user answers incorrectly, the software shows the adverse event that can affect the patient and a new evaluation and decision-making are encouraged. At the end of each procedure, there is an animation of the correct technique for better assimilation of the constructed knowledge.
Conclusion: this type of *mobile-learning* application allows for knowledge dissemination and assists safe care to children using the peripherally inserted central catheters.

DESCRIPTORS: Pediatric nursing. Patient safety. Catheters. Information Technology. Mobile applications. Decision-making.

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APLICATIVO MÓVEL PICCPED®: PREVENÇÃO DE EVENTOS ADVERSOS EM CATETER CENTRAL DE INSERÇÃO PERIFÉRICA EM PEDIATRIA

RESUMO

Objetivo: construir um aplicativo móvel no formato *mobile-learning* que favoreça a aprendizagem, dando suporte ao raciocínio clínico e tomada de decisão do enfermeiro na prevenção de eventos adversos relacionados ao cateter central de inserção periférica em pediatria.
Método: a construção da produção tecnológica *mobile-learning* foi realizada entre 2016 e 2020, seguindo sete passos que incluíram o Designer Instrucional Contextualizado. O conteúdo do aplicativo teve como base evidências científicas atuais, com inclusão de *guidelines*, diretrizes internacionais e nacional; ainda, foi elaborado embasado na Aprendizagem Baseada em Problemas. A equipe do projeto envolveu duas conteudistas, uma revisora, um programador e dois designers gráficos.
Resultados: o aplicativo é composto por um caso clínico pediátrico, que origina outros seis casos, explorando seis procedimentos de manutenção do cateter. Ao apresentar os casos, o usuário é estimulado a realizar avaliação clínica e tomar decisão acerca do problema levantado. Assim, quando o usuário responde corretamente à questão clínica, há uma mensagem de parabenização e o mesmo é estimulado a continuar seu aprendizado. Comparativamente, ao responder incorretamente, o *software* demonstra o evento adverso que pode acometer o paciente e uma nova avaliação e tomada de decisão são incentivadas. Ao final de cada procedimento há uma animação da técnica correta para melhor assimilação do conhecimento construído.
Conclusão: este tipo de aplicativo *mobile-learning* permite a disseminação do conhecimento e auxilia em uma assistência segura às crianças com cateteres centrais de inserção periférica.

DESCRITORES: Enfermagem pediátrica. Segurança do paciente. Cateteres. Tecnologia da informação. Aplicativos móveis. Tomada de decisões.

APLICACIÓN MÓVIL PICCPED®: PREVENCIÓN DE EVENTOS ADVERSOS EN CATÉTERES CENTRALES DE INSERCIÓN PERIFÉRICA EN PEDIATRÍA

RESUMEN

Objetivo: diseñar una aplicación móvil con el formato *mobile-learning* que sirva de suporte para el razonamiento clínico y la toma de decisiones del enfermero frente a la prevención de eventos adversos relacionados con el catéter central de inserción periférica en Pediatría.
Método: estudio metodológico que se constituye como una producción tecnológica del tipo *mobile-learning*. El contenido de la aplicación tuvo como base evidencias científicas actuales, con la inclusión de *guidelines*, directrices internacionales y nacionales; y, como marco referencial el Aprendizaje Basado en Problemas. Para servir de suporte al diseño de la aplicación se siguieron siete pasos. El equipo de trabajo estuvo compuesto por dos expertas en contenido y revisoras, una revisora, un programador y dos diseñadores gráficos, y el diseño tuvo lugar entre 2016 y 2020.
Resultados: la aplicación está compuesta por un caso clínico pediátrico, que da origen a otros seis casos, uno para cada procedimiento específico de mantenimiento del catéter. Al presentar el caso clínico específico, se incentiva al usuario a realizar una evaluación clínica y a tomar una decisión con respecto al problema presentado, de modo que, cuando el usuario elige correctamente las alternativas, aparece un mensaje de felicitaciones y se lo incentiva a proseguir con su aprendizaje; en contrapartida, cuando opta por una decisión incorrecta, el software demuestra el evento adverso que puede sufrir el paciente y se inicia un nuevo proceso de evaluación y toma de decisiones. Al final de cada procedimiento se presenta una animación de la técnica correcta para asimilare de mejor manera el conocimiento elaborado.
Conclusión: le espera que esta aplicación del tipo *mobile-learning* permita diseminar el conocimiento, auxiliando así a una asistencia segura a niños con catéteres centrales de inserción periférica.

DESCRIPTORES: Enfermería pediátrica. Seguridad del paciente. Catéteres. Tecnología de la información. Aplicaciones móviles. Toma de decisiones.

INTRODUCTION

Peripherally Inserted Central Catheters (PICCs) are vital devices to promote pediatric patient care and are considered safe and reliable as a method to obtain an efficient central access[1–2]. However, complications about the use of the PICC are frequently reported in the literature, including the occurrence of obstruction, accidental removal, infection, rupture, malposition, catheter fracture, pulmonary embolism and thrombosis[3–6]. Such Adverse Events (AEs) were frequently evidenced, including a French retrospective study (91 PICCs in 74 patients), which found an AE rate of 13 (14.4%), where in 4 (4.4%) the outcome was considered serious[6]. Many of these infection rates are the result of inadequate aseptic techniques and device handling. Therefore, training of the professionals in these procedures can aid in the prevention of these AEs[6–7].

The Information and Communication Technologies (ICTs) in health represent innovation potential to improve the training on clinical procedures and, consequently, patient safety[8–9]. Knowing that currently half of all the AEs are caused by some type of human error, the ICTs can have an important impact on the professional's clinical reasoning and decision-making[10].

Within the ICTs, virtual simulation through a Mobile Application (app) is a promising strategy and providing the professional with training in safety, in a simulated environment. This makes it possible to make a mistake without causing any harm, to learn from the error, and to know how to correct it. This conduct review exercise, as well as the possibility of consulting material based on scientific evidence, combined with the agility, ease of access and interactivity that an app can offer, culminates in the incentive to build apps that include virtual simulation[11].

Mobile-learning (m-learning) incorporates these resources in an app, where the user's learning is the objective of developing the technology. Through this approach, continuous and effective learning is sought, without limits of physical space and time. This approach favors shifting from exclusive classroom teaching to learning in any real-world context, where there is special concern with the development of the user's behavior, thinking and reasoning[12].

Learning how to maintain PICCs is complex, and significant AEs can occur if their care is not adequate. The professionals involved in this care can learn by means of processes that support knowledge construction in a flexible and safe environment. Therefore, in view of the advantages in the learning process that an app in the *m-learning* format can have, also integrating virtual simulation in search of the construction of clinical reasoning and decision-making increasingly assertive to the user; this study aims to build an app in the *m-learning* format that favors learning, offering support to the nurse's clinical reasoning and decision-making regarding the prevention of AEs related to the PICC in pediatrics.

METHOD

A methodological study that constitutes a technological production of the *m-learning type*. This study aims to present the development and construction of an app referred to as PiccPed®, which seeks to support nurses' decision-making regarding the prevention of AEs related to the maintenance of PICCs in pediatrics.

The development of the app took place in the period from 2016 to 2020. The facilities used were those of the Laboratory of Research, Technology and Innovation in Child and Adolescent Health (GEPESCA), the Graduate Program in Nursing (PEN/UFSC), as well as *on-line* platforms where meetings were held among the team of developers. The development team of PiccPed® was composed of two app coordinators, who were also content experts and reviewers (researchers); a proofreader (researcher); a programmer and two graphic designers.

For elaborating PiccPed®, the authors built up a methodological proposal with seven stages based on the Contextualized Instructional Designer (CID)[13]. This methodological proposal supports the stages and steps for the construction of the app, in order to follow a more objective methodological path throughout the process. The stages take place in a dynamic manner and, some, simultaneously, as follows: object definition and verification of the app viability; elaboration of the theoretical framework of the study object; *design of the app presentation*; preparation of the app content; completion of the process of building the app; and app registration.

First stage: object definition and verification of the app viability

Three systematized reviews were performed in the literature about the characteristics of the different ICTs and the theme of patient safety, PICC, clinical reasoning and decision-making.

First, a systematized review was carried out in order to verify which is the best ICT that would meet the proposed object and objective. For this, the search was conducted in the CAPES journal portal, selecting the following databases: Scientific Electronic Library Online (SciElo®), *Literatura Latino-Americana e do Caribe em Ciências da Saúde* (Lilacs®), PubMed Central (PMC®), *Centro Latino-Americano e do Caribe de Informação em Ciências da Saúde* (BIREME®), Cumulative Index to Nursing and Allied Health Literature (CINAHL®), Medical Literature Analysis and Retrieval System Online (Medline®), Web of Science® and SciVerse Scopus (Scopus®), with the following keywords/descriptors, in Portuguese, English and Spanish: “mobile app”, “m-learning”, “mobile-learning”, “app”, “digital simulation”, “technologies”, “communication technologies”, “information and communication technology”. Technologies such as computer software programs, mobile applications, serious-game, electronic-learning and mobile-learning tools, among other technologies in health were found. However, after analyzing the articles found, there was a preference for constructing an app, due to its differentiation from other technologies, to its greater scope, ease of access, possibility for the professionals to use it in their work environment or in another place or even on the move.

Subsequently, a systematized literature review was carried out with the objective of developing the app’s theme and content. The research included the same databases as the previous one, with the following keywords/descriptors: “patient safety”, “patient safety in pediatrics”, “peripherally inserted central catheter”, “adverse events”, “decision-making” and “clinical reasoning” in Portuguese, English and Spanish. It collected studies on the themes of patient safety and adverse events in PICCs in Pediatrics, and there was further deepening on the themes of clinical reasoning and decision-making.

The final systematized review aided in the design of the study technology, and the literature was searched for works that built ICTs. This search was carried out in the same databases as the previous review, with the following keywords/descriptors in Portuguese, English and Spanish: “information technology”, “software in health”, “mobile app” and “app in health”. The absence of studies with technologies for the safety of patients using PICCs was verified.

Simultaneously, in order to avoid the development of an already existing tool or even a similar one, a consultation was also carried out in repository databases focused on the ICTs, namely: Multimedia Educational Resource for Learning and Online Teaching (MERLOT), Campus Alberta Repository of Educational Objects (CAREO), Repository of Other Open Collections (ROCA) of the Federal University of Technologies of Paraná, Collection of Supporting Entities for the Use of Technology in Learning (CESTA) of the Federal University of Rio Grande do Sul (UFRGS), and the Repository of the International Virtual Education Network (RIVED) of the Ministry of Education - Brazil. From the consultation, it was verified that there was no technology that addresses the theme of PICC and patient safety in pediatrics published in the literature.

Therefore, after these inquiries, the decision was made to construct the technology of the app, considering that this type of ICT meets the objective proposed. Immediately after that, professionals from the IT area were searched - one programmer and two graphic designers - to verify the viability of the technology proposed. Then, they were presented with a first outline of the app, and it was verified that the idea was feasible and viable, therefore proceeding to the second stage.

Second stage: elaboration of the theoretical framework of the study object

Problem Based Learning (PBL) was chosen as the framework of this study. This choice was due to the possibility of support in the entire elaboration of the tool's content and proposal, which aimed at the learning of the professional at all moments, from the elaboration of the clinical cases to the answers with the possibility of feedback to the user. It is recalled that PBL, in addition to supporting the content, covers the desired learning needs in the app. The seven steps suggested by PBL were respected, being followed dynamically, not orderly as indicated in the framework[14].

Also, according to PBL, a fictitious pediatric clinical case was created, so that there was a possibility for directing the learning. From this general pediatric clinical case, specific clinical cases arose about each PICC maintenance procedure, namely: evaluation and inspection of the insertion site, change of the PICC dressing, adequate positioning, maintenance of permeability and fluid infusion.

Third stage: design of the app presentation

Considering the app proposal to be an *m-learning,* in this stage there was a delineation of the best way to approach the screens and commands in order to favor user's learning. It was then decided on the format of the content in clinical cases, described in the fourth stage. From this clinical case, the user is stimulated to perform clinical reasoning and decision-making in view of the contextualizations exposed. From this, the user will have the opportunity to perform evaluations and receive feedback, being stimulated to make new decisions.

Fourth stage: elaboration of the app content

The stage involved building the app content. This was based on current scientific evidence, through a compilation of the recommendations in the guidelines of important International and National Institutions that set up directives to improve patient safety worldwide: Centers for Disease Control and Prevention (CDC), National Health Surveillance Agency (ANVISA), Infusion Nurses Society (INS), Queensland Government and The Joint Commission[4,15–19].

The recommendations of the guidelines were organized in a two-column chart: recommended care and AE to be prevented. The content was basically divided into six axes: "evaluation of the insertion site", "PICC dressing", "proper positioning", "maintenance of permeability", "fluid administration" and "infection prevention". From this, the screens of the app were built up, being divided according to each catheter maintenance procedure.

Fifth stage*: construction of the prototype*

The content experts prepared a first design of the prototype. This was illustrated in Power Point® (Microsoft®), and the format, layout and designs of the app were defined and submitted for presentation and discussion with the *designers*.

Sixth stage*: completion of the app construction process*

The app construction process was completed by means of periodic meetings with the development team. And, above all, important definitions were established, such as construction planning and

discussion of tools and technologies for the development of the app. The initial prototype of the screens was presented to the *designers* and to the programmer, with debates being held among the team members about the exposed resources and the necessary changes. On the part of the content developers at this stage, content was adapted to the size of the screens.

Sequentially, the *designers* presented the first layout and interface of PiccPed®, choosing the use of 2D technology and the *flat design*. At the same time, the technology, methodology and tools to be used in the app's programming were delimited.

For programming PiccPed® JavaScript® was used as its language; the ReactJS® tool, which is JavaScript® framework, to increase the productivity of code development and organization in the mobile apps; HTML® was applied as markup language; and Cascading Style Sheets (CCS) was used as style sheet language.

The *Progressive Web App* (PWA) programming platform was used, allowing app access via the web both in the Android® and IOS® operating systems, not being necessary to download it from any virtual store (*Play Store*® or *Apple Store*®). Consequently, PWA is considered an innovating technology, as it encompasses and facilitates access to the app. To use PiccPed® on the smartphone, whether Android® or IOS®, it is only necessary to access the app's *link*, which automatically downloads and installs the icon on the phone's desktop. Thanks to PWA, it is also possible to access the web via a computer, also from the app's *link*.

In the entire construction phase, several rounds took place to present the partial development of the app among the team, with immediate adjustments being made, thus improving the product in each cycle, as set forth by *Scrum*[20]. He advocates that a project must be divided into small cycles of activities, with meetings among the team members so that improvements and agility in its construction process are assessed continually[20].

The resources used were deliberated throughout the tests, after analysis of the entire team, aiming at a resource that provides the user with greater usability, effectiveness, efficiency and satisfaction[21]. Subsequently, after submitting the final scope of PiccPed®, the content experts assessed the content, interface and the entire structure of the app were evaluated, suggesting final adjustments. Thus, a new review was made and the final version was approved.

Seventh stage*: app registration*

Finally, contact was made with the Innovation Department of the Federal University of Santa Catarina (SINOVA/UFSC) to start Software registration.

RESULTS

This process resulted in the PiccPed® *m-learning* app (Figure 1), which has the objective of favoring learning, supporting the nurse's clinical reasoning and decision-making in the prevention of PICC-related AEs in Pediatrics.

The app was developed to improve knowledge and, consequently, the practice of the nurses who assist the child and who maintain the PICC in their care practice. In each screen, this app aims at promoting the learning of the professional/user through problems similar to those found in their care practice, where it is necessary to perform a clinical evaluation and decision-making. However, unlike what is found in the practice, the app allows the nurses, when making a non-assertive decision, to explicitly find the AE that can affect the patient and return to the problem for further evaluation and decision-making. This process prepares them so that, when these problems are present in the clinical practice, they are familiar with the situation and carry out a process of clinical reasoning and decision-making with greater mastery, resulting in adequate and safe care.

The structure of PiccPed® is composed by a general clinical case, from which six other minor cases of the same child were derived, one for each PICC maintenance procedure, as already mentioned. In those, the nurse is encouraged to continue the clinical evaluation of the child using the PICC and make decisions in each procedure exposed. The decision to carry out clinical cases derived from the general clinical case, instead of their formulation with different patients and situations, was intended to expose the user that the clinical evaluation for decision-making in the management of the PICC must be continuous. Inadequacy or discontinuity of the clinical evaluation can cause AEs, even if the other decisions have been assertive. In this way, PiccPed® intends to encourage the nurse to conduct frequent assessments and to present the complexity of decision-making in the assistance provided to the patient.

PiccPed® does not assign scores. There is no option to proceed to the next screen without an assertive decision being made. In this way, in all situations the users receive feedback on their choices, them being correct or incorrect. And, in case they are incorrect, sequentially the same is stimulated to perform a new clinical reasoning and decision-making process that at the end of the situation brings benefit, and not harm to the patient.

The initial screen is composed by the logo and the symbol of the Supporting Institutions (Figure 1).

By clicking on "*COMEÇAR*" ("START"), the user is directed to a screen with a brief introduction of the app, including its objective. By selecting the arrow to proceed, the user is presented with the possibility of knowing definitions, which will be important for conducting the learning in the app. In this screen, when clicking on the desired term, the user receives its concept.

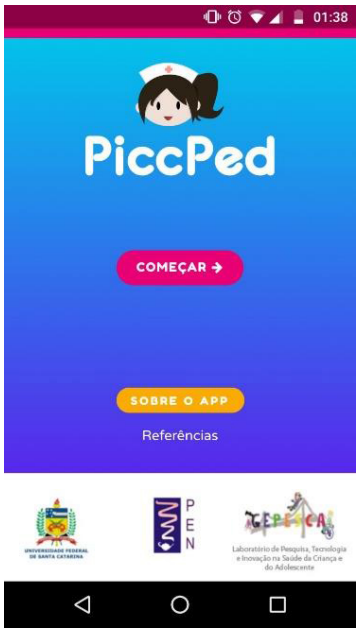

Figure 1 – Initial screen of PiccPed®**.** Florianópolis, SC, Brazil, 2021.

The terms and definitions presented are based on the literature reviews, including: *segurança do paciente* (patient safety); *evento adverso* (adverse event); *CCIP* (PICC); *simulação virtual* (virtual simulation); *raciocínio clínico* (clinical reasoning); and *tomada de decisão* (decision-making). After the concepts have been elucidated, the figures representing the AEs to be prevented are displayed and, by clicking on the figure, it is possible to know its definition. The highlighted adverse events are: Central Catheter-Related Bloodstream Infection (CCRBI), phlebitis, obstruction, incorrect positioning, thrombosis and catheter rupture (Figure 2). It is important to highlight that these figures will also appear along the app to demonstrate to the user the result of inadequate decision-making that may occur.

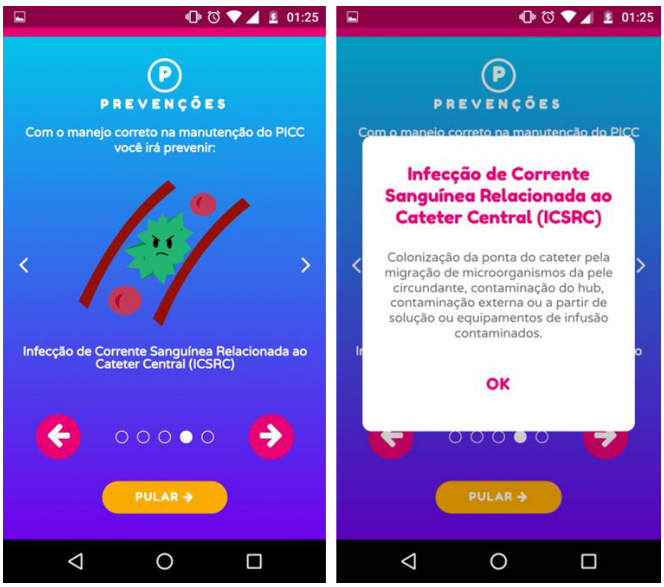

Figure 2 – Adverse events to be prevented during the app. Florianópolis, SC, Brazil, 2021.

After this representation, the user is directed to the general clinical case which, as mentioned, was elaborated from the PBL systematized reviews, where it will be possible to read it or select the option to listen to it (Figure 3). The voice of the narrator was chosen by preference of the authors, who sought a female voice in order to be compatible with the nurse character and to have a soft and clear tone. In this first clinical case there is the report of a PICC insertion procedure successfully performed in a two-year-old child, identified as Arthur, with confirmation of central position of the catheter by X-ray The case is concluded by placing the user in the role of the nurse on duty the following day and requesting that the evaluation be carried out regarding the aspects of the PICC.

Once the screen has been read, clicking on the "*PROCEDIMENTOS*" ("PROCEDURES") button, there will be six possible procedures to be performed: "evaluation of the insertion site", "PICC dressing", "proper positioning", "maintenance of permeability", "fluid administration" and "infection prevention".

Figure 3 – Presentation of the general clinical case. Florianópolis, SC, Brazil, 2021.

By clicking on one of the procedures, the users will be directed to a specific clinical case, where they will find a report and the command to start their evaluation and decision-making. In the specific clinical case of PICC dressing, for example, the user is informed that the dressing made at the insertion moment, 24 hours ago, with gauze and transparent film is stained with blood, and the user is asked to perform the clinical evaluation and decision-making given the above.

In all procedures, after the report of the specific clinical case, when clicking on the “PRÓXIMO” (“NEXT”) button, the user will find a question and alternatives to be chosen. In all the procedures, there is the possibility of reviewing again: the general clinical case (represented by the acronym CG), specific clinical case (represented by the acronym C), definitions (represented by the acronym D) or adverse events to be prevented (represented by the acronym P) (Figure 4).

In most of the screens a pattern is followed with an option to expand the image. This scenario contains the representation of the problem situation presented to the user in order to contextualize the questioning that is being performed. The user is sequentially asked to perform their clinical evaluation and decision-making by choosing the option(s) that they consider correct. For better elucidation, some screens of the PICC dressing change procedure will be demonstrated (Figure 4) When clicking on an incorrect option, there will be an alert with the illustration of the AE that could reach the patient, a brief explanation, and the request for a new evaluation to be performed (Figure 4). When the correct decision is made on an item, the button will be green until all the correct options are selected (Figure 4).

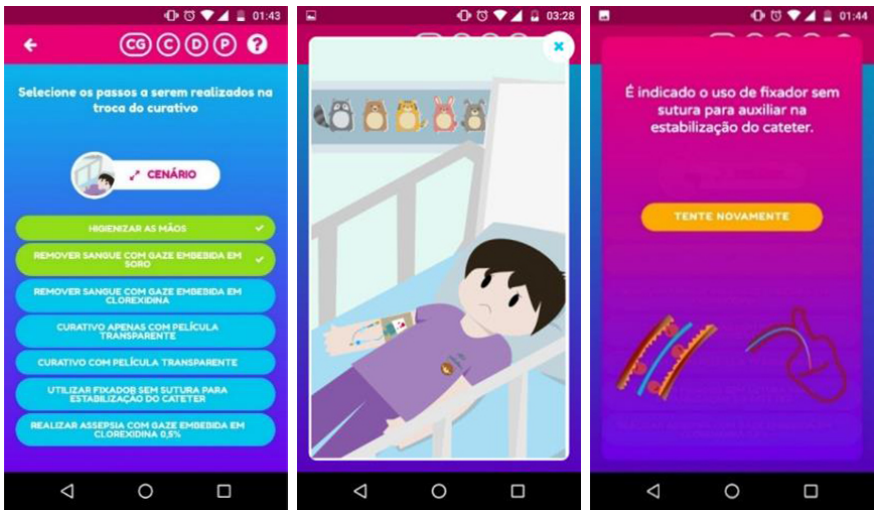

Figure 4 – Screen with the selection of the correct options, setting and representation of incorrect decision-making. Florianópolis, SC, Brazil, 2021.

When all the correct options are selected, there is an alert congratulating the user and encouraging them to continue their evaluation in the next stage (Figure 5). Sequentially, in some procedures there is an animation demonstrating the correct technique, in order to compile learning (Figure 5).

At the end of all the evaluations of a procedure, the user is encouraged to return to the screen with the list of procedures and continue their evaluation and decision-making in another.

The user can choose to perform as many procedures as they wish while using the app, without having to follow an order; each procedure is independent of the other.

Finally, in view of the above, the app aimed at performing the clinical evaluation to build clinical reasoning and decision-making given all the situations regarding PICC handling. The animation included at the end of the procedures aims, through virtual simulation, at showing the correct way to perform the procedure, as well as it intends to collect and compile the knowledge constructed during the process of performing each clinical case.

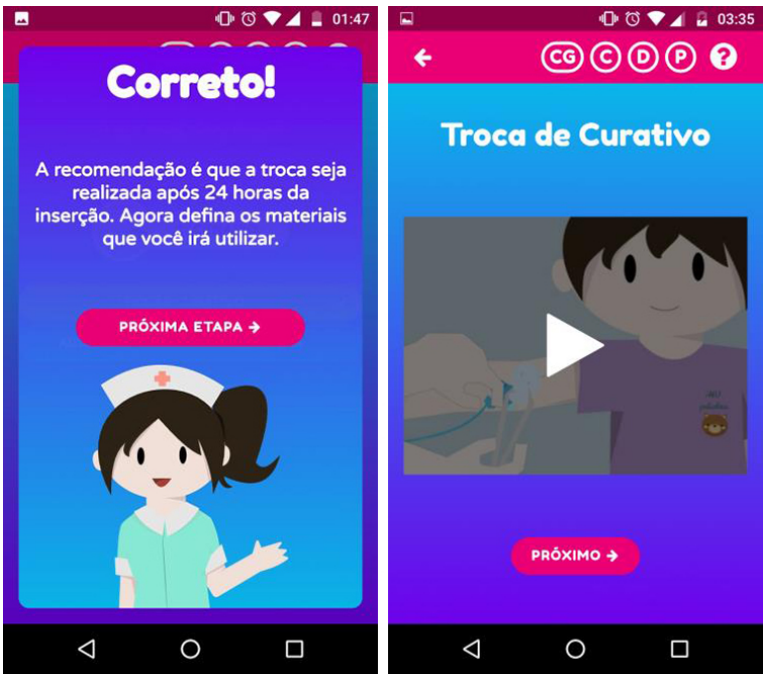

Figure 5 – Screen of correct answer for decision-making and procedure animation. Florianópolis, SC, Brazil, 2021.

DISCUSSION

Complications related to inadequate PICC maintenance are found in national and international research studies. The AEs highlighted in those research studies are the same than those listed in PiccPed®, namely: PICC rupture, obstruction, suspicion/infection of bloodstream related to the central catheter, venous thrombosis, phlebitis and incorrect catheter tip positioning[1–5,22–23].

A recent study conducted in the United States assessed the practices involved in the insertion and maintenance of the PICC comparing them to the current scientific recommendations in neonatal intensive care units. It found many practices which are contrary to the evidence, as well as incorrect information used by the professionals. These results highlight the concern regarding the safety of newborns using PICCs, mainly for this being a necessary device for this population. Moreover, there was a wide variation in the management of PICCs in multiple insertion and maintenance aspects. This would be different if there was guidelines integration and standardization of the current practices, including instruments such as protocols and technologies which support the nurse in decision-making[22].

In addition, a prospective cohort study that monitored 438 patients using PICCs for 70 days in the United States of America, observed that 61.4% presented signs of at least one complication related to the catheter, including complications with high harm potential, such as CCRBI (17.6%) and deep venous thrombosis (30.6%). In addition, more than one fourth (27.9%) of the patients presented milder complications such as hyperhemia in the insertion site, discomfort or difficulty removing the catheter.

Consequently, it is noted that, to ensure safe use of the PICC, it is necessary to rigorously standardize its handling, as well as the skill and knowledge of the professional in charge, minimizing AEs that routinely affect patients using this device[3,23].

PiccPed® meets the clinical challenges highlighted in the aforementioned literature. The app stimulates clinical reasoning and decision-making in the nurse to perform assertive interventions in the maintenance of the PICC. These improvements can prevent the occurrence of adverse events, ensuring Nursing care based on current scientific evidence. It uses virtual simulation to train the professionals, preparing them to act correctly in similar situations experienced in the care practice.

A strong point in choosing the app technology is its scope of action as an ICT. There are nearly 5 billion mobile Internet subscribers, 70% of them living in low- and mid-income countries, covering more than 85% of the world population[9]. Mobile technology has revolutionized the way to communicate, share and use content, penetrating various sectors of society, including health care. These customized technological tools offer new teaching and learning possibilities and, when they do, they are conceptualized as *m-learning*[24].

PiccPed® is considered *m-learning* because it integrates knowledge building situations for the professionals/users in the interaction and collaboration in the construction of learning. Technologies based on *m-learning* have the potential to improve the quality of learning, increase accessibility to knowledge/teaching, and offer innovative ways of education available to more people[9,25].

The concern about improving clinical learning was integrated in the entire construction process of PiccPed®. This includes PBL as theoretical framework, ensuring that the user thinks and formulates solutions for the problems presented in the app. The clinical cases started from fictitious situations, but similar to problems encountered in professional daily life in relation to PICC management.

When PBL transposes a technology like the app, it shows itself with potential for innovation, giving up traditional teaching and transforming the way in which clinical situations are conducted for user training[14,24–25]. This learning methodology covers the context of clinical reasoning and decision-making throughout the formulation of a technology. Through PBL, the content is organized in a way that encourages the user/student/professional to organize their ideas transcending the effectiveness of the action taken. There is the intention of solving problems, testing hypotheses, applying theoretical knowledge, practicing the process of clinical reasoning and decision-making during the clinical practice, increasing critical thinking and later clinical judgment[10,25–27].

Clinical reasoning, inherent to the use of the app, requires prior clinical knowledge of the users, in order for them to relate data to institute the most appropriate diagnosis for a given demand, and consequently make the decision about the interventions to be performed. This clinical reasoning process is considered to be directly related to the quality of the decisions made and, consequently, to the quality of the nurse's work process[27].

For this process of clinical reasoning to occur, there are some prerogatives. This includes the conception of the idea, in order to seek as much information as possible about what it is being investigating; the elaboration of the judgment, which is based on knowledge, attitudes and previous experiences through critical thinking; and finally, the construction of clinical reasoning, from which decision thinking is allied in order to respond to the demand presented. It is encouraged that these stages occur simultaneously and are constantly practiced by the nurse[26–27]. As the final product of clinical reasoning, decision-making is defined by the choice of a decision among several alternatives seeking to achieve the objective of solving a situation[10].

The importance of technologies such as apps, which stimulate the professional to make assertive decisions, is illustrated when it is known that the nurse who assists a patient in an acute health condition makes a decision every 10 minutes, with a decision made every 30 seconds in the care of patients in intensive care by the nurse[10]. Therefore, decision-making is a key factor to reduce the occurrence of AEs and contribute to safe care[28–29].

In this way, tools that help and support decision-making are stimulated, apps and software standing out, which can be arranged for the management of safe assistance. However, it must be guaranteed that these are based on current scientific evidence, with proven practices at national and international levels[29].

In PiccPed®, in addition to the presentation of the app content being based on PBL and the stimulation of the process of clinical reasoning and decision-making, some other important strategies for the construction of user learning were used, cited below. By clicking on an incorrect option, the user

is alerted to the AE that could have been caused in the patient and asked to perform the evaluation and decision-making again. The fact of demonstrating the AE, especially in an illustrative manner, in the wrongly chosen options makes the user, in their clinical practice, exercise careful clinical reasoning and decision-making, taking into account the knowledge of the AE that incorrect choices can cause. Moreover, by allowing the user to select another option, i.e., make a new decision, it favors the adherence of clinical reasoning and the review of behaviors.

At the end of the "PICC dressing" procedure, "maintenance of permeability" and "administration of fluids" animations by means of illustrative videos are carried out after the completion of the stages, which also occurs during the "infection prevention" procedure. In these cases, the animations are used in order to compile the content covered, exemplifying and illustrating the correct way to perform a certain procedure, so that there is greater assimilation of content.

PiccPed® has the potential to modify the quality of the assistance provided to children with PICCs. This app is designed to improve clinical reasoning in the professionals involved in this population. The recommendations for the practice included in the app are based on high-quality scientific evidence. This promotes the user/nurse assertive decision-making that improves children safety in this care. As a study limitation, the high cost involved in the construction of an app stands out and, with this, the difficulty in making more elaborate animations, as well as the high cost for availing it in app search stores, such as *Play Store*® or *Apple Store*®.

CONCLUSION

To date, there is no single *mHealth* app that promotes education and improves PICC safety, especially in Pediatrics. Consequently PiccPed® presents an innovative solution, with the potential to change the technology paradigm in Pediatric Nursing. It is proposed that the use of the app technology assists the nurse in learning the formulation of clinical reasoning and decision-making in PICC maintenance situations, in order to prevent AEs and improve patient safety on a large scale.

PiccPed® uses the *m-learning* technology and PWA, which aims at knowledge distribution without restrictions, such as physical space, time and difficulty in accessing knowledge. Due to these advantages, the construction of applications aimed at transforming the clinical practice must be increasingly present in the literature, especially in the area of Pediatric Nursing. However, it is of utmost importance that these applications are developed with methodological rigor and content based on the scientific literature.

PiccPed® will be updated when necessary, especially when there are changes in the recommendations in relation to the prevention of AEs in the maintenance of PICCs. New studies are being planned to validate this technology.

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NOTES

ORIGIN OF THE ARTICLE

Extracted from the thesis – PICCPED®: Construction of a mobile app for the safety of pediatric patients in the maintenance of the peripherally inserted central catheter, presented to the Graduate Program in Nursing, Universidade Federal de Santa Catarina, in 2018.

CONTRIBUTION OF AUTHORITY

Study design: Souza S, Rocha PK.
Data collection: Souza S, Rocha PK.
Data analysis and interpretation: Souza S, Rocha PK, Avelar AFM.
Discussion of the results: Souza S, Rocha PK, Avelar AFM, Tomazoni A, Anders JC, Ullman A.
Writing and/or critical review of the content: Souza S, Rocha PK, Avelar AFM, Tomazoni A, Anders JC, Ullman A.
Review and final approval of the final version: Souza S, Rocha PK, Avelar AFM, Tomazoni A, Anders JC, Ullman A.

CONFLICT OF INTEREST

There is no conflict of interests.

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CORRESPONDING AUTHOR

Sabrina de Souza
sabrinas.enfer@gmail.com