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SOFTWARE DEVELOPMENT OF THE PRESSURE ULCER SCALE FOR HEALING (PUSH): AN INNOVATION STUDY

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ABSTRACT

Objective: To develop a software for pressure injury assessment and monitoring using the pressure ulcer scale for healing (PUSH). **Method:** This is a methodological research of technological innovation and software development. An application was developed to monitor pressure injuries using the PUSH created by National Pressure Ulcer Advisory Panel, and it went through the content validation process. **Result:** This study resulted in the first stage of an integrative review, in which nine articles were identified between the years 2012 and 2018. In the second stage, the process of building the application took place. It has 16 screens, among them PUSH scale, monitoring through graphics, and anamnesis. In the third stage, the content validation process was carried out, and it was obtained an overall content validity index of 0.95, an acceptable value to validate an instrument. **Conclusion:** It was observed that the software is applicable and serves as support to the clinical practice of the nursing professional.

DESCRIPTORS: Software. Pressure ulcer. Wounds and injuries.

DESENVOLVIMENTO DE SOFTWARE DA PRESSURE ULCER SCALE FOR HEALING (PUSH): ESTUDO DE INOVAÇÃO

RESUMO

Objetivo: Desenvolver *software* para avaliação e acompanhamento da lesão por pressão utilizando a *pressure ulcer scale for healing* (Push). **Método:** Trata-se de pesquisa metodológica de inovação tecnológica e de desenvolvimento de *software*. Foi desenvolvido um aplicativo para acompanhamento de lesão por pressão utilizando a Push elaborada pela National Pressure Ulcer Advisor Panel, passando pelo processo de validação de conteúdo. **Resultado:** Como resultado da primeira etapa, produziu-se uma revisão integrativa, em que foram identificados nove artigos entre os anos de 2012 e 2018. Na segunda etapa ocorreu o processo de construção do aplicativo. Este possui 16 telas, entre elas a escala de Push, o acompanhamento por meio de gráficos e a anamnese. Na terceira etapa houve o processo de validação de conteúdo, com escore geral de 0,95, um valor aceitável para validar um instrumento. **Conclusão:** Observou-se que o *software* é válido e pode servir de amparo à prática clínica do profissional de enfermagem.

DESCRITORES: Software. Lesão por pressão. Ferimentos e lesões.

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DESARROLLO DE SOFTWARE DE LA *PRESSURE ULCER SCALE FOR HEALING* (PUSH): UN ESTUDIO DE INNOVACIÓN

RESUMEN

Objetivo: Desarrollar un software para la evaluación y el seguimiento de las lesiones por presión utilizando la *pressure ulcer scale for healing* (PUSH). **Método:** Se trata de una investigación metodológica de innovación tecnológica y desarrollo de software, donde se desarrolló una aplicación para monitorear lesiones por presión utilizando la escala PUSH desarrollada por *National Pressure Ulcer Advisory Panel* donde pasó por el proceso de validación de contenido. **Resultado:** Este estudio resultó en la primera etapa de una revisión integradora, donde se identificaron nueve artículos entre el año 2012 y 2018 que componían la revisión, en la segunda etapa se llevó a cabo el proceso de construcción de la aplicación, donde cuenta con 16 pantallas entre ellos Escala PUSH, seguimiento a través de gráficos, anamnesis, en la tercera etapa se realizó el proceso de validación de contenido, donde se obtuvo un índice de validación de contenido global de 0.95, valor aceptable para validar un instrumento. **Conclusión:** Se observa que el software es aplicable y sirve como apoyo a la práctica clínica del profesional de enfermería.

DESCRIPTORES: Programas informáticos. Úlcera por presión. Heridas y lesiones.

INTRODUCTION

Pressure ulcers (PUs) are a complication that brings suffering to patients, their families and society, representing an important impact on public health, besides being considered an indicator in the quality of nursing care[1].

According to the National Pressure Ulcer Advisory Panel (NPUAP), a PU is a localized injury to the skin and/or underlying soft tissue, usually over a bony prominence, related to medical device use, or other artifacts. Pressure ulcers can present in intact skin, as occurs in stage 1 PU, with partial thickness skin loss with dermis exposure (stage 2), with full thickness skin loss (stage 3), and with full thickness skin loss and tissue loss, as occurs in stage 4[2].

The treatment of PUs is often time-consuming, costly, and painful, and needs to be evaluated by professionals specialized in the area to prescribe the ideal dressings and bandages to close the lesion. This evaluation is continuous, because professionals must have knowledge about the whole healing process of an injury in order to follow the whole evolution of the wound, which includes different stages and consequently different prescriptions for frequency and type of dressing or coverage needed[3].

Healthcare professionals who deal daily with this type of injury need to be aware of the technological innovations, both related to dressings and dressings and to the instruments for the evaluation and follow-up of the injury. For this, training with the necessary knowledge, skills and attitudes has been essential, in which the professional seeks agility and ease in using the tools of the job[4].

New technologies are a fundamental part of PU patient care, especially when linked to the lesion assessment process. In this sense, the pressure scale for healing (Push) is an effective tool in assessing the PU healing process; the simplicity and objectivity of use through the systematic application of subscales such as wound area, amount of exudate, and tissue type stand out[5]. The instrument also has a table where the scores of each parameter and the total score are registered according to the date, a graph to visualize the evolution of the total scores, and an instruction sheet for the evaluator. From this perspective, the Push scale was translated and adapted into Portuguese in 2005 and since then has been used in studies and clinical practice in Brazil[6].

Health technological innovations (HTIs) are gaining space in the world market, with the creation of primers, protocols, films, software, among others, but regarding PU there are still few validated instruments, and most concern risk assessments, which use the Braden and Norton scales as references. Regarding the Push scale, there are many studies, such as the evaluation and implementation of the scale in hospitals, literature reviews and even softwares, but without presenting as much detail on the type of injury nor on the evaluation instrument in question[7,8].

It was observed that the use of computer tools in the health area is in increasing expansion, because this type of support can provide professionals with more precision and agility in their work[9].

Considering the need to advance technological innovations that allow the applicability and accessibility of Push in all contexts, the importance of its adaptation to the digital context with its use in apps emerges.

Thus, in order to systematize nursing actions, the nurse must assess, clinically judge, and strategize for the evolution of the wound in view of the specificity and complexity of this type of wound[5]. Thus, the study aimed to develop and validate a software for PU assessment and monitoring using Push.

METHODS

This is a methodological study of the technological innovation and software development type. An application was created for PU tracking using the Push developed by NPUAP.

The study occurred from February 2019 to August 2021 and was conducted at the Graduate Course in Enterostomal Therapy at the Universidade Regional do Cariri. It fulfilled the steps for developing a software and was divided into three stages: integrative literature review, software development (data communication and survey, planning, modeling-artifact, construction, and employment), and content validation of the software by judges[10].

In the integrative review, the study had as a guiding question: What is the knowledge production on software for PU assessment? Next, the objectives were plotted and the inclusion criteria were determined, starting with the understanding that the purpose of this study was to analyze the PU evaluation methods used in healthcare research that employed software in previous years. Inclusion criteria were studies assessing PUs and using software to assist the lesion assessment process, publication year from 2009 to 2019, and full database availability. The descriptors *Pressure Ulcer*, *Software*, and *Wounds and Injuries* found in the Descritores em Ciências da Saúde (DeCS)/Medical Subject Headings (MeSH) were searched in the databases Medical Literature Analysis and Retrieval System Online (MEDLINE), Base de Dados em Enfermagem (BDENF), Literatura Latino-Americana e do Caribe em Ciências da Saúde (Lilacs), and Scientific Electronic Library Online (SciELO).

After gathering all the scientific content to be used in the software, it was forwarded to the computer science expert, who developed it following the steps of communication, planning, modeling, building, and employment[10]. Communication and planning involve the definition of content, the structure of screen navigation, visual organization, layout composition, colors, and the positioning of figures. In modeling, the actual sketch was created, and the construction involved the language needed for the effective understanding of the information offered in the application.

To build the mockups, the Sketch tool was used, which allows the diagramming of the screens and their navigation flow for the Android platform. The mockups are screen drawings (sketches) that serve to show in a direct way the architecture and navigation flow of what the final application will look like, as specified. The working phase consisted of the production of the learning object itself, that is, coding the application in computer language and storing it on the chosen platform, and was carried out by a programmer with a degree in Computer Science. The application's interface was developed using the JavaScript and HyperText Markup Language (HTML) 5 programming language, frameworks Ionic v3 and Angular v4. To store the information, the SQLite and Firebase databases were used, making the development more dynamic and more compatible with the Android platform.

Thus, at all stages, typical support activities were performed as a way to ensure the methodological quality of the study: project control and monitoring, risk management, quality assurance of software, technical reviews, measurement, management of reusability, and preparation and production of the software artifact.

The content and relevance validation contemplates the third stage and was performed by experts in the health area, especially by those with academic and practical experience in the areas of PU healing, according to the specific criteria, and they were scored respectively: being a doctor with a thesis or dissertation in the area of interest (5 points), being a doctor (4 points), being a master with a dissertation in the area of interest (4 points), being a master (3 points), having professional practice (clinical, research or teaching) (2 points) in the area of interest and being an expert in

enterostomal therapy (3 points). All participants who scored at least three points were invited to participate in the study. There is no consensus as to the ideal number of judges, although some authors report that five to ten experts are sufficient for the validation process[11]. In the present study, seven judges were delimited, since an odd number facilitates tie-breaking opinions.

The identification and selection of judges for content validation (health care specialist) was done through network and snowball sampling, in which a list was made with names and contacts of professionals working in the area of PU healing. Then, a brief reading of the Lattes curriculum was carried out and the potential profile according to the selection criteria was observed. Eligible participants were contacted by e-mail and, after confirming interest, received the URL to download the software, the evaluation questionnaire in Google Form, the informed consent form, and the software's questionnaire of acceptance with space for comments. Finally, seven experts were selected.

The form contained an identification questionnaire (age, gender, profession, degree, time in education, time working in the field, participation in research groups/projects, and scientific production) and a questionnaire with questions to validate the application in terms of functionality, usability, reliability, efficiency, and maintainability, with items ranging from 1 (inadequate) to 4 (totally adequate).

The data analysis was done by calculating the content validity index (CVI), by summing the agreement of the items that were scored by 3 or 4 by the experts divided by the total of all responses. Answers with scores of 1 and 2 were discarded. Thus, items with a minimum agreement of 0.80 were considered valid[12,13].

The study respected the ethical aspects of Resolution No. 466, 2012, of the National Health Council, regarding research with human beings, being approved under opinion No. 3,770,728, in addition to authorization from NPUAP to use the Push tool.

RESULTS

In the result of the integrative review (first stage), nine articles that composed the review were identified between 2012 and 2018: two were about software development for PU assessment and seven about clinical use of softwares with patients. The synthesis of knowledge revealed that the use of applications as a tool for teaching, care, and diagnosis in the area of wounds is innovative and presents itself as a method capable of modifying professional practice.

The gap in the use of health technology for the treatment and evaluation of PUs based on a validated instrument was evidenced in this study, which provided support for the development of this research. The second stage was the development of the application, which started with the construction of the flowchart, which took place in six steps: welcome to the application (registration or login), patient registration (name, date of birth, address, and chart number), patient history, lesion characteristics, completion of the Push scale with a URL to obtain images, and evolution (coverage used and general observations).

A navigation design was made and given to the developer, in which the menu with the flowchart of how the pages would look like, was drawn up. Then, the sketching of the prototype began, with handing over to the graphic designer to start the illustration process and the color scheme. Finally, the prototype received final approval from the researcher of this study.

After completion of the previous steps and their detailed review by the researchers and the developer, the last stage of the application development began, this being the final stage in which the application was implemented for the Android platform. In this stage each content turned into an application was sent by URL via WhatsApp to the researchers in order to verify its execution. The abstract interface of the application can be seen in Fig. 1.

Figure 1. Pressure ulcer scale for healing (Push) application Interface, Crato, CE, Brazil, 2021.

Source: Elaborated by the authors, 2021.

The application has 16 screens, which followed the initial flowchart, with screens for patient registration, medical history, lesion registration, Push with image capture and lesion characteristics. Figure 1 shows clips of some screens from the application, which direct to the next page by clicking on the links.

Seven healthcare specialists participated in the validation phase, with an average age between 35 and 40 years old and an average time of training of 16 years, as shown in Table 1.

Table 1. Characterization of the study participants, Crato, CE, Brazil, 2021.

Judge	Age (years)	Sex	Education time (years)	Field of work	Qualification
S1	> 50	Female	30	Hospital	PhD
S2	25-30	Male	7	Hospital/homecare	PhD
S3	35-40	Female	16	Dermatological nursing	PhD
S4	> 50	Female	31	Hospital/ enterostomal therapy	PhD
S5	35-40	Female	10	Enterostomal therapy/homecare	Specialization
S6	35-40	Female	12	Enterostomal therapy/hospital	Master's Degree
S7	35-40	Female	11	Enterostomal therapy	Master's Degree

Source: Elaborated by the authors, 2021.

Regarding the CVI calculation, the items evaluated by the experts obtained a total score higher than 0.80, which makes them valid as to content. The values for each response and the corresponding CVI can be seen in Table 2.

Table 2. Validation of software content, Crato, CE, Brazil, 2021.

	Inadequate	Partially adequate	Adequate	Totally adequate	Content validity index
The software has the main functions needed to evaluate a pressure ulcer			4	3	1
The software is precise in the executions of its functions		1	2	4	0.85
It is easy to understand the software's concept and usage			3	4	1

Source: Elaborated by the authors, 2021.

According to the result, the overall CVI of 0.95 was achieved, an acceptable value for validating an instrument. As for the validation of appearance, looking at functionality, usability, efficiency, and reliability, the answers corresponding to Table 3 were obtained.

Table 3. Validation of software appearance, Crato, CE, Brazil, 2021.

Variable/Question	Inadequate	Partially adequate	Adequate	Totally adequate	Content validity index
Functionality					
Does the software have password access security?	3	4	0	0	1
Reliability					
Does the software react appropriately when failures occur?	2	2	2	1	0.57
Does the software inform the user about invalid data entry?	2	3	1	1	0.71
Usability					
Is it easy to learn how to use the software?	3	4	0	0	1
Does the software offer help in a clear way?	2	2	2	1	0.57
Efficiency of the software					
Is the software runtime adequate?	2	4	0	1	0.85
Are the features provided in the software adequate?	2	3	2	0	0.71

Source: Elaborated by the authors, 2021.

When analyzing the answers to all items (10 questions for seven judges, totaling 70 answers), we aimed to evaluate the agreement index, and the following results were obtained: The predominant answer was adequate, with a total of 31 (44.29%); followed by totally adequate, with 27 (38.57%); partially adequate, with eight (11.43%); and inadequate, with four answers (5.71%). Thus, the index of agreement for the adequate and totally adequate answers was 0.82.

At the end of the software questionnaire, the evaluator also answered the acceptance questionnaire, which aimed to evaluate the overall reaction to the use of the application, as shown in Fig. 2.

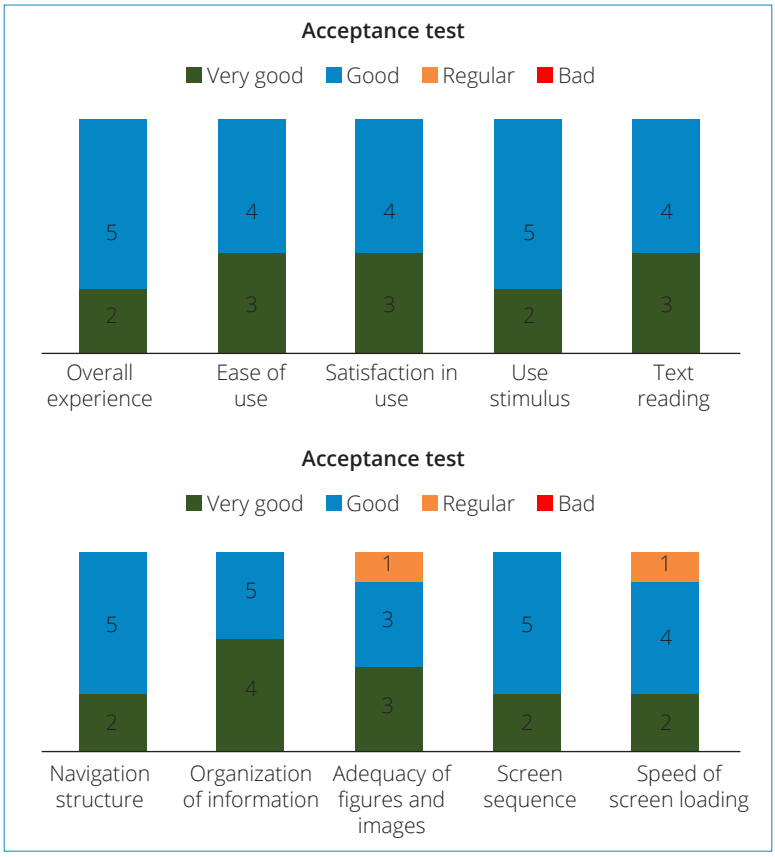

Figure 2. Acceptance survey responses, Crato, CE, Brazil, 2021.

Source: Elaborated by the authors, 2021.

To evaluate the level of satisfaction (acceptance test), the judges answered 10 questions, marking only one of the alternatives, from very good to bad. The application was considered good by the evaluators, had very good evaluations, and to a lesser extent regular, but no evaluations were considered bad. At the end of the evaluation process, the judges left their impressions of the application with positive comments and suggestions. There were a greater number of reports on the link "capture image," where three judges reported difficulty with using the camera, since they could not get the image from the camera roll. So, all the corrections and adjustments were taken for the developer to optimize the software for the best use.

DISCUSSION

Health technologies correspond to a technical and scientific apparatus equivalent to instruments used in the practice of professionals, especially nursing professionals. This type of technology aims to improve professional communication and excellence of care and to modify the care, fundamentals, and essence of the work with actions that favor healing[1].

In an integrative review that aimed to identify research involving the construction of mobile application in Brazil, the conclusion was that the development of mobile applications related to scientific research is important, because the contents tend to be analyzed and tested by professionals who know the real needs of the end users. Recognizing the needs of these users is essential to plan and implement new technologies in a coherent and appropriate way, according to specific demands, tested in research and implemented in practice[9].

The technologies associated with PU assessment show that the Push becomes, to nursing care, an essential tool in the treatment of injuries, since it allows to assess, prescribe and observe their evolution[6]. The Push scale is comprehensive and used in changing standards regarding the treatment time of a PU and promotes patient-client rehabilitation with excellent practical results[5]. In this regard, it was observed that Push is adaptable and valid to an application software by having IVC equal to 0.95.

The use of the application with the Push evaluates the three main parameters of a wound's evolution: size, secretion, and tissue type. The professional will fill in this data, and the result will automatically be according to the Push score, a scale that is already validated and used in several countries6. In this study, the questions related to the specific parameters received a higher proportion of adequate answers, which demonstrates the reliability of the virtual instrument. The agreement index was 0.82, which is considered acceptable, since the minimum value is 0.80[13].

It is worth mentioning that the implementation of the anamnesis in the application was of utmost importance, since there is necessary information on the patient's past and current health history to better conduct the healing of the lesion[14]. Studies point out that, for good wound healing, systematic methods of continuous assessment must be developed by means of a complete anamnesis[15,16]. So, in the application it could be no different. Some essential questions should be answered even in the first consultation, such as: current medical treatment; allergic history; presence of a pacemaker; cardiac changes; hypo/hypertension; circulatory disorders; renal disorder; hormonal disorder; gastrointestinal disorder; epilepsy-convulsions; psychological/psychiatric changes; stress; oncological history; smoking; alcoholism. It is known that when there are favorable conditions and effective investigation of the lesions with directed measuring apparatus there is favorable evolution of the lesions[14,15].

Another relevant tool for the application was the possibility of capturing images, since the use of images is important for wound follow-up[17].

In a particular study two softwares for wound measurement were analyzed, and it was observed that they have spaces to measure lesions as a way to fidelity the importance of wound area measurement, and in the comparison between two softwares for assessment the most reliable were Motic and AutoCAD®. It was concluded that both instruments have small measurement errors. Although there is statistical difference and low reproducibility, they agree with each other, being more reliable and accurate than simple area measuring techniques, thus allowing better follow-up of the PUs healing evolution[18].

Another study describes the precise way to measure the lesion: the area is measured by evaluating the greatest length and the greatest width, in the cephalocaudal direction, in the longitudinal axis, using a graduated ruler[19].

Many authors, in order to improve the evaluation of the results, propose the standardization of the photography for imaging. The authors themselves describe the need for photographs and registration in patients' medical records to record their diagnoses, treatments and progress, considering the tool, besides a duty, a source of scientific information and a great ally in potential legal cases[17].

It is worth noting that the use of photography is of paramount importance in the follow-up of complex wound healing. Obtaining the image facilitates the diagnosis, its measurements and surgical programming, assisting the entire team in monitoring the wound's evolution and intervention. It facilitates interdisciplinary communication, making it possible to draw up strategic treatment plans, and is considered a tool for legal documents and for teaching[17]. It is important to emphasize that photography is an integral part of the evaluation process and the evolution of an injury. A photograph of the wound may be more useful than digitized tracings, because it simultaneously captures the appearance of the wound[20].

Different softwares can evaluate lesions using Push; however, the software described here has in a particular way technological innovation and technoscientific apparatus as important hallmarks in its process. Technological innovations in health are increasingly present in the area of wounds, with the purpose of improving care, making it faster and safer[21];

however, a limitation of this study is the nonperformance of the validation stage with the target audience, which may limit the access to the software by professionals and patients with PUs.

CONCLUSION

The Push App PUSHMo software has the purpose of improving direct care to the patient affected by a PU, having how to evaluate evolution parameters by means of graphs and photographic records, instruments that facilitate the life of the professional who is going to perform the care and the decision of the best conduct to follow.

In the course of this study, it was possible to build and validate an application-type technology, and it was concluded that the software is valid in content, with a CVI of 0.95.

It is expected that the PUSHMo application can contribute to the performance of nursing professionals by providing greater support in PU assessment. In the improvement of the healing process, the objectives of this study were reached, since satisfactory feedback was obtained from the judges, making it a valid technology in terms of content.

AUTHORS' CONTRIBUTION

Formal Analysis: Feitosa MEE; **Conceptualization:** Feitosa MEE; **Data Curation:** Feitosa MEE; **Methodology:** Feitosa MEE; **Writing – First Draft:** Feitosa MEE; **Writing – Review & Editing:** Feitosa MEE, Sampaio LRL, Oliveira JD and Feitosa YS; **Supervision:** Feitosa MEE, Sampaio LRL and Oliveira JD; **Validation:** Feitosa MEE; **Visualization:** Feitosa MEE, Sampaio LRL, Oliveira JD and Feitosa YS.

AVAILABILITY OF RESEARCH DATA

All data were generated or analyzed in the present study.

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