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Development of a mobile application for emergency shift handovers using the National Early Warning Score

Desenvolvimento de aplicativo móvel para passagem de plantão na emergência utilizando o National Early Warning Score

Desarrollo de una aplicación móvil para el manejo de turnos de emergencia utilizando la National Early Warning Score

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ABSTRACT

Objective: To develop and validate a prototype of a mobile application shift handover between nurses in the emergency room using a severity scale.

Method: This is a technological tool carried out at the Universidade Estadual de Maringá using design thinking, divided into four phases: discovering, defining, developing, and delivering. To structure the information, a checklist was used based on the Situation Background Assessment Recommendation, and to categorize patients in terms of severity, the National Early Warning Score was used. The validation of the sample was carried out by 10 nurses, specialized in the field of urgency and emergency, using the System Usability Scale questionnaire to assess usability. The content validity coefficient was used for analysis.

Results: The application scored 75.75 in usability and had a content validity coefficient of 0.8.

Conclusion: The prototype obtained an excellent evaluation of usability and agreement between evaluators. Future studies are needed for implementation in practice, evaluating the practicality, applicability, efficiency and time savings in shift information transfer.

Descriptors: Continuity of patient care. Emergency nursing. Medical informatics. Mobile applications. Patient handoff.

RESUMO

Objetivo: Desenvolver e validar um protótipo de aplicativo móvel para passagem de plantão de enfermeiros na emergência utilizando uma escala de gravidade.

Método: Trata-se de uma produção tecnológica realizada na Universidade Estadual de Maringá utilizando Design Thinking, dividido nas fases: descobrir, definir, desenvolver e entregar. Para estruturação das informações utilizou-se um checklist baseado na *Situation Background Assessment Recommendation*, e para categorizar quanto à gravidade, utilizou-se a *National Early Warning Score*. Amostra para validação foi realizada por 10 especialistas enfermeiros na área de urgência e emergência pelo questionário *System Usability Scale*, avaliando a usabilidade. Para análise utilizou-se o coeficiente de validade de conteúdo.

Resultados: O aplicativo obteve 75,75 pontos de usabilidade e um coeficiente de validade de conteúdo de 0,8.

Conclusão: O protótipo obteve excelente avaliação de usabilidade e concordância entre os especialistas. Estudos futuros são necessários para implementação, avaliando a praticidade, aplicabilidade, eficiência e economia de tempo nas informações de transferência de turnos.

Descritores: Continuidade da assistência ao paciente. Enfermagem em emergência. Tecnologia da informação em saúde. Aplicativos móveis. Transferência da responsabilidade pelo paciente.

RESUMEN

Objetivo: Desarrollar y validar un prototipo de aplicación móvil para el cambio de turno de enfermeras en la emergencia utilizando una escala de gravedad.

Método: Se trata de una producción tecnológica realizada en la Universidade Estadual de Maringá, utilizando design thinking, dividida en cuatro fases: descubrir, definir, desarrollar, y entregar. Para la estructuración de la información se utilizó una lista de cotejo basada en la *Background Assessment Recommendation* y el *National Early Warning Score* para categorizar según la gravedad. La muestra para validación fue realizada por 10 enfermeras especialistas en el área de urgencias y emergencias mediante el cuestionario *System Usability Scale*, para evaluar la usabilidad. Para el análisis se utilizó el coeficiente de validez de contenido.

Resultados: La aplicación obtuvo 75,75 puntos de usabilidad y un coeficiente de validez de contenido de 0,8.

Conclusión: El prototipo obtuvo una excelente evaluación de usabilidad y concordancia entre evaluadores. Son necesarios futuros estudios para su implementación en la práctica, evaluando la practicidad, aplicabilidad, eficiencia y ahorro de tiempo en la transferencia de información entre turnos.

Descriptores: Continuidad de la atención al paciente. Enfermería de emergencia. Informática médica. Aplicaciones móviles. Pase de guardia.

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INTRODUCTION

Communication between emergency health workers is essential, in addition to guaranteeing the continuity of care to the patient and the quality of assistance. Shift handovers SH) are related with the process of giving specific information about a patient through effective communication, guaranteeing the safety of the information transmitted[1].

The effectiveness of communication between health workers reduces the number of errors and, consequently, favors patient safety. The consequences from communication failure can cause significant harm to the patient, interrupting treatment and reducing the quality of care[2].

However, in HS, certain difficulties show gaps in communication, leading to harm to the patient due to the interruption of calls, distractions between workers, simultaneous conversations, lack of workers, lack of time, low voice from the worker who is carrying the HS out, and even complications during assistance to critical patients, which can prevent safe communication[2].

Therefore, seeking improvements in patient safety, the World Health Organization (WHO) proposed a series of actions through international discussions started in 2004, in the 57ª World Congress of Patient Safety, where programs and actions with six international goals were proposed. The second of these goals, improving effective communication between health workers, stands out[3]. The lack of effective communication will have serious consequences during SH, harming assistance and leading to potential adverse events (AEs), which can cause from minimal damage to patients, with mild symptoms to permanent sequelae and death.

Regarding AEs, a study carried out in Sweden shows that their mean incidence from 2013 to 2016 was of nearly 8% in hospitalizations. Considering that the mean number of hospitalizations per year is nearly 1.4 million, estimates indicate that approximately 110,000 avoidable AEs would have taken place in the period in hospitalizations, with a cost per year of 880 million Euros[4]. In Brazil, the II National Hospital Care Safety Yearbook (2018) shows 235,127 deaths in the group of patients who had at least one AE. Of 54,769 deaths from serious AEs,36,174 were avoidable, the equivalent of 4.6% in-hospital deaths in the general population[5].

As a result, we decided to develop a mobile application (app), leading to faster and improved communication between nurses during SH, by using systematized information based on a scale of severity. Therefore, we elaborated the following research question: How can a mobile app aid nursing workers during SH in the emergency room?

Therefore, seeking to improve the speed of information exchange, while ensuring important data would not be omitted, our goal was to develop and validate the prototype of a mobile application, in order to exchange the shift of nurses in emergency using a severity scale, the *National Early Warning Score* (NEWS).

METHOD

This is a technological production study, carried out through the construction of the prototype for a mobile app for SH in the emergency room through *design thinking* (DT) methodology. We employed a creative approach, since this is a technological resource also known as a double diamond, proposed by the British Design Council, and formed by four stages (discover, define, develop, and deliver)[6]. The study was conducted from January 2020 to March 2021.

This study had two stages, which were: developing the mobile app, and validating it. To develop the app prototype, we used a sketch elaborated by the researchers. The graphic creations were carried out by a contracted junior company formed by computer science undergraduates from the Universidade Estadual de Maringá, in Paraná. The study field was the Universidade Estadual de Maringá, through the program of professional master's degree in Management, Technology, and Innovation in Urgencies and Emergencies.

To validate the prototype, we invited specialist nurses through convenience sampling; they were selected using their curriculum in the Lattes platform to participate in the validation process. The inclusion criteria of the study were a score of five in the adapted Fehring criteria, as long as the participant responded to the questionnaire with 10 questions in 30 days.

The adapted Fehring criteria are: PhD in nursing (3 points); PhD in nursing with a thesis on urgency and emergency (5 points); MS in nursing (2 points); MS in nursing with a dissertation on urgency and emergency (4 points); specialist in the field of urgency and emergency in nursing (2 points); experience as a nurse in the field o urgency and emergency (1 point per year). Exclusion criteria: specialists which, although they reached the score of 5 required in the Fehring test, did not respond or send back the questionnaire within 30 days.

The research project was submitted and approved by the Research Ethics Committee with Human Beings at the Universidade Estadual de Maringá, Paraná, under CAAE 23642019.70000.010. All ethical requirements were respected.

From January to February 2020, we carried out a research about apps used during SH on Google Play ® and Apple

Store®, using the terms, in Brazilian Portuguese, equivalent to "shift handover", "nursing", "health communication", "emergency room", "mobile app", and "patient transfer". No apps on the subject could be found. During this period, we also searched literature for information in the databases Virtual Health Library (VHL); *PubMed, Scientific Electronic Library Online* (SCIELO), *Web of Science, and the Cumulative Index to Nursing and Allied Health Literature* (CINAHL), using the same terms as above. The inclusion criteria for the selection of the articles were: texts in Portuguese, English, or Spanish, available in full, published at any point in time, as long as they presented, as results, the use of mobile apps by health workers in the emergency room during SH. Our survey found 248 articles, applying the following exclusion criteria: articles that were not primary, theses, dissertations, opinion articles, and articles which, after a full reading, were not able to respond to the goal of our revision. After an analysis of the articles found, we selected two which addressed the topic in a specific manner.

In the prototype developed, we used a classification of severity known as National Early Warning Score (NEWS)[7], created by the Medicine Faculty of the Royal College, in the United Kingdom. This score classifies patients according to six physiological parameters: systolic arterial pressure, cardiac rate, respiratory rate, temperature, oxygen saturation, mental state, and use or lack thereof of supplementary oxygen to maintain saturation. The score varies from 0 to 20 (Figure 1), according to the severity of the patient, serving as a warning for the need of medical evaluations. The NEWS scale has been adapted to the Brazilian culture[8].

Figure 1 – National Early Warning Score 2 Maringá, Paraná, Brazil, 2021

	Score						
Physiological parameters	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory rate (per minute)	≤ 8		9-11	12-20		21-24	≥25
Sp O2 - Scale 1	≤91	92-93	94-95	≥96			
Sp O2 - Scale 2	≤83	84-85	86-87	88-92 ≤93 in ambient air	93-94 taking oxygen	95-96 taking oxygen	≤97 taking oxygen
Ambient air or oxygen?		Oxygen		Ambient air			
Systolic arterial pressure (mmHg)	≤90	91-100	101-110	111-219			≥220
Pulse (per minute)	≤40		41-50	51-90	91-110	110-130	≥131
Consciousness				Alert			Acute confusion Responds to voice or pain, non-responsive
Temperature (C)	≤35,0		35.1-36.0	36.1-38.0	38.1-39.0	≥39	

Source: National Early Warning Score 2: transcultural adaptation into Brazilian Portuguese[8]

The recommendations from NEWS score the clinical worsening of the patient in four possible levels. Considering this score, the moment for clinical reevaluation is considered[7].

To elaborate the checklist of the prototype, we chose the methodology Situation-Background-Assessment-Recommendation (SBAR)[9], as it is considered a management tool to organize the SH and recommended by the WHO through the Joint Commission International, used to improve effective communication of health workers and foster a safety culture to the patient[9]. The checklist had all the most relevant information needed to respond the mnemonic SBAR, considering: the situation of the patient, medical diagnoses, hospitalization places; the priors of the patient, prior history of diseases, allergies, continued medication use; evaluations, including clinical state, physical exams, including the description of drainage, tubes, vital signs, oxygen use, and types of diet; and recommendations for the next shift, including complications, evaluations, exams carried out and outstanding.

To validate this technology, we followed recommendations from at least seven specialists[10]. However, we selected 25 specialists, a considerable number, compared to other researchers, which denoted a response rate of 15% when using electronic questionnaires.

Considering that, we sent 25 invitation letters via email, including the link for the download of the app, a form with instructions on how to use the prototype, and a questionnaire to evaluate it, in Google Forms, using the e-health *System Usability Scale* (SUS)[11]. 10 questionnaires were responded to and sent back by nurses, and included in the study.

The Google Forms evaluation questionnaire had three parts. The first was the Free and Informed Consent Form; if the specialist accepted participation, they would then open the second part of the questionnaire, which contained demographic and socioeconomic questions. The third part included 10 questions on the usability of the system.

The specialists could download the prototype and use it, after reading the basic guidance on how to do so. After the first contact with the prototype, the specialists answered the 10 questions, evaluating the usability of the app, using the SUS instrument, developed in the labs of the Digital Equipment Corporation[11], in the United Kingdom. The SUS has 10 questions used to measure the usability of the product and is the most used for the evaluation of attributes and criteria of quality and usability in e-health products[11]. Its questions are described below:

Question 1. I think that I would like to use this system frequently.
Question 2. I found the system unnecessarily complex.
Question 3. I thought the system was easy to use.
Question 4. I think that I would need the support of a technical person to be able to use this system.
Question 5. I found the various functions in this system were well integrated.
Question 6. I thought there was too much inconsistency in this system.
Question 7. I would imagine that most people would learn to use this system very quickly.
Question 8. I found the system very cumbersome to use.
Question 9. I felt very confident using the system.
Question 10. I would need to learn a lot of things before I could get going with this system.

The responses received a score from 1 to 5 (meaning "strongly disagree"; "disagree"; "neutral"; "agree"; "strongly agree"), in a Likert type scale, presenting the aspects of agreement and difficulties regarding the prototype. The odd questions (1,3,5,7, 9) express positive attitudes, and their total score is the sum of each answer minus 1; the pair questions (2,4,6,8, 10) express negative attitudes, and their score is 5 minus the score for each question added up. The results are then added up and multiplied by 2.5, generating a global value that can go from 0 to 100. The final classification of the SUS is: scores from 0 to 25 (worst possible); 26 to 39 (bad); 40 to 52 (reasonable); 53 to 74 (good); 75 to 85 (excellent); and 86 to 100 (best possible)[12].

Emphasizing the importance of specialist validation, we used the content validity index (CVI), based on the responses to the SUS questionnaire. The CVI was created to respond, as adequately as possible, to the needs of this type of validity, evaluating the level of agreement between the specialists who evaluated the prototype[13].

The CVI is calculated in five stages. First, the mean of the judgment of specialists, based on the SUS questionnaire, was ascertained. Then (second stage), based on this mean (Mx), we calculated the initial CVI of each item (CVIi), dividing it by the maximum value each question could receive (4). In the third stage, we calculate the error (Pei) of specialist polarization, in order to discount potential biases. In this case, we divided the total number of specialists by 1, elevating it to the same power as the number of specialists. In the fourth stage, the final CVI (CVIf) of each question is determined by the subtraction of the CVCi by the Pei The fifth and final stage determines the total CVC of the questionnaire (CVCt) by subtracting the mean of CVCi by the mean of Pei After calculations, questions whose CVC was between 0.7 and 0.8 are acceptable[13]. To analyze the data collected, we used Microsoft Excel®.

RESULTS

Results address two stages of the research: development of the mobile app and specialist validation.

The prototype was developed using a framework called LoopBack, which creates an application programming interface (API) using Node.Js (JavaScript) as a programming language. For data safety, API authentication is carried out using passwords encrypted in the database, and as the user is registered, they click in the Free and Informed Consent Form, which emphasizes the Law of Data Reliability, as a part of the General Law of Data Protection (Law No. 13.709/2018)[14].

To use the prototype, a smartphone or tablet is necessary. These can be the nurse's own device or made available by the institution. These apps will have direct access to information stored in the cloud, and it will be possible to integrate the prototype into an electronic record, in order to seek the main data of identification, the place of hospitalization, and the medical diagnosis. However, in places where there is no access to electronic records, information must be added manually. The app will not be made available in app stores; it will be acquired by each hospital, considering the information that will be integrated to the system of the institution itself.

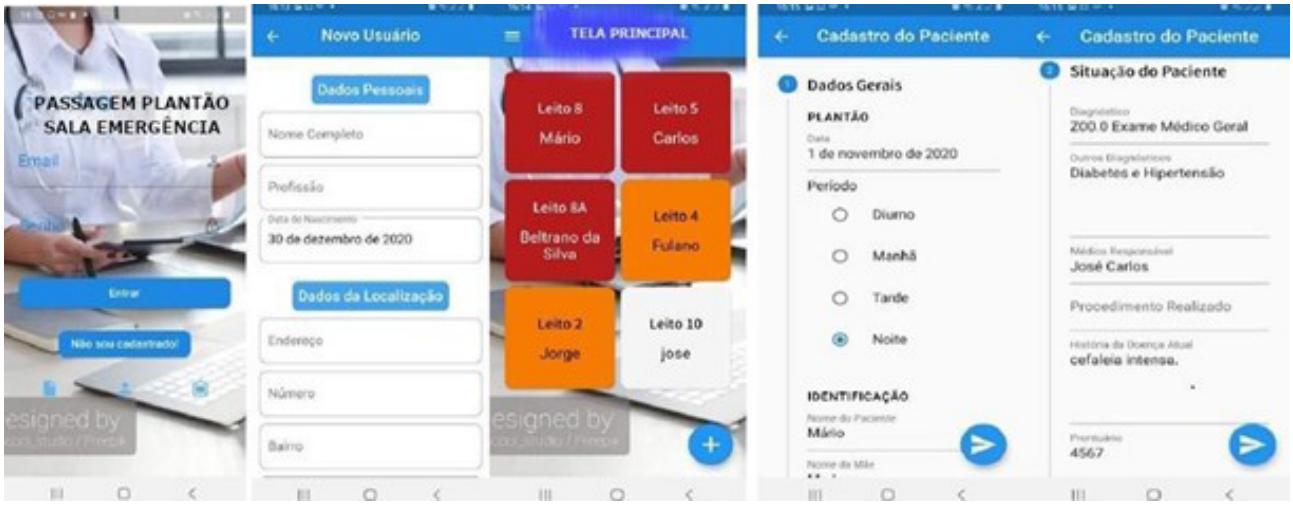
The app was created with a main screen for registering and loging in (Figure 2). The user will be able to connect using their e-mail and password. If they are not registered, they can register by clicking "I am not registered" (Figure 2). The app is called Emergency Room Shift Handover (ERSH).

Then, by scrolling down the screen, item 2 presents information on the mnemonic SBAR[9] (Figure 2): Situation, with information on main and secondary medical diagnoses related with the hospitalization; physician responsible; history of current disease; and number of medical record. Item 3 (Figure 3), Background, includes priors of the patient, such as: prior history (PH), use of continued medication and potential allergies. All information is saved in the prototype, and, in the next uses, it will be stored. It is necessary to update the data from the day and shift and continue filling in the information needed starting with item 4 (evaluation).

As the user continues filling the SH in, item 4 (Figure 3), assessment will include important information for effective communication and for the continued care to the patient. Physiological parameters of the patient will be registered (cardiac and respiratory rates, arterial pressure, oxygen saturation, temperature, and level of consciousness). The NEWS warning score[7] will be automatically generated using the data inserted, prioritizing the attention to more serious cases, thus allowing improvement in the safety of care.

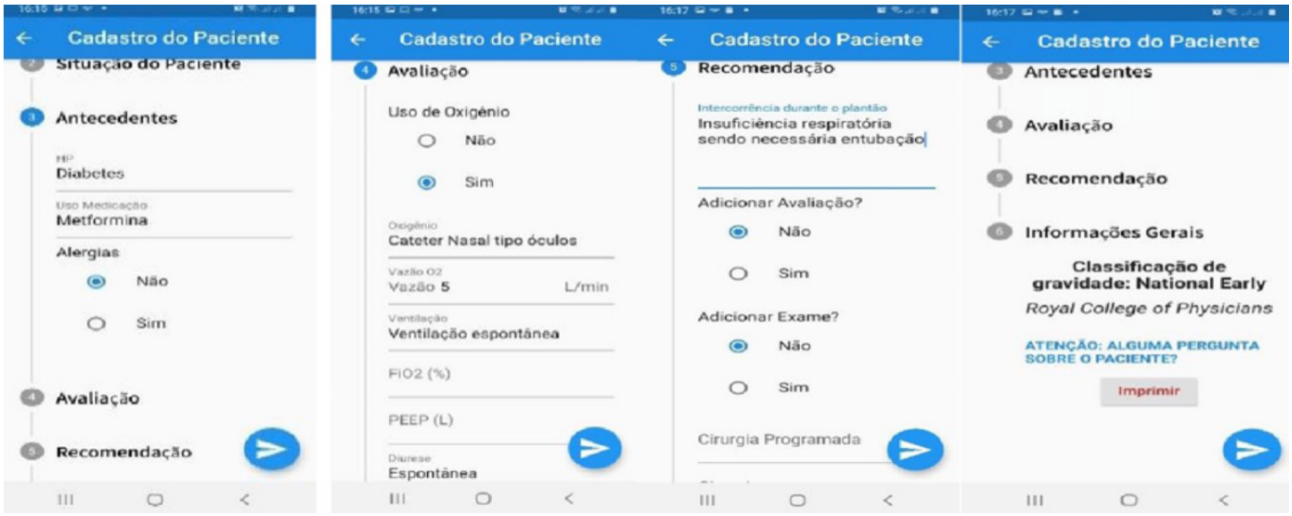
Finally, item 5 (Figure 3), recommendations, will include recommendations for the next shift, with information such as: complications; outstanding and scheduled evaluations and exams; records of surgeries, including date and type, to facilitate preparation. Item 6, at the end, includes general information on the prototype, with credits of the use of the National Early Warning Score[7] *to the* Royal College of Physicians,, and a final question: "ATTENTION: DO YOU HAVE ANY QUESTIONS ABOUT THE PATIENT?" This is an extremely important question, as it asks the professional who is being handover the shift for their insights, in such a way that they can interact with the information received and clarify doubts emerged during the SH, reiterating effective communication.

Figure 2 – Layout of the prototype of Emergency Room Shift Handover. Maringá, Paraná, Brazil, 2021



Source: the authors, 2021.

Figure 3 – Layout of the prototype of Emergency Room Shift Handover. Maringá, Paraná, Brazil, 2021



Source: the authors, 2021.

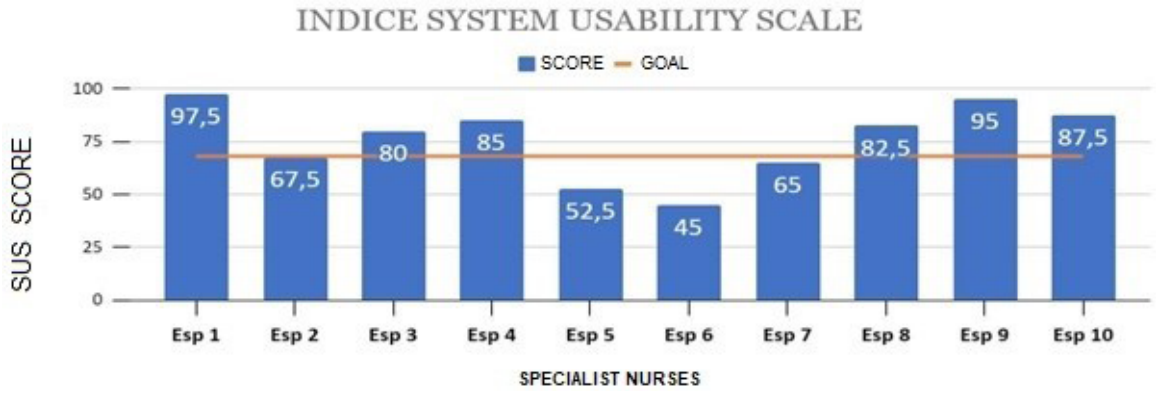
Going back to the first screen, it will be necessary to scroll down to update and reclassify patients according with severity (Figure 2). Patients will be classified according to their score, and the highest the severity, the higher the icon identifying the patient will be on the screen, with the others below according to the scales. This method will help nurses to make decisions on how to prioritize and systematize their care and how to better plan to guarantee patient safety, according to logic, to clinical reasoning, and to the best scientific evidence.

The specialists who validated the app were mostly female (70%), distributed according to age from 20-29 years old (10%), 30-39 y/o (40%), and 40-49 y/o (50%), from the states of Paraná (30%), Goiás (20%), and one (10%) representative each of the states of Pernambuco, Piauí, São Paulo, Minas Gerais, and Bahia; regarding marital status, most were married (50%). Their time working in the field varied from 2 to 10 years, with a mean of 8 years since graduation. 50% were specialist nurses with experience in urgency and emergency, working in public hospitals (80%) and other locations (20%).

To categorize and classify the answers of the specialists, in a scale from worst possible to best possible[12], we calculated the mean score of the prototype as 75.75. This classification is considered as "Excellent" (Figure 4), with most specialist responses indicating a score from 75-100, that is, from "excellent" to "best possible".

The stated goal for our prototype was to reach the score of 68 in the scale, potentially changing this value according to the responses from the specialists. Our score was above this goal for six specialists, with one of them scoring 67.5, quite near our goal. The evaluation of specialists 5 and 6 scored below our goal. These specialists justified this score by stating that "the app is too hard to use" and "I would need a technical person to help me learn how to use it".

Figure 4 – Validation index of the prototype of Emergency Room Shift Handover according with specialist evaluation. Maringá, Paraná, Brazil, 2021



Source: the authors, 2021.

After all questions carried out were analyzed using Microsoft Office Excel, the total CVI of the questionnaire was 0.8, considered to be acceptable for our evaluation, whose result should vary from 0.7 and 0.8[13].

DISCUSSION

The prototype developed proposed improving effective communication, including essential information for humanized, integral care, through the severity score, a factor which determines systematization, making assistance more agile and improving care planning.

Considering the popularity of mobile devices, especially smartphones, whose use by health workers has increased substantially due to their ease of access, practicality, portability, and functionality[15], the WHO, in their publication that classifies digital health interventions, shows the importance of e-health in all sectors and categories, including emergency[16].

The use of smartphones in urgency services has been promising. They have been used in practice to discuss clinical cases; find specialist opinions, including the transmission of messages and photos through the apps; in addition to calculating medication dosage and burnt body surfaces[17].

Other apps in literature showed efficiency and a good adherence to the use of these technologies. The app *Patient Handoff*[18] is an example, created for SH between physicians, although 50% of the access was by nurses. This app is used in computers, not in mobile devices, and is integrated into the hospital information system, facilitating the search for basic patient information, including date of birth, name of the mother, allergies, and others. However, its usability can be changed, decreasing the quality of the information sent to the next shift, as there are no fixed registries.

The app *Dynamic Pocket Card*[19] is used in intensive care units, including the same standard of communication, SBAR. The advantage of ERSH when compared to these apps is the use of a severity scale which prioritizes patients according with the degree of clinical deterioration, favoring the systematization and prioritization of health team reevaluations. This increases the likelihood the app will have positive results in its use in emergency rooms.

As we developed and validated ERSH, we found studies which showed that a standardized information system and an electronic care transfer system improve the communication of crucial information to continue care[20,21]. The stated goal of ERSH is the same, with specialists highlighting its importance in the practice of nursing: Esp 1: "The app is quite complete, including the main information about shift handover in the emergency room"; Esp 2: "the app can adapt well to the reality of each region in the country".

Regarding the use of NEWS in emergency, two studies stand out. The first, carried out in the states of California and Illinois, in the United States[22], was carried out in 28 hospitals and showed the superiority of NEWS when compared to the qSOFA (quick sequential organ failure assessment) and SIRS (systemic inflammatory response syndrome), both related to the detection of clinical worsening in patients. The use of NEWS reduced the percentage of patients in risk situations who needed to be examined from 5% to 20%, increasing the identification of AEs from 3% to 25%. The second study highlights that implementing the NEWS score in emergency services improved the early monitoring of the clinical worsening of the patients being watched in the emergency room who needed to be transferred into intensive care units.

The prototype developed seeks to fill the gap during SH, which is the lack of standardization of information sent during shift handovers, facilitating the organization of the nursing work process. Thus, the priority of the attention is for the shift that is starting, providing a list of patients ordered according with the severity, as automatically calculated by the app using the NEWS score.

One of the limitations of the study is the fact that the ERSH prototype will use mobile data to send and receive information. This means that, in places where the mobile signal is reduced, there could be trouble operating the app. Therefore, for the prototype to be agile and to simplify its system functionalities, we chose not to load images and videos. Another limitation was the lack of time to implement the prototype in clinical practice. Further study is necessary to evaluate the practicality of the app, the time it can save in SH, and the potential reduction of adverse events after implementing the prototype in actual Emergency Rooms.

CONCLUSION

The prototype of Emergency Room Shift Handover was developed with the main goal of making care more agile and correct is priorities, treating more severe patients with a critical look and better scientific evidence in order to prevent and predict the worsening of their situations. We use the severity scale National Early Warning Score, a public domain score created by the Royal College Physicians, to aid the nurse in organizing and systematizing care. Thus, we seek to improve effective communication between nurses, avoiding omitting information during transfers of care, which is one of the goals put forth by the World Health Organization through its Joint Commission.

The prototype was validated by specialists from different Brazilian regions with different realities, all of whom had experience in urgency and emergency services and have

been working in the field for many years. As a result, our main goal was reached, that is, bringing important information to this essential moment of care, in such a way that no complication, outstanding need, or preoccupation is omitted or forgotten, guaranteeing better communication between shifts, and prioritizing the safety of the patient in regard to the continuity of assistance, so teams can interact and exchange doubts, optimizing the transfer of care and making it more agile.

Regarding our guiding question, on how the mobile app could aid the nurse during shift handovers in the emergency room, it became clear, through the evaluation of experts, that the app would make the transmission of important information more dynamic, optimized, and systematized, categorizing the patient according with the severity of the case, which could lead to the reduction of adverse events and to improvements in nursing care. However, for this answer to the question to become concrete, further study will be necessary to actually implement the app in the clinical practice of nurses in emergency, thus evaluating the practicality and applicability of the app, as well as the time it can gain in shift turnovers and how effective it is in improving the transmission of information between the shifts. Furthermore, the information could be transferred not only between shifts, but between sectors or hospital units. Thus, we can prioritize and carefully seek to guarantee nursing care that is free from imprudence, negligence, and, especially, from any harm to the patient.

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