Mobile application for accessible communication with pre-hospital emergency care: e-SU

Aplicativo de telefonia móvel com comunicação acessível na urgência pré-hospitalar: e-SU

Aplicación de telefonía móvil con comunicación accesible para urgencias prehospitalarias: e-SU

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Abstract

Objective: To describe the process of developing and evaluating a mobile application prototype to enable people with complex communication needs to call pre-hospital emergency services.

Methods: This methodological study was conducted in three stages: determining the target population's functional requirements; developing and making available a prototype application for touchscreen mobile phones to request pre-hospital services; experts assessed the usability heuristics using a checklist, while the target population (people with complex communication needs) used the System Usability Scale. Descriptive statistics were performed, and the scores assigned to the application were analyzed.

Results: The application obtained high usability scores (mean=58.75) and 21 individuals from the target population reported an excellent user satisfaction index (mean=89.5), which allowed registering and applying for the prototype's patent.

Conclusion: The prototype showed the ability to enable individuals with complex communication needs to access and request pre-hospital emergency services.

Resumo

Objetivo: Descrever o processo de construção e avaliação de um protótipo de aplicativo de telefonia móvel que promova acessibilidade em chamada de socorro pré-hospitalar por pessoas com necessidades comunicativas especiais.

Métodos: Estudo metodológico, realizado em três etapas: definição de requisitos funcionais da população alvo; construção e disponibilização do protótipo de aplicativo para celulares *touchscreen* para solicitação de atendimento pré-hospitalar; avaliação das heurísticas de usabilidade por peritos, por meio de checklist, e pela população-alvo, pessoas com necessidades comunicativas especiais, utilizando a *System Usability Scale*. Foi realizada análise estatística descritiva e calculadas as pontuações e escores de avaliação do aplicativo.

Resultados: O aplicativo apresentou alta usabilidade (média de 58,75 pontos) e 21 sujeitos da população-alvo indicaram um excelente índice de satisfação do usuário (média de 89,5 pontos), oportunizando o registro e patente do protótipo.

Conclusão: O protótipo construído, demonstrou capacidade para promover acessibilidade comunicativa de convocação de socorro pré-hospitalar para pessoas com necessidades comunicativas especiais.

Resumen

Objetivo: Describir el proceso de elaboración y evaluación de un modelo de aplicación de telefonía móvil que promueva la accesibilidad en llamadas de asistencia prehospitalaria para personas con necesidades comunicativas especiales.

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Conflicts of interest: extracted from the thesis "Construction and evaluation of a mobile phone application software prototype for accessibility in pre-hospital assistance requests" presented to the Postgraduate Program in Fundamental Nursing at the Escola de Enfermagem de Ribeirão Preto, Universidade de São Paulo (EERP/USP) in 2020.

Métodos: Estudio metodológico realizado en tres etapas: definir los requisitos funcionales del público destinatario; elaborar y poner a disposición el modelo de la aplicación para celulares *touchscreen* para la solicitación de asistencia prehospitalaria, y evaluar las heurísticas de usabilidad por peritos, mediante *checklist*, y por el público destinatario, personas con necesidades comunicativas especiales, utilizando la *System Usability Scale*. Se realizó el análisis estadístico descriptivo y se calcularon los puntajes de evaluación de la aplicación.

Resultados: La aplicación presentó una alta usabilidad (promedio de 58,75 puntos) y 21 personas del público destinatario indicaron un excelente índice de satisfacción del usuario (promedio de 89,5 puntos), lo que permite el registro y patente del modelo.

Conclusión: El modelo elaborado demostró tener capacidad para promover la accesibilidad comunicativa de pedido de asistencia prehospitalaria para personas con necesidades comunicativas especiales.

Introduction

Pre-hospital care (PHC) advancements are vital in healthcare delivery, especially in urgent and emergency contexts. PHC was first conceived by a French surgeon in the Napoleonic Armed Forces, and early care on the battlefield laid the foundation for the development of this field.[1]

However, it was only at the end of the 19th century that PHC became more prominent in New York, gaining increasing emphasis after WW II. It was subsequently reintroduced in France, including screening emergencies as a regulated practice in 1986.[2] Such development resulted in two models of pre-hospital care: the Franco-German model, which is centered on the physician figure, and the Anglo-American model, based on rapidly removing victims to receive definitive treatment.

The influence of both models is noticeable in Brazil. Technical cooperation was established between France and Brazil in the 1990s, and the military took an approach focused on Anglo-American protocols.[3] This context triggered a reflection on communication access in emergency calls to pre-hospital services, considering that the first contact is usually through a phone call, internationally known as teletriage. However, current teletriage in Brazil does not serve deaf people, hearing or visually impaired older individuals, nor victims unable to verbalize their needs.[4,5]

Data from the Brazilian Institute of Geography and Statistics (IBGE) show that more than 10 Million people in Brazil experience some level of hearing impairment, with 2.7 million with profound deafness. Additionally, more than 6.5 million people have visual impairment, including 500,000 blind people and around 6 million with visual impairment. At the same time, the Brazilian population is aging, with a significant increase in the proportion of people 60 years old or older, who now represent 14.7% of the total population. Another relevant piece of information is that Brazil has 11.8 million people who live alone.[6] Hence, these figures highlight the importance of considering the specific needs of these groups when devising solutions for pre-hospital care.

Therefore, accessibility became a central concern when developing devices and health applications, including in the PHC context, to contribute to digital literacy and concomitantly decrease inequalities among this population. This proposition can also contribute to achieving goal "10" of the Development Goals Sustainable Development Goal (SDG), among the other 16 established by the United Nations (UN).[7]

In this context, this study aims to describe the development and evaluation process of a prototype mobile application to enable people with complex communication needs to call pre-hospital emergency services.

Methods

This methodological study comprises the development of an application prototype (App) for touchscreen cell phones using Java language and based on User-Centered Design (UCD), (8) following three prototyping steps: 1) Establishing prototype objectives, 2) Determining its functionalities; and 3) Development and evaluation.[9]

First, scientific evidence regarding what people with complex communication needs require when calling for help was determined to establish the prototype's objectives and functionalities.[4] Next, the system requirements were established, and the ap-

plication prototype was developed considering the interaction flow with the user interface (mockup), enabling the experts to assess its usability and satisfaction among the target audience.[10]

Nine judges with expertise in mobile application development, evaluation, and marketing were invited via email in August 2020 to assess the prototype's usability. Each expert accessed a free and informed consent form, a sociodemographic characterization form (gender, date and city of birth, area of professional activity, academic background, and information on scientific publications), and a checklist to assess the usability heuristics for touchscreen cell phones. This checklist, developed and validated for the Brazilian context, enables experts to determine an application's usability.[11] It comprises 48 questions addressing the heuristics of Nielsen's assumptions.[12] There were three answer alternatives for each question: "Yes" when the application meets the requirement, "No" when it does not, and "Does not apply." Each "Yes" scores 1.25 points, totaling a total score of 60. Usability is classified as poor (score < 40), fair (40-50), or high (> 50).[11,13]

Data were collected and organized on the Internet. Five experts completed the checklist and provided suggestions to improve the prototype's style, design, interfaces, and symbols to increase its usability and accessibility. After making the adaptations, the prototype was assessed by 21 participants, who were representative of people who were hard of hearing, lost sight, and older people. The primary author contacted them via voice and video calls. The participants were allowed to have a trusted companion during the assessment to ensure accessibility. They received a form addressing sociodemographic information, the System Usability Scale (SUS), and a link to install the prototype on Android, with interpretation support in Brazilian Sign Language for participants with hearing loss.

After installing the application prototype on their smartphones, the participants were instructed to test its effectiveness and efficiency, rating their satisfaction. The SUS comprised ten statements rated on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). An open-ended question enabled the participants to add observations about the product. One point was subtracted from the score assigned to odd-numbered items (1, 3, 5, 7, and 9), which address agreement with the application. Five points were subtracted from the score assigned to even-numbered items (2, 4, 6, 8, and 10), which address the difficulties one faced with the application. The total score was obtained by summing up the scores of all items and multiplying it by 2.5, which results in a total score ranging from 0 to 100. Such a score does not represent a percentage; it is a user satisfaction index. The SUS mean score is 68; higher or lower scores indicate the design's overall usability according to six categories: the best imaginable (90 - 100), excellent (80- 89.9), good (51 - 79), acceptable (40 - 50), poor (30 - 39), and worst imaginable (0 - 29).[14.15]

Data were automatically entered into the Microsoft Access® platform. All instruments to collect data were available in the cloud; hence, no data went missing. The scores assigned by the target audience were calculated using the freely available System Usability Scale Calculations created by Satori Interactive LLC.[16] Descriptive statistical analysis was performed (frequency, percentage), and the scores assigned to the application were calculated, considering the justifications of each data collection instrument.

The Institutional Review Committee (CEP 0108/2020) approved the study under No. CAAE 28469120.0.0000.5393.

Results

The final version of the application prototype intended to facilitate pre-hospital distress calls for people with complex communication needs is called "e-SU." It presents a graphical representation of a siren to signal urgent situations. High-contrast colors like red facilitate visualization, especially among people with impaired vision. The interface includes input buttons and registration, accessibility icons for text adjustment, sign language display, and audio description. Registration requires personal information, emergency contacts, and health details. The password is alphanumeric or verbal. The app's

menu spans six icons, including automatic dialing for the SAMU-192, alternative communication, editing of personal data, assistance to third parties, location via GPS, and health information updates. All experts were men, aged 36.2 on average; four lived in the Southeast; all were entrepreneurs in mobile phone application development; three had a Bachelor's degree in Systems Analysis, and two were Technologists in Application Design, both with 3.5 years of training experience on average. Two experts had a Master's degree in Technologies, and one was a specialist. Note that all experts were experienced in producing and selling mobile applications. The five experts were coded E1, E2, E3, E4 and E5. The level of agreement concerning the experts' responses to the application prototype's assessment is presented in Table 1.

The experts did not make any additional observations or suggestions for improving the usability of the e-SU application prototype in heuristics 2, 3, 5, 6, 8, 9, and 10. Suggestions were provided to heuristic 1, "Provide updates in case of system slowdowns" (P4); heuristic 4, "Highlight the control buttons of each layout to show that they are clickable, facilitating the use of the prototype" (E3) and "Show the clickable buttons" (E4); and heuristic 7, "Improve the color palette" (E1) and "I propose using a darker red and replacing the yellow with gold" (E5). These suggestions were incorporated into the prototype's final version (Figure 1), which was returned to the experts who participated in the first analysis. The experts unanimously confirmed that the version was suitable to be tested with the target audience.

The sample comprised 21 participants from the target audience to analyze the prototype's usability. There were three blind people, three with impaired vision, three deaf, three with impaired hearing; three older people; three people who lived alone; 1 (4.7%) older person who lived alone; 1 (4.7%) blind person who lived alone; and 1 (4.7%) deaf person who lived alone. Most participants were women, 15 (71.4%), aged 44.2 years on average; 7 (33.3%) were single; 7 (33.3%) were in a stable union; 3 (14.2%) were widowed; 2 (9.4%) married; and 2 (9.4%) divorced. Twelve (57.1%) reported to be Afro-descendants, 6 of mixed race (28.5%), and 3 (14.2%) reported to be Caucasian. All participants reported experience using Android operating system applications for mobile phones and access to the Internet in their homes. All participants reported a satisfaction index above 68, even when grouped into their categories (Table 2).

Discussion

This study was initiated in 2020. Its primary result was developing and assessing an application prototype to enable deaf, blind, older people, and those living by themselves to make distress calls to pre-hospital services. Hence, the authors took the initiative to proceed with the "e-Su" patent registration process at the National Institute of Industrial Property (INPI), which was concluded in 2022 under No. BR 512022001038-0.[17]

Note that nursing plays a crucial role in advancing health systems, working on the front line of healthcare delivery and promoting the health of the population. However, despite its undeniable importance, the nursing profession often faces challenges, not being fully acknowledged as a science and profession that contributes significantly to humanity.[18-20]

From this perspective, this study culminated in developing an innovative application prototype designed to promote communication accessibility to pre-hospital care services. After its registration process, the next step is to advertise the product.

Thus, this prototype not only meets a critical need in emergency care but also represents an important step towards recognizing nursing as a science capable of leading and innovating in the healthcare field. Furthermore, patent registration for later scientific dissemination, in addition to safeguarding intellectual property, reinforces authors' interest in encouraging nursing to stand out as an essential profession, a source of innovation, and a driver of socio-academic development.

Hence, we present the prototype of the e-SU application as a response to the concern discussed in this study, considering that the experience of de-

Table 1. Evaluation of e-SU heuristics by experts

Heuristics	Items	P1	P2	P3	P4	P5
1- Visibility of system status (0-5p)	1	1.25	1.25	1.25	1.25	1.25
	2	1.25	1.25	1.25	1.25	1.25
	3	1.25	1.25	1.25	1.25	1.25
	4	1.25	1.25	1.25	0	1.25
2- System matching (0-2.5p)	5	1.25	1.25	1.25	1.25	1.25
	6	1.25	1.25	1.25	1.25	1.25
3- User Control and Freedom (0-6.25p)	7	1.25	1.25	1.25	1.25	1.25
	8	1.25	1.25	1.25	1.25	1.25
	9	1.25	1.25	1.25	1.25	1.25
	11	1.25	1.25	1.25	1.25	1.25
	12	1.25	1.25	1.25	1.25	1.25
4 – System Consistency and Standards (0-13.75p)	13	1.25	1.25	1.25	1.25	1.25
	14	1.25	1.25	1.25	1.25	1.25
	15	1.25	1.25	0	0	1.25
	16	1.25	1.25	1.25	1.25	1.25
	17	1.25	1.25	1.25	1.25	1.25
	18	1.25	1.25	1.25	1.25	1.25
	19	1.25	1.25	1.25	1.25	1.25
	20	1.25	1.25	1.25	1.25	1.25
	21	1.25	1.25	1.25	1.25	1.25
	22	1.25	1.25	1.25	1.25	1.25
	23	1.25	1.25	1.25	1.25	1.25
5- Recognition instead of remembrance (0-2.5p)	24	1.25	1.25	1.25	1.25	1.25
	25	1.25	1.25	1.25	1.25	1.25
6 – Flexibility and efficiency of use (0-6.25p)	26	1.25	1.25	1.25	1.25	1.25
	27	1.25	1.25	1.25	1.25	1.25
	28	1.25	1.25	1.25	1.25	1.25
	29	1.25	1.25	1.25	1.25	1.25
	30	1.25	1.25	1.25	1.25	1.25
7 – Aesthetics and Minimalist design (0-7.5p)	31	1.25	1.25	1.25	1.25	1.25
	32	1.25	1.25	1.25	1.25	1.25
	33	0	1.25	1.25	1.25	0
	34	1.25	1.25	1.25	1.25	1.25
	35	1.25	1.25	1.25	1.25	1.25
	36	1.25	1.25	1.25	1.25	1.25
8 – Human device interaction (0-1.25p)	37	1.25	1.25	1.25	1.25	1.25
9 – Physical interaction and ergonomics (0-6.25p)	38	1.25	1.25	1.25	1.25	1.25
	39	1.25	1.25	1.25	1.25	1.25
	40	1.25	1.25	1.25	1.25	1.25
	41	1.25	1.25	1.25	1.25	1.25
	42	1.25	1.25	1.25	1.25	1.25
10 – Legibility and layout (0-7.5p)	43	1.25	1.25	1.25	1.25	1.25
	44	1.25	1.25	1.25	1.25	1.25
	45	1.25	1.25	1.25	1.25	1.25
	46	1.25	1.25	1.25	1.25	1.25
	47	1.25	1.25	1.25	1.25	1.25
	48	1.25	1.25	1.25	1.25	1.25
Total per expert (0-60p)	58,75	60.00	58.75	57.50	58.75	58.75
Average final total score						

veloping, evaluating, and registering an application prototype reaffirms that science and the development of technologies is a fundamental investment to ensure older people and people with complex communication needs can access healthcare services. Such a statement is justified by the prototype's suitability in heeding the users' limitations and needs to minimize operational barriers and obstacles related to usability.[21,22]

When considering UCD principles, we thought about the centrality of users in the process, understanding their needs at the beginning of the project, using tests, and assessing the application's usability and user satisfaction, as provided in the results.[21-27]

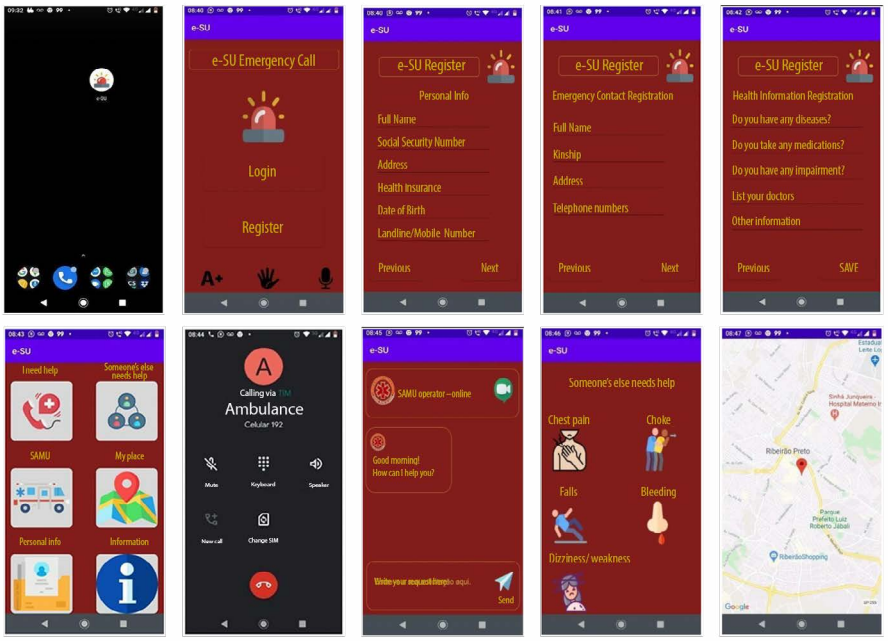

Figure 1. Final version of the e-SU prototype, presented on a smartphone with Android operating system

Table 2. Distribution of the responses provided to the System Usability Scale - SUS, index and average user satisfaction index

Participant		Items										User Satisfaction Index	Mean user satisfaction index
		1	2	3	4	5	6	7	8	9	10		
Blind	C1	4	4	4	3	4	4	4	3	4	3	92.5	83.3
	C2	3	3	3	4	2	2	3	4	2	2	70.0	
	C3	4	4	4	4	2	4	4	1	4	4	87.5	
Impaired vision	BV1	4	4	4	4	4	4	4	4	3	4	97.5	87.5
	BV2	4	3	4	3	4	4	3	4	4	1	70.0	
	BV3	4	4	4	2	4	4	4	4	4	4	95.0	
Deaf	S1	4	4	4	4	4	4	4	4	4	4	100.0	96.6
	S2	4	4	3	4	4	4	4	4	4	4	97.5	
	S3	4	4	4	4	3	4	2	4	4	4	92.5	
Impaired hearing	BA1	2	4	4	4	4	4	4	4	4	2	90.0	95.0
	BA2	4	4	4	4	4	4	4	2	4	4	95.0	
	BA3	4	4	4	4	4	4	4	4	4	4	100.0	
Older person	I1	4	4	4	3	4	4	4	4	2	4	92.5	89.1
	I2	4	4	4	1	4	4	4	4	4	4	82.5	
	I3	1	4	4	4	4	2	4	2	4	4	92.5	
Lives alone	MS1	4	3	4	4	4	4	4	4	4	4	97.5	95.8
	MS2	4	4	4	4	4	1	3	4	4	4	92.5	
	MS3	4	4	4	4	3	4	4	4	4	4	97.5	
Blind and lives alone		1	4	4	4	4	4	4	4	1	1	75.0	75.0
Deaf and lives alone		2	4	3	4	4	1	4	4	1	2	72.5	72.5
Older person, and lives alone		4	4	3	4	3	4	4	3	4	4	90.0	90.0
Total													89.5

The experts in this study were entrepreneurs in mobile application development with training in the technology field, confirming the participants' mastery of the subject. The individual assessments concerning the usability of the e-SU application prototype scored above 50, with a mean of 58.75, i.e., the prototype was considered highly usable. Hence, fundamental principles were followed in the prototype development process to ensure efficient interaction with its users.[13]

Despite efforts, the experts suggested some adjustments, such as developing an automatic re-

sponse in the system in case of slowness, highlighting the buttons to show that they are clickable, and changing the palette colors. Given their relevance, all recommendations were complied with before submitting the prototype to be assessed by its target audience. In line with this proposition, a methodological study reported the high usability of an application for patient education; however, the experts made suggestions that changed the construct's functionality flows and increased the satisfaction of end users.[28]

The e-SU application prototype is intended to provide an accessible artificial intelligence interface to enable flow with other systems, making it widely used, even with restricted Internet data access. Nevertheless, there may be situations in which the system›s automatic responses ensure comfort and safety to users. A methodological study building a mobile phone application to assist the doctors' decision-making regarding clinical conducts concluded that the inclusion of automatic responses in the system qualified and enhanced the achievement of objectives.[29]

Regarding sociodemographic characterization, all 21 subjects from the target population with complex communication needs share characteristics with other individuals, as reported in Brazilian studies promoting digital accessibility.[20,29] These results seem to be a trend worldwide because, in percentage terms, social definitions of sex, self-reported ethnicity, age, Internet access, and the use of mobile phones are comparable to the population surveys held by the World Health Organization Health.[30-33]

The individuals using the e-SU prototype reported a high level of satisfaction, except for deaf and blind individuals living alone. Nevertheless, the lowest mean scores were found among blind people (83.3 points) and those with impaired vision (87.5 points). These scores are believed to be a result of these individuals evaluating the e-SU application in a prototyping phase in which the system's interaction capabilities with other applications were limited, and there was some difficulty in imagining the resource interface functionality, which will be included in the next development phase. However, compared to other studies, the results found here indicate a high level of satisfaction among users.[21,30]

Therefore, this study's results bring to light important evidence about the accessibility provided by the e-SU App prototype to its potential users, indicating this study's likely outcomes through the formulation of a high-quality prototype, with the integration of interfaces with other pre-existing systems on mobile phone devices, providing accessibility to users, and through the creation and availability of the final version of the e-SU App, after due evaluations and adjustments to its functionalities. Other studies conducted with people with impaired vision and deafness reaffirm that accessibility features on mobile devices are responsible for independent access to these devices, providing combined and different arrangements diversity for use.[34]

The fact that the e-SU App prototype does not include an interface with the PHC service in its functionality presents itself as the most significant limitation of this stage. However, as it is an application prototype, there is no need to ensure the functioning of the entire operating system. Furthermore, The objective is to design the modulation of an interface with the SAMU-192 service when the e-SU App reaches the high-fidelity prototyping phase.

It is also evident that the authors' decision to publicize the development of this prototype only after its registration and patent enhance the intention of reinforcing the principles that guide Modern nursing, as it once again elevates its performance beyond "bedside" assistance, in which care is holistic, decisive, and based on scientific knowledge to promote the recognition of this fundamental profession. This study calls for the authors' commitment to advancing and continuing the application development process at the extended fidelity level for adaptation and a new assessment with the target audience.

Conclusion

The e-SU, in its prototype version, proved to be an efficient response in promoting accessibility

for people with special communication needs to call for help with high usability and excellent user satisfaction.

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Collaborations

Montandon DS, Oliveira LCS, Araújo AAC, Sant'Ana RSE, Mendes IAC, and Godoy S contributed to the study's design, analysis, and interpretation of data, redaction, relevant critical review of the intellectual content, and approval of the final version.

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