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PREHOSPITAL ACUTE STROKE TRAINING APP (PASTAPP) — PROTOTYPE DEVELOPMENT AND INITIAL VALIDATION

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Abstract

INTRODUCTION: Acute ischemic stroke (AIS) is a medical emergency that destroys roughly 2 million neurons each minute, highlighting the importance of treating it with the "time is brain" approach.

MATERIAL AND METHODS: This article will explain the development process of a new smartphone application called PASTApp (Prehospital Acute Stroke Training App) designed to help Emergency Medical Teams diagnose and triage suspected acute stroke patients in the field. We describe the app's features, content, and development and maintenance methods. This smartphone app was developed using a combination of user-centered techniques, including the Information Systems Research methodology and design thinking.

RESULTS: The PASTApp was designed iteratively to satisfy prehospital care workers' preferences.

CONCLUSIONS: Using such an app may improve management, speed, data quality, and communication during patient handover.

KEY WORDS: prehospital care; stroke; mHealth; app

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INTRODUCTION

According to the Global Burden of Disease Study, stroke was the second leading cause of disability-adjusted life-years worldwide in both the 50–74 and 75+ age groups in 2019 [1]sound evidence on trends by cause at the national level is essential. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD .

Acute ischemic stroke (AIS) is a time-sensitive medical emergency that is estimated to destroy approximately 2 million neurons per minute, emphasizing the critical nature of the "time is brain" treatment approach [2].

The key to successful AIS management is early recognition in the prehospital setting (ambulance) and prompt diagnosis in the Emergency Department (ED) [3]. In clinical practice, several features of the clinical history, such as the abrupt onset of focal neurologic symptoms (e.g., slurred speech, asymmetrical facial weakness, asymmetrical arm weakness), suggest a stroke diagnosis. At the same time, it is essential to realize the importance of other conditions which may mimic stroke symptoms — such as metabolic derangements, cardiovascular events, and psychiatric issues [4]. Ischemic stroke is distinguished from hemorrhagic stroke and mimics using neuroimaging modalities such as brain computed tomography and, in some centers, magnetic resonance imaging to obtain a more

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precise assessment of infarcted brain tissues and hemorrhages [5].

The complex diagnostic algorithm used to assess the indication for therapy is so time-consuming in its traditional form that, despite multiple ongoing efforts to optimize pre-and in-hospital processes, thrombolysis rates in regular clinical practice remain poor [6].

Numerous studies have shown that administration of recombinant tissue plasminogen activator (rt--PA) intravenously soon after the onset of symptoms of acute ischemic stroke increases the likelihood of a favorable functional outcome within 90 days [7–9].

Recognition of this fact has prompted providers to improve efficiency in identifying candidates for intravenous thrombolysis and reduce delays in prescribing rt-PA to these patients. Emergency Medical Service (EMS) paramedics are essential partners to more quickly identify ischemic stroke patients who may benefit from thrombolysis administration. In addition, paramedics' prehospital reporting of acute strokes is associated with improved time to care, better imaging results, and overall treatment rates [10, 11].

In the work of medical rescue teams operating based on the Act on State Medical Rescue Service, the necessity of creating electronic medical documentation of a patient in life and health-threatening emergency has been introduced. Documentation in the form of several forms taken directly from the Card of Medical Rescue Actions allows to describe the patient's condition by the description of the incident, determination of the level of consciousness, e.g., using the Glasgow Coma Scale, description of the procedures performed, confirmation of the administration of drugs and medical materials used during medical rescue actions at the place of call and on the way to the hospital ED or the emergency room. However, one of the limitations of the above system is the lack of tools to provide more structured and accurate patient information, depending on the reason for the intervention.

The European Stroke Action Plan 2018–2030 [12] addresses the entire chain of stroke care, from primary prevention to life after stroke, through seven domains: primary prevention, organization of stroke services, management of acute stroke, secondary prevention, rehabilitation, evaluation of stroke outcome and quality assessment, and life after stroke. In addition, this document makes recommendations for digital health solutions that have the potential to improve access to stroke care. The term "digital health" refers to healthcare interventions offered by digital technologies such as telemedicine, Web-based techniques, e-mail, mobile phones, mobile applications, text messaging, and monitoring sensors [13]. Mobile health (mHealth) is a term that refers to the practice of medicine and public health services that incorporates the use of mobile devices [14].

Therefore, we have attempted to prepare a mobile application based on the most recent guidelines of the Expert Group of the Section of Vascular Diseases of the Polish Neurological Society [15] designed to offer paramedics immediate access to the knowledge and resources necessary to excel in prehospital stroke management. An ideal platform should be cost-free to the end-user and be widely and easily accessible with excellent portability while providing a user-friendly interface and decision algorithm that reduces cognitive load. The majority of those characteristics are met by applications designed for smartphones. Indeed, smartphone use has increased significantly among healthcare professionals and is already being used for various purposes in the field of stroke. The purpose of this article is to discuss a new smartphone application named PASTApp (Prehospital Acute Stroke Training App) that was developed to aid emergency medical professionals in the field assessment and destination triage of patients with acute stroke. We detail the application and its content, and the processes involved in its development and maintenance.

MATERIAL AND METHODS

The study was approved by the Institutional Review Board of the Polish Society of Disaster Medicine (approval No. 06.11.2021.IRB). We used a combination of user-centered methodologies, notably the Information Systems Research framework and design thinking, to define and describe the development process of this mobile app (Fig. 1) [16].

RESULTS

Relevance cycle

The objective of the relevance cycle was to ascertain the various groups of end-users and their prehospital stroke treatment needs.

Empathize mode

The target audience was defined by conducting structured interviews with prehospital providers (n = 10) to better understand their practice in taking care of patients in the prehospital phase and the use of mobile medical applications. Table 1 presents the types of questions used.

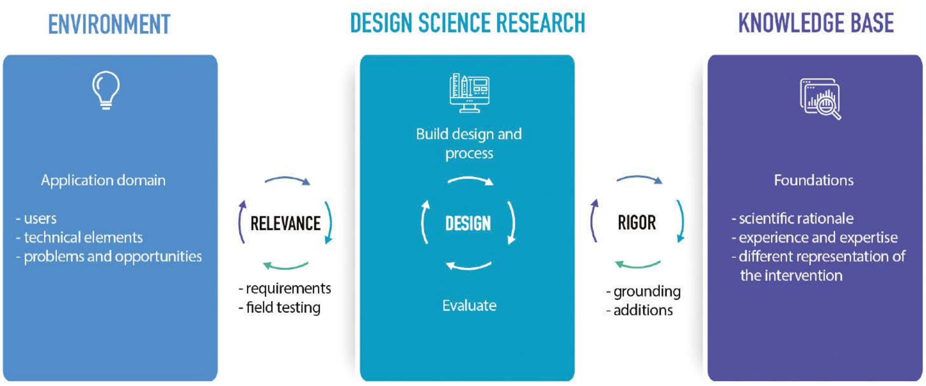

FIGURE 1. The adapted framework for Information Systems Research, incorporating design thinking practices into the relevance, design, and rigor cycles. Adapted from [16] (Creative Commons Attribution License)

Table 1. Questions asked during the semi-structured interviews

Demographic and practice questions

1. I am…
   a) A physician
   b) A paramedic

2. Years of professional experience
   a) Less than 1 year
   b) 1–5 years
   c) 5–10 years
   d) 10–15 years
   e) More than 15 years

3. Where do you work?
   a) Ambulance services
   b) Emergency department
   c) Air ambulance
   d) Other

4. What is the number of your duties per month?
   a) 0–5
   b) 6–10
   c) 11–15
   d) 16–19
   e) 20 and more

5. Please specify your confidence in making decisions in the event of emergency treatment of a patient suspected of having a stroke
   a) 1 — lowest
   b) 2
   c) 3
   d) 4
   e) 5 — highest

6. How often do you work with a patient suspected of having a stroke within a month?
   a) Never
   b) 1–4
   c) 5–10
   d) > 10

7. Have you participated in workshops/training improving your qualifications on how to proceed in the event of a stroke?
   a) Yes
   b) No

8. Do you pre-notify the stroke unit/emergency department about the transport of a patient with suspected stroke?
   a) Always
   b) Often
   c) Sometimes
   d) Rarely
   e) Never

9. Do you use the Rapid Assessment Protocol for Suspected Stroke (please tick all that apply)?
   a) FAST
   b) LAPSS (Los Angeles Prehospital Stroke Screen)
   c) CPSS (Cincinnati Prehospital Stroke Scale)
   d) ROSIER (Recognition of Stroke in the Emergency Room)
   e) Not using any

Mobile health questions

10. Do you utilize mobile devices daily in your practice for patient-related tasks?
    a) Yes
    b) No

11. I avoid using mobile devices for patient-related work because… (check all that apply)
    c) I am unsure of how to incorporate mobile technology into my daily practice appropriately
    d) I see no way in which mobile technology can improve my daily practice
    e) My practice prohibits me from using my personal mobile devices
    f) Other (please comment)

12. Name medical apps you use for yourself:

13. Please rate the following challenges to integrating medical apps into your regular clinical practice (with 1 being the most significant and 5 being the least significant):
    a) Insufficient knowledge of practical applications
    b) Absence of a reliable source for accessing effective applications
    c) Inaccessibility to mobile devices
    d) Insufficient practice incentives
    e) Inability to comprehend the benefits

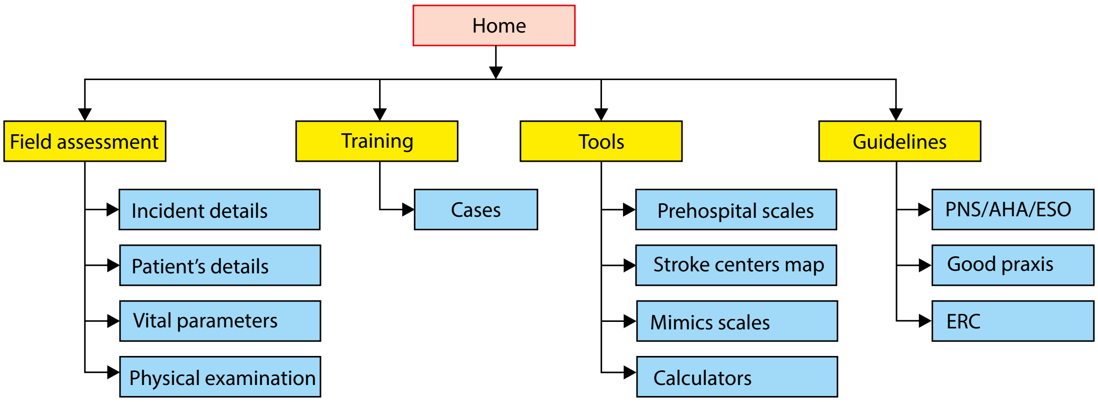

FIGURE 2. Sitemap of the mobile application; AHA — American Heart Association; ASA — American Society of Anesthesiologists; ERC — European Resuscitation Council; ESO — European Stroke Organization; PNS — Polish Neurological Society

Define mode

End-user comments and clinical observations were compiled, processed, and analyzed. This enabled the identification of end-user needs and the assessment of the app's technical requirements.

Design cycle

The design cycle's objective was to compile all of the data obtained in the prior cycle to develop new ideas in the ideate mode. This was utilized to develop a vision for the app prototype's design.

Ideate mode

Ideas were generated in time-constrained intervals, which DT encourages, and represented with sticky notes and pictorial depictions to accommodate the visual nature of creative DT practices. Some of the ideas formulated included: bilingual interface text, using videos and images for instruction, minimal to no text, and visual directives during performing procedures. Most ideas were included in the prototypes, as many of the ideas addressed different themes and problems with the interface.

Prototype mode

We began with a paper prototype to build the application's information flow and incorporate all of the relevant information specified by prehospital providers during the study of the needs. Figure 2 shows the sitemap of the application.

The information flow was later transferred to InVision platform for collaborative development of interface layouts. Figure 3 presents an example user flow diagram applied to the "Field Assessment" module. This particular diagram was developed

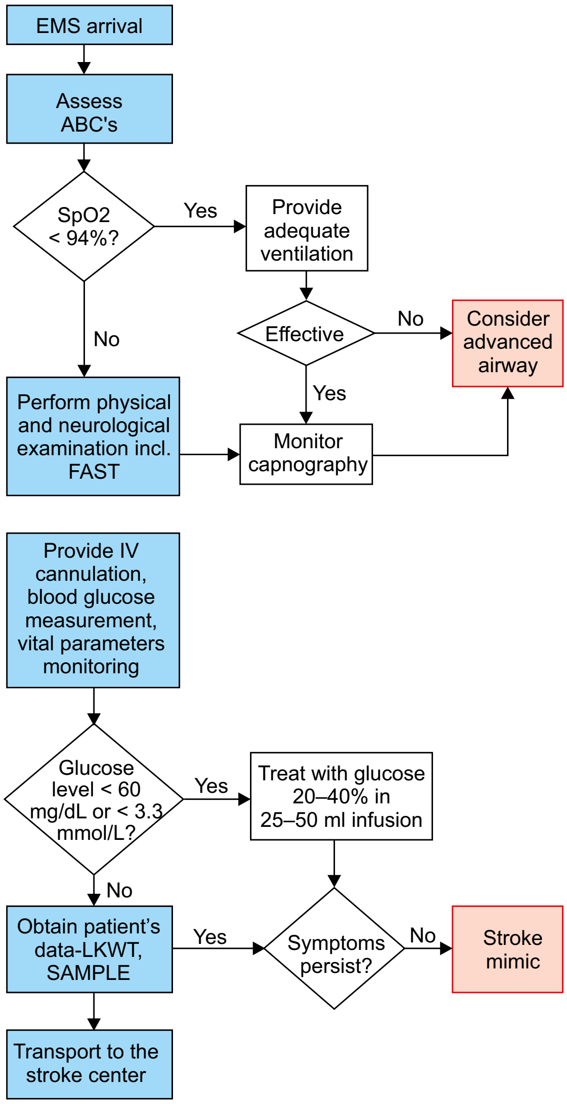

FIGURE 3. User flow diagram applied to the "Field Assessment" module; ABC — Airway, Breathing, Circulation; EMS — Emergency Medical Service; FAST — Field Assessment Stroke Triage for Emergency Destination; LKWT — Last Known Well Time; SAMPLE — Symptoms, Allergies, Medications, Past medical story, Last meal, Events prior to injury

based on three relevant documents — the most recent guidelines of the Expert Group of the Section of Vascular Diseases of the Polish Neurological Society [15], European Academy of Neurology, and European Stroke Organization Consensus Statement and Practical Guidance for Prehospital Management of Stroke [17] as well as guidelines on "Good praxis in treating patients with suspected brain stroke for medical dispatchers and emergency medical services teams" issued on January 24, 2019, by the Ministry of Health, in collaboration with National Consultants in neurology and emergency medicine [18].

We then refined and developed a high-fidelity prototype (Fig. 4) and evaluated it using two types of usability inspection: cognitive walk-throughs to identify potential usability issues with the application's functionality and heuristic evaluations to determine whether the application's screen design adhered to established design principles. Following that, we changed the prototype interface based on the findings of these inspections. In addition, the cognitive walk-through enabled us to ascertain how a novice user would navigate the application.

FIGURE 4. High-fidelity prototype

Rigor cycle

We conducted a study of the available literature for papers that addressed the topic of stroke training for prehospital clinicians, classified them by subject matter, and then tabulated the findings to ascertain knowledge gaps. Examples included the one-hour seminar covering stroke epidemiology, symptoms, diagnosis, therapy, and identifying the start time. The instructional program boosted stroke awareness and increased the precision with which dedicated EMS providers triaged patients [19]. A comparable study conducted in Dubai found that an educational lecture effectively increased stroke awareness [20]. In addition, the online training intervention implemented in Catalonia successfully increased EMS professionals' awareness and compliance with prenotification requirements during stroke code activation and ensured widespread adoption of a new prehospital stroke severity assessment scale (i.e., the RACE scale) [21].

We reviewed the primary relevant publications on similar apps that are available in the literature. Following a review of the relevant literature, a review of the available mobile apps and websites was undertaken. Google Play Store and Apple App Store were utilized to search for mobile applications, as they are the two largest app stores. Our team later evaluated these apps in terms of their strengths and weaknesses. Table 2 summarizes our findings.

Test mode

After finalizing the high-fidelity prototype, we conducted formative evaluations using usability testing. First, we gathered a convenience sample of ten prospective users for the usability testing, consisting of paramedics, medical doctors, and medical students.

To monitor how users navigated the application, one of us provided verbal directions on accessing the application from the home screen. Additionally, the researcher provided the participant with a scenario involving a stroke patient, for which the individual would need to evaluate immediately. We gave no further instructions about application navigation, as the application itself had all the necessary instructions for completing the task of producing a case report.

Following completion of the timed task, we conducted usability testing. Participants were invited to explore the prototype freely and think aloud throughout the interviews to identify usability issues. Interviews were manually recorded, transcribed, coded, and analyzed. Table 3 summarizes the key themes identified during the interviews.

Table 2. Strengths and weaknesses of similar apps

App	Strengths	Weaknesses
Code Stroke Alert [22]	Clinical score calculators and guidelines Instant messaging and reading receipts Interhospital referral Tracked and timestamped data entries for audit Real-time GPS tracking Open-source	Not universally available An early phase of deployment Lacks data on the impact on the outcome
Green [23]	Real-time communication Enables hospital prenotification by EMS Staff is able to create and edit clinic records. Then, the data is automatically entered into the chosen hospitals' electronic clinic records Semi-automated timestamping of events Provides the data to identify weak points in treatment plans and makes comments	The performances of the platform in less populated areas should be examined further Not universally available
JoinTriage (formerly known as FAST-ED [24])	Timestamps events (Last Seen Well, CT, MRI, Angio suite, Reperfusion) Instant messaging platform GPS technology with real-time traffic information Provides information on stroke symptoms, thrombolytic treatment, and prescribed actions when stroke is suspected Computes patient's eligibility for intravenous tissue-type plasminogen activator or endovascular treatment	Not universally available Risk of triage mismatches Lacks data on the impact on the outcome
Stop Stroke Pulsara [25, 26]	Improves communication between staff involved in treatment (EMS, ED, radiology, neurology, and Interventional team) All care team members have real-time access to the most up-to-date patient information Includes stroke scales (LAMS, NIHSS, RACE, FAST/Cincinnati) Keeps running track of LSW, tPA times, and MT times Alerts when images are available Transmits images Allows tPA contraindication review by all Data (limited) on the impact on logistical outcomes	Not integrated to medical records
Stroke 119 [27]	Provides rapid self-screening for stroke Identifies nearby hospitals that provide thrombolytic treatment Facilitates calling emergency services	It is inconclusive that this application can improve patient outcomes in actual practice

EMS — Emergency Medical Service; CT — computed tomography; MRI — magnetic resonance imaging; ED — Emergency Department; LAMS — Los Angeles Motor Scale; NIHSS — National Institutes of Healths Stroke Scale; RACE — Rapid Arterial oCclusion Evaluation; FAST - Face, Arm, Speech, Time; LSW — last seen well; tPA — tissue plasminogen activator; MT — mechanical thrombectomy

Table 3. Summary of topics covered during interviews

Topic	Aspects covered
Appropriacy of an application	Questions concerning the app's scope, audience, and purpose; the app as a learning aid; the app's familiarity and acceptability; and the app's anticipated limitations
Contents	Which prehospital scales should be used; which sources to consult; examination of scientific evidence
Usability	Information presentation; linguistic use; potential decision algorithms; visual design; and familiarity
Safety	Mobile device as a target for theft; data security

DISCUSSION

The article details a step-by-step technique for designing a user-centric mobile health application. PASTApp (Fig. 5) is intended to assist prehospital providers who are confronted with obstacles in caring for acute stroke patients. An early search of the literature found that there are already various solutions accessible in the aforementioned area. However, the bulk of solutions offered makes no mention of user-centered or collaborative design approaches. It is important to emphasize that our application is intended for educational use first.

FIGURE 5. App's welcome screen

Subsequent app development processes will be aimed at preparing the app for use in the management of patients with suspected stroke.

Various educational options based on technology for EMS stroke detection are becoming available. The utilization of online resources and video education for EMS education (e.g., the American Heart Association's FAST-ED video) enables EMS providers to receive education at a convenient time for them and the ability to conduct pre-and post-education testing to determine knowledge retention [28].

Numerous prehospital stroke measures are available, most of which have been field validated against the NIHSS and are streamlined in format, with some, such as the RACE scale, having been field confirmed [29, 30].

Numerous smartphone applications are available to assist stroke patients with self-screening and hospital selection, as well as to potentially reduce hospital arrival time (e.g., FAST-ED [24], Mayo Clinic Acute Stroke Evaluation app [31], Stroke 119 [27], Green [23]).

The apps often include built-in automated decision-making algorithms based on clinical data, a database of all regional stroke centers classified according to their ability to provide Efficient Video Transport (EVT), and Global Positioning System technology with real-time traffic information to determine a patient's eligibility for t-PA or EVT, as well as distances/transportation times to the various neighboring stroke centers to assist EMS professionals in making the most appropriate defibrillation decision.

Currently, data on the implementation of the majority of these applications are in a preliminary phase.

Our study has some limitations. To begin, while our mobile application was successfully constructed, its usability was only tested on a small sample group. Its true impact and safety should now be evaluated and compared to other prehospital stroke treatment delivery methods, first in simulation research and then in the clinical setting.

CONCLUSIONS

The iterative development approach aided in the design of the PASTApp to accommodate prehospital care professionals' preferences. Using such an app may result in improved and faster management and an increase in data quality, which may improve communication during patient handover.

Additional research is necessary to determine the effect of the PASTApp on closing knowledge gaps and enhancing prehospital stroke care in simulated scenarios.

Conflict of interest

All authors have no affiliations or involvement with any organization or entity having any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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