

## ORIGINAL RESEARCH

# Functional requirements of a mobile-based application for stroke self-management: A Delphi study

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## Abstract

This study aimed to determine the functional requirements of a self-management mobile application for stroke survivors. For extracting the initial functional requirements, a literature review as well as interviews with 17 patients and caregivers were done. The results were analyzed using the content analysis method. The initial extracted requirements were then provided to the specialists by the Delphi technique to determine the final functional requirements. Content validity ratio (CVR) and content validity index (CVI) were calculated according to the Lawshe model. Criteria for item approval included CVR > 0.49 and CVI > 0.79. Finally, the approved items were turned into a five-point Likert scale questionnaire and were then provided to 53 experts and items with a mean score higher than 3.75 were approved. Functional requirements including creating a user account, educational material, support services, providing reminders and alerts for drugs administration and physician appointments, and rehabilitation exercises (to improve balance, upper and lower extremities rehabilitation, and activities of daily living (ADLs)) were approved. Most of the approved functional requirements were related to rehabilitation exercises for improving upper limb motor function. The experts did not approve the requirements for using splints and slings or the recommendation to take some medications.

## 1 | INTRODUCTION

Every year, 26 million people experience stroke worldwide, making it the second leading cause of death and the main cause of long-term disability worldwide [1]. In 2019, 6.55 million deaths caused by stroke were recorded, including more than 312 thousand deaths in North Africa and the Middle East, and more than 40 thousand deaths in the country under-study [2]. In general, it is estimated that, in the EU-states, the total number of strokes will increase by 34% from 2015 to 2035, but the death rate of this disease will reduce and more people have to live with the consequences of the disease [3]. In the first year after a stroke, 30% of survivors are dependent on others for their activities, such as walking, dressing, and using the bathroom [4]. Between 60% and 80% cannot walk [5], and 31% suffer from

depression up to 6 months following the stroke [6]. On the other hand, in terms of the socio-economic impact, stroke has a financial burden of about € 27 billion for Europe annually [7].

Most clinical guidelines suggest using rehabilitation services for patients following stroke. However, access to formal rehabilitation services in low-income countries is very low and sometimes non-existent, which might also apply to some high-income countries [8].

Multiple studies have been conducted on the effects of information technology (IT)-based interventions on patient care, among which some studies have shown the positive effects of this type of intervention on the outcomes of care [9, 10]. Mobile technology as an IT tool can be made available to patients or care providers for self-management [11]. This technology plays an essential role in improving self-care, patient communication

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with physicians, and access to health information, and there is much evidence that confirms the positive effect of this technology on patients' self-care [12–16]. In a systematic review study, Whitehead and Seaton [17] showed that mobile-based applications potentially improve the management of patient's symptoms and outcomes. Mohammad Mosa et al. [18], in their study reviewing 83 smartphone-based applications in the field of medical science, demonstrated that smartphones can prove useful for patient education and self-management of chronic disorders. Another study by Zhou et al. [19] emphasized the positive effect of mobile-based interventions on the rehabilitation of stroke survivors. However, it was stated that further studies are needed to prove such effects.

The first step in the development of Information Systems (ISs) is performing a needs assessment of stakeholders, and the functional requirements of the system must be determined according to the stakeholders' needs [20]. Functional requirements are defined as major operational activities or the highest level of performance that the system must reach [21]. Some studies have shown that stakeholders' participation in developing new technologies is essential and can reduce user resistance and increase technology acceptance in individuals [22–24]. However, according to the researchers' review, no study in the under-study country has been conducted using a comprehensive needs assessment of the stroke care stakeholders, and in general, determining the functional requirements for such applications has received less attention globally.

This study aimed to determine the functional requirements for a stroke self-management mobile-based application using stakeholders' needs assessment. This mobile-based application can be developed to be used at home by stroke survivors. It can be the basis for developing an application to facilitate access to telerehabilitation and self-management services.

## 2 | MATERIALS AND METHODS

This study was a qualitative one conducted using the content analysis approach and Delphi technique. Figure 1 shows the methods of this study. The following steps have been taken in the present study:

### 2.1 | Extraction of functional requirements using literature review

Initially, functional requirements were extracted from PubMed, ScienceDirect and Google Scholar databases using related keywords, from which articles and related previous studies were extracted. Related keywords included mobile applications, stroke, self-care (MeSH terms) and all their synonyms that were combined with AND Boolean. In this search, six related systematic review studies were found [18, 19, 25–28], and all the included articles referring to the development of self-care software—mobile-based, desktop or web-based—related to stroke were imported. Since there was no approved national clinical guideline for stroke in the country under study, the

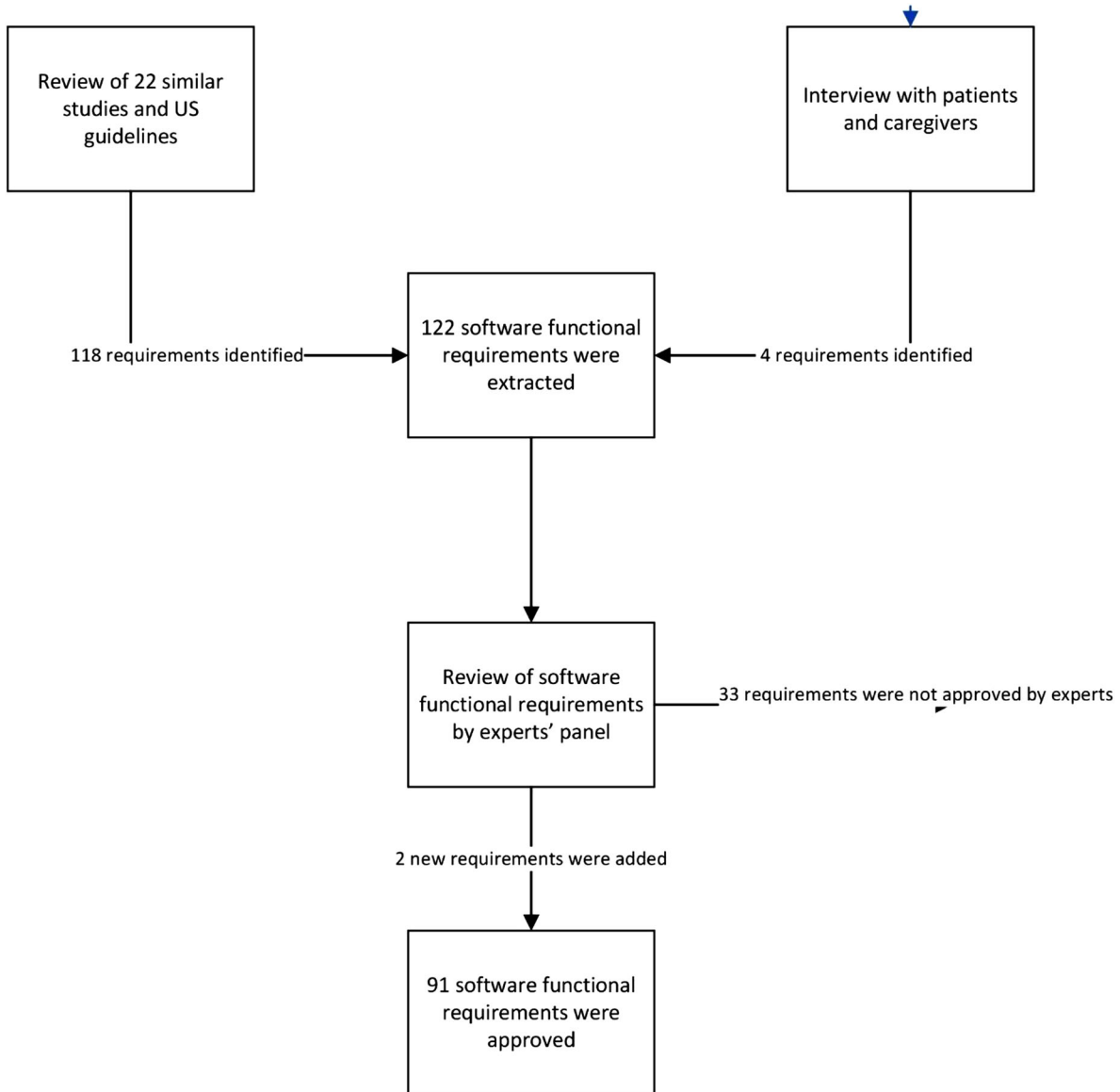
guidelines of other developed countries were reviewed in order to prepare a comprehensive draft for the Delphi questionnaire. The guidelines for stroke care suggested by the United States, the United Kingdom, Canada, Australia, and the World Health Organization (WHO) were reviewed. Five neurologists with a degree of Associate Professor and above and with at least five years of work experience in neurology approved one of the guidelines (US guidelines) [29–34]. According to them, the selected guidelines were more comprehensive and more similar to the care plans used by the clinicians of the country under study. These neurologists had been selected by convenient sampling method, and they studied the guidelines of all countries. Finally, the functional requirements were extracted and placed on a list by studying the US guidelines and their mentioned care. It should be noted that the functional requirements focus on hemiplegia disorder and do not include some disorders such as visual, cognitive, and speech impairment as they require a separate application.

### 2.2 | Assessment of patients' needs through interviews

Needs assessment of patients and caregivers, as the primary users of this application, was performed. Data collection was performed at this stage using an in-depth semi-structured interview. The sample size was not predetermined and the interview continued until the data saturation level was reached. Patients having a stroke in the past year who had experienced hemiplegia or hemiparesis as well as their nearest caregiver were interviewed. Individuals (patients or their caregivers) who could use a smartphone were selected to ensure that they better understand the questions. Therefore, the sample was selected based on the purpose of this study, and patients with global aphasia and cognitive disorders were excluded from the study. The interview was conducted using seven predetermined questions, and the interviewer tried to identify all patients' problems during the illness and extract their needs using targeted questions. Patients' responses reached saturation level after 17 interviews with 17 patients and their caregivers. The interviews were recorded and written immediately after each interview and analysed by the content analysis method. For this purpose, the entire interview text was studied by two researchers separately and all their codes were extracted. The extracted codes were then reviewed in a single session and similar cases were written; in case of different cases, a final agreement was reached. Then, all codes were assigned to identify sub-themes and related themes, and finally, based on patients' identified needs, the relevant functional requirements were identified.

### 2.3 | Using the Delphi technique for performing needs assessment of experts

Another stakeholder included in the study to confirm the functional requirements were experts. At this stage, all the functional



**FIGURE 1** Overview of the study methods

requirements identified in the two previous steps were written in two similar tables, with one table including the functional requirements of mobile-based application which neurologists were asked to approve based on patients' degree of necessity and the other one including patient rehabilitation exercises presented to physiotherapists and occupational therapists. At this stage, experts with a Ph.D. degree and at least three years of experience as a faculty member of the University of Medical Sciences in the field of stroke were selected. Initially, all of the identified functional requirements were listed in the table. To start the Delphi stage, an expert panel was required to confirm the content validity ratio (CVR) and content validity index (CVI) of all items. CVR refers to the degree of necessity of an item from the experts' point of view, and CVI refers to the degree of relevancy, simplicity and clarity of each item. The required sample size for CVR and CVI confirmation was 15 experts. Tables

were sent to 20 neurologists, 20 physiotherapists, and occupational therapists considering the 30% probability of sample fall. The requirements were divided in terms of necessity (CVR) at three levels (necessary and useful, useful but unnecessary and unnecessary) [35]. In terms of CVI, the items were divided into four levels (completely relevant, simple or clear; relevant, simple or clear; needs to be reviewed and irrelevant or non-simple or unclear) [36, 37]. Calculation of CVR and CVI was done based on the Lawshe study formula as follows [35, 36, 38]:

$$CVR = \frac{\left[ n_e - \left( \frac{N}{2} \right) \right]}{\frac{N}{2}}$$

$$CVI = \left( \frac{a}{N} + \frac{b}{N} + \frac{c}{N} \right) / 3$$

$n_e$ : number of panel members indicating an item “essential,”  
 $a$ : number of answers of completely relevant and relevant  
 $b$ : number of answers of completely simple and simple  
 $c$ : number of answers of completely clear and clear  
 $N$ : number of panel members

Items whose CVR score was higher than the baseline number (0.49 for 15 individuals and 0.42 for 16 individuals) were confirmed, and items with lower CVR scores were removed [39]. Regarding CVI, items with a score above 0.79 were approved, and items with a lower CVI score were reviewed and modified [37]. After modification, they were returned to 10 experts and this process continued until final approval. Given that there was an open question for possible suggestions at the end of the table, if some experts added an item, it was sent to the experts along with the modified items. The output of this stage was a set of functional requirements that the experts approved based on their CVR and CVI scores. For performing the Delphi technique, a sample was considered including 25 individuals for each group (50 individuals in total), which was approved with a 40% probability of sample fall (due to the possibility of the multi-stage process). The questionnaire prepared in the previous stage were sent to 35 experts in each group. The experts' responses were according to a 5-points Likert scale scoring from 1 to 5 (strongly disagree = 1, disagree = 2, no idea = 3, agree = 4, and strongly agree = 5) and then the mean score of each item was calculated. The minimum acceptable mean score for each item was 3.75. If the score was between 2.5 and 3.74, that item was revised and items with a score less than 2.5 were removed. The questionnaires were sent to the experts meeting the inclusion criteria in person and via e-mail. The response rate of experts was 77.5% (15 physiotherapists and occupational therapists and 16 neurologists) and 75.7% (25 physiotherapists and occupational therapists and 28 neurologists) in the validity confirmation stage and the Delphi stage, respectively. The data were entered in Microsoft Excel 2019 software program and the CVR and CVI scores of each item were calculated based on the relevant formulae. Then, the experts' agreement score in the Delphi stage was calculated by determining the average score of each item.

### 3 | RESULTS

Following reviewing similar studies, functional requirements were extracted from 22 articles [26, 40–60]. Rehabilitation requirements for patients with stroke were also extracted from the US guideline [31]. Finally, based on text reviews, 118 functional requirements were identified and sent to the panel of experts. Patient interview analysis showed that the mean age of the interviewed patients was  $68.53 \pm 14.63$  (between 44 and 90 years), and nine patients were females. Based on the content analysis of the interview, four themes and nine sub-themes were determined. The themes, sub-themes, codes, and functional requirements identified in this step are listed in Table 1.

In general, based on interviews with patients and caregivers, the following four new requirements were identified and added to the previous functional requirements of the mobile-based application. This mobile-based application must have the following capabilities:

- Ability to presentation significant side effects of prescribed drugs to patients
- Ability to train patients in important drug–drug interactions (DDIs) (commonly prescribed drugs for stroke)
- Train patients in the possible consequences arising from stopping the treatment
- Train patients in disease curability and encourage them to continue the treatment

All the identified requirements, the CVR, CVI, and the average score obtained for each item are presented in Table 2. According to this table, 33 identified requirements were not approved by experts, and two new requirements, including the ability to contact application support and the ability to view the medical record summary of the patient, were added to the previous requirements.

## 4 | DISCUSSION

This study aimed to determine the functional requirements of a stroke self-management mobile-based application, where ultimately 91 functional requirements in 11 groups were approved by experts, including creating an account for patient and teaching materials to improve patient knowledge, skin injury prevention, bowel and bladder problems, hemiplegic shoulder pain, fall prevention, depression prevention as well as presenting support services, reminders and warnings, physician application requirements, and rehabilitation exercises.

### 4.1 | Rehabilitation exercises

The highest number of exercises approved by experts was related to upper limb rehabilitation. Improving upper limb function is the core of post-stroke rehabilitation, playing a crucial role in daily activities [61]. Several studies have shown that home-based intervention can improve the rehabilitation and motor function of the upper limb [62–64]. While Coupar et al. [65], in a meta-analysis study analysing four RCTs, concluded that there was no significant difference in upper limb functional recovery in patients receiving home-based interventions following a stroke from other patients, they found no sufficient evidence for their statement. Overall, it seems that, according to the experts in this study, the essential component of a mobile-based self-care application that intends to serve patients with stroke at home is to provide and train patients to perform upper limb rehabilitation exercises. Upper limb rehabilitation can improve ADLs and quality of life, which is the reason why the need to do it is highlighted by experts.

**TABLE 1** Content analysis of patients' interviews

| No. | Theme   | Subtheme   | Code (response frequency)  | Identified functional requirements for mobile-based application  |
|-----|---|--|--|--|
| 1   | Problems related to hemiplegia or hemiparesis               | - Difficulty in doing ADLs <sup>1</sup><br>- Difficulty in walking and maintaining balance     | Disorder in:<br>Going to the toilet (11), bathing (8), eating (7), dressing and undressing (8), walking (10), balance (8), and history of falls (6).   | Ability to train patients in upper and lower limbs rehabilitation ***  |
| 2   | Stroke complications  | - Disease complications<br>- Treatment complication <sup>DDI</sup> <sup>2</sup>                | Urinary Incontinence or leakage (10), faecal incontinence (2), hemiplegic shoulder pain (7), speech disorder* (3), dysphagia* (2), visual disorders* (4), bed sores (2), UTI <sup>3</sup> (2), cognitive impairment* (3), increase in blood creatinine level (drug complication) ** (1), tremor (drug complication) ** (3), purpura (drug complication) ** (2), Digestive problems (drug complication) ** (2), Severe hypoglycaemia (drug interaction) ** (2). | - Ability to train patients to do exercises strengthening the pelvic floor muscles ***<br>- Ability to train patients in doing exercises for hemiplegic shoulder pain relief***<br>- Ability to train patients in doing activities to prevent bed sores **<br>- Ability to train patients regarding drug side effects +<br>- Ability to train patients regarding important DDI <sup>2</sup> in order to attend as soon as possible + |
| 3   | Psychological disorders                                     | - mood disorders - Emotional problems  | Depressed mood (5), mania mood (frequent and loud laughter) (2), feeling helpless (2), anxiety and worry (3), aggression and anger (1), fear of death (1), a severe decrease in life expectancy (3), lack of hope for recovery (4), lack of cooperation in taking medication and following up the treatment (1).   | - Ability to train patients in prevention of depression and seeing a doctor early ***<br>- Ability to train patients regarding the importance of doing exercises ***<br>- Ability to train patients regarding the possible consequences of stopping the treatment +<br>- Ability to train patients in disease curability and encourage them to continue the treatment +  |
| 4   | Information asymmetry between the physician and the patient | - Insufficient knowledge about the disease<br>- Insufficient knowledge about treatment methods | Lack of informing the patient about the duration of medication by the physician (3), Lack of informing the patient about the correct use of medications by the physician (2), lack of informing the patient about the possible consequences of the disease by the physician (5), Lack of informing the patient about subsequent visit time (2).  | - Ability to provide communication between the physician and the patient to resolve possible ambiguities ***   |

<sup>1</sup>ADLs: Activities of daily living.

<sup>2</sup>DDI: Drug-drug interaction.

\*Although interviewed people have expressed these items because they were not in line with the objectives of this study, they have not been considered in determining functional requirements.

\*\*According to the patients, items of complications and DDI were approved by the doctor. The physician has stated these symptoms are due to complications or DDI.

\*\*\*The identified items in the previous step (identifying requirements based on previous studies and guidelines) which are not considered as new.

+New requirements identified in interviewing patients and caregivers.

## 4.2 | Requirements added in the present study

The ability to communicate between users and the support of the application and the ability to view patient record summary by the physician were the requirements that were not extracted from the literature review and were added to the requirements based on the suggestion of some experts followed by their confirmation. Experts finally approved all of the requirements set that were presented by patients. In the present study, experts emphasized the importance of communication between patients and the support team. Even when a

software application is not outdated, support services are still required so that the software can be upgraded to meet customer needs. Following product delivery, support services can resolve potential bugs and meet new functional needs [66]. Therefore, it is suggested that users communicate with the application support team to resolve their issues. In the present study, some patients and their caregivers reported serious DDIs during post-discharge treatment. Some commonly prescribed medications for stroke, such as antithrombotic drugs (e.g., aspirin), have interactions with some over-the-counter (OTC) medications that patients take at home (such as some non-steroidal anti-inflammatory drugs (NSAIDs)) [67], leading to heart attack [68]

**TABLE 2** Functional requirements identified for the self-management application for patients with stroke<sup>+</sup>

| Group  | Functional requirement  | CVR   | CVI   | Strongly agree | Agree | No idea | Disagree | Strongly disagree | Mean score |
|--|---|-------|-------|----------------|-------|---------|----------|-------------------|------------|
| Creating an account  | Possibility to enter patient username (unchangeable)  | 0.625 | 0.958 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Possibility to enter patient age  | 0.75  | 1     | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Possibility to enter patient gender   | 0.875 | 1     | 27             | 0     | 1       | 0        | 0                 | 4.92       |
|  | Possibility to enter patient weight   | 0.875 | 0.979 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Possibility to enter patient height   | 0.875 | 0.916 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Automatic calculation of body mass index  | 0.875 | 0.937 | 27             | 0     | 1       | 0        | 0                 | 4.92       |
| Patient facts  | Definition and explanation of the disease   | 0.875 | 0.937 | 27             | 0     | 1       | 0        | 0                 | 4.92       |
|  | How the stroke has happened   | 0.625 | 0.937 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | The risk factors for this disease and the necessary diet  | 0.875 | 0.937 | 27             | 0     | 1       | 0        | 0                 | 4.92       |
|  | Common signs and symptoms of the disease  | 0.875 | 0.916 | 27             | 0     | 1       | 0        | 0                 | 4.92       |
|  | Warning signs and symptoms  | 1     | 0.812 | 28             | 0     | 0       | 0        | 0                 | 5          |
|  | Common complications of the disease on balance, bowel, and bladder thinking, pain, physical problems, sleep, fatigue, feeling, speech, and swallowing | 0.75  | 0.916 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Methods of prevention and treatment of the disease  | 0.75  | 0.916 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Side effects of the most common drugs prescribed  | 0.625 | 0.937 | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|  | Important DDIs <sup>1</sup> of the most common drugs prescribed   | 0.75  | 0.875 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Patient improvement methods *   | 0.25  | 0.937 | —              | —     | —       | —        | —                 | —          |
|  | Description of program goals for patients   | 0.625 | 0.916 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
|  | The importance of the repeated practice of exercises  | 0.625 | 0.916 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
|  | Explanations about the curability of the disease and encouragement to follow up the treatment   | 0.625 | 0.854 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
|  | Possible consequences of discontinuing the treatment  | 0.875 | 0.895 | 27             | 0     | 1       | 0        | 0                 | 4.92       |
| Training prevention of spasticity and skin injury                                | Putting a soft pillow under the seat and behind one's back in their wheelchair  | 0.75  | 0.874 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|  | Avoiding washing too much   | 0.625 | 0.895 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
|  | Using appropriate moisturizer creams and lotions *  | 0.375 | 0.895 | —              | —     | —       | —        | —                 | —          |
|  | Observing skin hygiene  | 0.625 | 0.937 | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|  | Using a special mattress  | 0.5   | 0.895 | 24             | 0     | 3       | 1        | 0                 | 4.67       |
|  | Changing the position on the bed regularly  | 0.875 | 0.937 | 27             | 0     | 1       | 0        | 0                 | 4.92       |
|  | Changing the position of the hemiplegic shoulder in the form of maximum external rotation, every day for 30 min*                                      | 0.375 | 0.645 | —              | —     | —       | —        | —                 | —          |
|  | Using suitable wrist, elbow, and hand splints to manage spasms at rest (with figure) *  | 0     | 0.708 | —              | —     | —       | —        | —                 | —          |
| Using suitable splints for the ankle when resting or during assistive standing * | -0.125  | 0.812 | —     | —              | —     | —       | —        | —                 |            |

(Continues)

TABLE 2 (Continued)

| Group   | Functional requirement   | CVR    | CVI   | Strongly agree | Agree | No idea | Disagree | Strongly disagree | Mean score |
|---|--|--------|-------|----------------|-------|---------|----------|-------------------|------------|
| Training<br>prevention of<br>bowel and<br>bladder<br>problems | Recommendation to see or contact the doctor in case of symptoms of urinary retention or urinary incontinence   | 0.75   | 0.958 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|   | Recommendation to use a bedpan every 2 h during waking hours and every 4 h during sleeping hours *   | 0.25   | 0.875 | —              | —     | —       | —        | —                 | —          |
|   | Recommendation to taking laxatives such as magnesium hydroxide or lactulose in case of constipation *  | 0      | 0.791 | —              | —     | —       | —        | —                 | —          |
|   | Training pelvic floor muscles strengthening *  | 0.125  | 0.479 | —              | —     | —       | —        | —                 | —          |
|   | Seeing the doctor if the consistency, number, and timing of bowel movements' have changed significantly before the stroke  | 0.625  | 0.895 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
| Training<br>prevention of<br>hemiplegic<br>shoulder pain      | Training shoulder movement range and shoulder positioning (with animation or video) - Exercising in the rehabilitation exercises section   | 0.625  | 0.854 | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|   | Training to use supportive tools and slings during hemiplegic shoulder pain (with animation or video) *  | 0      | 0.791 | —              | —     | —       | —        | —                 | —          |
|   | Advising the patient to contact the physician if pain develops   | 0.625  | 0.916 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
| Training<br>prevention of<br>fall                             | Observing balance exercises **   | 0.625  | 1     | 25             | 0     | 2       | 1        | 0                 | 4.75       |
|   | Advising the patient and their families to change the home arrangement to reduce the risk of falls   | 0.625  | 0.875 | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|   | Doing tai chi training for patients *  | -0.375 | 0.708 | —              | —     | —       | —        | —                 | —          |
| Training<br>prevention of<br>Depression                       | Advising the patient or caregivers to see the doctor if the patient experiences any of the following symptoms over two weeks: Decreased interest and desire to do daily activities, frustration and depressed mood, sleep disturbance, extreme tiredness and lack of energy, decreased or increased appetite, feeling of failure, severe disorders of concentration, talking too slowly or too fast, restlessness or agitation, negative and self-harming thoughts | 0.625  | 0.875 | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|   | Yoga and tai chi training and playing games actively to reduce stress and increase the quality of life *   | -0.5   | 0.479 | —              | —     | —       | —        | —                 | —          |
|   | Possibility of making an offline or online visit with a psychiatrist monthly to assess the psychological status of the patient   | 0.625  | 0.916 | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|   | Encouraging the patient to participate in entertainment programs and maintain a healthy lifestyle (watching TV, listening to the radio, communicating with friends, doing crosswords, reading, playing with children and grandchildren, going out etc.)  | 0.5    | 0.875 | 25             | 0     | 2       | 1        | 0                 | 4.75       |
|   | Ability to set weekly goals and make improvements through notes *  | 0      | 0.770 | —              | —     | —       | —        | —                 | —          |

(Continues)

TABLE 2 (Continued)

| Group   | Functional requirement  | CVR   | CVI   | Strongly agree | Agree | No idea | Disagree | Strongly disagree | Mean score |
|---|---|-------|-------|----------------|-------|---------|----------|-------------------|------------|
| Support services  | Frequently asked questions (FAQ) *  | 0.125 | 0.687 | —              | —     | —       | —        | —                 | —          |
|   | Ability to communicate between patient and the therapist through the following: voice message, video message, and text message **   | 0.625 | 1     | 25             | 0     | 3       | 0        | 0                 | 4.78       |
|   | Ability to contact the application support team to fix problems ***   | 0.8   | 0.866 | 25             | 0     | 1       | 2        | 0                 | 4.71       |
|   | Possibility of a weekly phone call from a counsellor or therapist with the patient to remind him/her to do the exercises  | 0.5   | 0.854 | 24             | 0     | 3       | 1        | 0                 | 4.67       |
| Providing alerts and reminders  | Reminding the patient to arrange doctor appointments  | 0.75  | 1     | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|   | Reminders for daily blood pressure (BP) measurement   | 0.75  | 0.937 | 26             | 0     | 2       | 0        | 0                 | 4.85       |
|   | Warning the patient to contact the doctor if the systolic BP is over 185 mm Hg <sub>2</sub> and diastolic BP is over 110 mm Hg.   | 0.875 | 1     | 27             | 0     | 0       | 1        | 0                 | 4.89       |
|   | Reminders to record pulse rate (PR) daily *   | 0.375 | 0.854 | —              | —     | —       | —        | —                 | —          |
|   | Reminders to take prescribed medications  | 0.875 | 1     | 27             | 0     | 1       | 0        | 0                 | 4.92       |
|   | Reminders to take vitamin D and calcium supplements   | 0.5   | 0.853 | 22             | 0     | 5       | 1        | 0                 | 4.53       |
| Functional requirements of the therapist application  | Creating an account for the doctor, including first and last name and type of specialty   | 0.625 | 0.937 | 21             | 3     | 3       | 1        | 0                 | 4.57       |
|   | Ability to view some items of the patient record summary (including patient name, record number, age, gender, date of discharge, disease complications at discharge time, affected side, major comorbidities, prescribed medications) *** | 1     | 1     | 24             | 1     | 2       | 1        | 0                 | 4.71       |
|   | Possibility of voice or text chat with the patient if necessary   | 0.875 | 0.979 | 26             | 0     | 1       | 1        | 0                 | 4.82       |
|   | Ability to receive patients' offline contact and send answers to them   | 0.75  | 0.916 | 26             | 0     | 1       | 1        | 0                 | 4.82       |
|   | Ability to receive weekly line charts for patients' BP and the ability to provide appropriate feedback for each patient   | 0.75  | 0.875 | 26             | 0     | 1       | 1        | 0                 | 4.82       |
|   | Ability to receive weekly line chart for patients' PR and the ability to provide appropriate feedback for each patient *  | 0.25  | 0.770 | —              | —     | —       | —        | —                 | —          |
|   | Overall mean  |       | 0.566 | 0.879          |       |         |          |                   |            |
| Rehabilitation exercises (Simple and understandable videos must be displayed for all exercises) |   |       |       |                |       |         |          |                   |            |
| Grading the exercises   | Grading all exercises (simple, medium, difficult) and arranging exercises from simple to difficult  | 0.866 | 1     | 21             | 4     | 0       | 0        | 0                 | 4.84       |
| Stretching exercise for beginning   | Repeating stretching exercises of upper and lower limbs and trunk to start the exercises 10 to 15 times   | 0.6   | 0.844 | 16             | 2     | 7       | 0        | 0                 | 4.36       |

(Continues)



TABLE 2 (Continued)

| Group   | Functional requirement   | CVR    | CVI   | Strongly agree | Agree | No idea | Disagree | Strongly disagree | Mean score |
|---|--|--------|-------|----------------|-------|---------|----------|-------------------|------------|
| Circuit class therapy   | Sitting-to-stand exercise (standing from a sitting position on the chair with assistance, standing from a sitting position on the chair without assistance, sitting from the floor to a chair)   | 0.6    | 0.866 | 14             | 6     | 2       | 3        | 0                 | 4.24       |
|   | Lateral and forward step (the patient places the affected foot on a front or side stair and, with the help of guards on both sides, puts himself/herself on the stair. The patient then stands on the stairs and lowers the unaffected foot to touch the ground) | 0.733  | 0.822 | 20             | 0     | 0       | 3        | 0                 | 4.24       |
|   | The heels are lifted off the ground in an upright position*  | 0.2    | 0.488 | —              | —     | —       | —        | —                 | —          |
|   | Mini-Scott practice  | 0.733  | 0.8   | 20             | 1     | 1       | 0        | 3                 | 4.4        |
|   | Strengthening hamstring actively (the patient sits in a chair and lifts the affected lower limb as far as possible and bends forward from the hip)   | 1      | 0.844 | 22             | 0     | 3       | 0        | 0                 | 4.76       |
|   | Reaching to different directions in the sitting position (to strengthen leg muscles) *   | -0.066 | 0.444 | —              | —     | —       | —        | —                 | —          |
|   | Stretching the gastrocnemius and soleus muscles in a standing position   | 0.6    | 0.866 | 14             | 6     | 5       | 0        | 0                 | 4.36       |
| Sitting to standing, walking exercises  | Cycling on a stationary bike (if available) *  | 0.2    | 0.733 | —              | —     | —       | —        | —                 | —          |
|   | Standing from a sitting position on a chair  | 1      | 0.955 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
|   | Going up and down the stairs   | 0.6    | 0.933 | 17             | 6     | 1       | 1        | 0                 | 4.56       |
|   | Walking forth and back and sideways  | 1      | 0.933 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
|   | Walking around an object or from an obstacle, on a soft surface such as a carpet   | 0.6    | 0.822 | 17             | 4     | 4       | 0        | 0                 | 4.52       |
|   | Carrying an object while walking, carrying an object while walking on an obstacle *  | 0.066  | 0.862 | —              | —     | —       | —        | —                 | —          |
|   | Lateral bending of the knee and hip while lying on the unaffected side   | 0.733  | 0.888 | 20             | 4     | 1       | 0        | 0                 | 4.76       |
|   | Bridge exercise  | 0.733  | 1     | 18             | 7     | 0       | 0        | 0                 | 4.72       |
|   | Lower limb crossover (lifting and bending one leg and dropping it on the other leg and reopening and repeating with the other leg) *   | -0.2   | 0.799 | —              | —     | —       | —        | —                 | —          |
|   | Slipping the heel (bending the knees and then sliding the heel until the lower limb is flat and slipping again until it bends and then the other one)  | 1      | 0.955 | 22             | 0     | 0       | 3        | 0                 | 4.64       |
|   | Lying down on the side to sit down (lying down on the unaffected side, pressing the elbow and hand on the floor or bed, and sitting and hanging the feet from the edge of the bed)   | 1      | 0.866 | 19             | 3     | 0       | 3        | 0                 | 4.52       |
| Static sitting balance (sitting for 30 s in a balanced position on both hips (on the chair), changing the weight to the pelvis by lifting one leg while sitting on a chair for 5 s and then the opposite leg) | 1  | 0.866  | 19    | 6              | 0     | 0       | 0        | 4.76              |            |

(Continues)

TABLE 2 (Continued)

| Group  | Functional requirement  | CVR   | CVI   | Strongly agree | Agree | No idea | Disagree | Strongly disagree | Mean score |
|--|---|-------|-------|----------------|-------|---------|----------|-------------------|------------|
|  | Dynamic sitting balance (bending diagonally towards the stronger leg with hooked hands and then raising and stretching the hands to the affected side and repeating the movement for the opposite side) | 1     | 0.866 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
| Improve control while standing   | Standing behind a table and moving the lower limb to the sides using the hip joint abduction  | 0.733 | 0.888 | 20             | 4     | 1       | 0        | 0                 | 4.76       |
|  | Standing in a tandem position and touching an object on the ground *  | 0.2   | 0.644 | —              | —     | —       | —        | —                 | —          |
|  | Standing in a marked area, touching the floor in the front, side, and behind the standing area with one foot and then repeating the same with the other foot.   | 0.733 | 0.866 | 17             | 0     | 3       | 2        | 3                 | 4.04       |
|  | Lifting an object from the floor and then giving it to another person. *  | 0.333 | 0.733 | —              | —     | —       | —        | —                 | —          |
|  | Touching the front step regularly with the toes. Then touching and lifting a paper glass without any deformation. *   | -0.2  | 0.511 | —              | —     | —       | —        | —                 | —          |
|  | Throwing the ball to another person and catching the ball thrown by him/her **  | 0.6   | 0.9   | 17             | 3     | 0       | 5        | 0                 | 4.28       |
|  | Standing on one leg   | 0.6   | 0.933 | 17             | 6     | 2       | 0        | 0                 | 4.6        |
| Upper limb Rehabilitation  | Heel-to-toe style walking (in the next step, the front foot's heel sticks to the big toe of the back foot, and this cycle continues). **  | 0.733 | 0.866 | 20             | 1     | 1       | 0        | 3                 | 4.4        |
|  | Sitting behind the table and stretching arms and shoulders to lift a distant object   | 0.733 | 0.911 | 20             | 4     | 1       | 0        | 0                 | 4.76       |
|  | Positioning of the affected shoulder forward while lying down and returning to the original position  | 1     | 0.911 | 22             | 0     | 3       | 0        | 0                 | 4.76       |
|  | Moving the shoulder up and down and rotating the shoulder joint   | 0.6   | 0.866 | 19             | 5     | 1       | 0        | 0                 | 4.72       |
|  | Weight-bearing while sitting on the floor by the opening of the bent affected elbow to strengthen the elbow and shoulder muscles  | 0.733 | 0.866 | 17             | 8     | 0       | 0        | 0                 | 4.68       |
|  | Lying down in a supine position and flexing and extending the affected elbow  | 0.6   | 0.866 | 19             | 6     | 0       | 0        | 0                 | 4.76       |
|  | Lifting and moving objects (such as books) in different sizes on the shelves *  | 0.333 | 0.755 | —              | —     | —       | —        | —                 | —          |
|  | Opening and closing bottle caps *   | 0.066 | 0.8   | —              | —     | —       | —        | —                 | —          |
|  | Picking up clothespins and placing them on a horizontal or vertical bar **  | 0.733 | 0.9   | 17             | 8     | 0       | 0        | 0                 | 4.68       |
|  | Collecting coins off the surface of a table *   | 0.333 | 0.666 | —              | —     | —       | —        | —                 | —          |
|  | Spooning into a cup full of water and pouring water from one cup to another *   | 0.2   | 0.866 | —              | —     | —       | —        | —                 | —          |
|  | Turning cards over *  | 0.333 | 0.688 | —              | —     | —       | —        | —                 | —          |
|  | Positioning of the hands in a supine (palms facing up) and prone position (palms facing the ground) and repeating that **   | 0.733 | 0.866 | 17             | 7     | 1       | 0        | 0                 | 4.64       |
| Placing the palm on the table and moving the wrist side to side (in more advanced methods, the patient can place a towel under the forearm and hold objects with his/her hands and perform the movement) | 0.733   | 0.866 | 17    | 8              | 0     | 0       | 0        | 4.68              |            |

(Continues)

TABLE 2 (Continued)

| Group                      | Functional requirement   | CVR    | CVI   | Strongly agree | Agree | No idea | Disagree | Strongly disagree | Mean score |
|----------------------------|--|--------|-------|----------------|-------|---------|----------|-------------------|------------|
|                            | Bending and opening the wrist joint in the supine and prone position   | 0.733  | 0.866 | 20             | 5     | 0       | 0        | 0                 | 4.8        |
|                            | Active wrist stretching using small weights *  | 0.2    | 0.644 | —              | —     | —       | —        | —                 | —          |
|                            | Internal and external rotation of the shoulder joint with the use of a rubber band to create resistance **                       | 0.733  | 0.866 | 20             | 1     | 4       | 0        | 0                 | 4.64       |
|                            | Moving the joints of the fingers with small elastic bans   | 1      | 0.933 | 19             | 3     | 3       | 0        | 0                 | 4.64       |
|                            | Using Constraint-Induced Movement Therapy (CIMT) to strengthen the affected upper limb (for 1 h daily)                           | 1      | 0.933 | 19             | 0     | 6       | 0        | 0                 | 4.52       |
| Lower limb rehabilitation  | Rehabilitating the ankle by moving the foot to kick a ball   | 0.733  | 0.888 | 20             | 1     | 4       | 0        | 0                 | 4.64       |
|                            | Lying down on the unaffected side and bending the affected knee, and then opening it   | 0.733  | 0.888 | 20             | 5     | 0       | 0        | 0                 | 4.8        |
|                            | Lying down in a supine position with the bent knees (45°) and then moving the bent knee side to side by moving the hip joint *   | -0.066 | 0.844 | —              | —     | —       | —        | —                 | —          |
|                            | Sitting in a chair and bending diagonally to the affected side to reduce lower limb spasticity                                   | 0.733  | 0.911 | 20             | 4     | 1       | 0        | 0                 | 4.76       |
|                            | Bending and opening the affected lower limb while standing on the affected leg to strengthen the muscles                         | 1      | 0.933 | 22             | 0     | 3       | 0        | 0                 | 4.76       |
|                            | Safe transfer, walking for a short distance with assistive devices   | 1      | 0.933 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
|                            | Ergometry of the leg, arm, or a combination of arm and leg for 20–60 min per day (three periods of 10–15 min) five days a week * | -0.466 | 0.4   | —              | —     | —       | —        | —                 | —          |
|                            | Strengthening the extensor muscles of the lower limb in the weight-bearing position  | 1      | 0.888 | 22             | 0     | 3       | 0        | 0                 | 4.76       |
| ADLs <sup>3</sup> training | Brushing training *  | 0.2    | 0.688 | —              | —     | —       | —        | —                 | —          |
|                            | Eating training  | 0.733  | 0.866 | 20             | 5     | 0       | 0        | 0                 | 4.8        |
|                            | Bathing training   | 0.733  | 0.888 | 20             | 4     | 1       | 0        | 0                 | 4.76       |
|                            | Going to toilet training   | 1      | 0.888 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
|                            | Grooming training *  | 0.333  | 0.755 | —              | —     | —       | —        | —                 | —          |
|                            | Hand and face washing training   | 1      | 0.933 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
|                            | Dressing and undressing training   | 1      | 0.933 | 22             | 3     | 0       | 0        | 0                 | 4.88       |
| Overall mean               |  | 0.610  | 0.834 |                |       |         |          |                   | 4.65       |

<sup>1</sup>DDI: Drug-drug interaction.<sup>2</sup>mm Hg: Millimetre of Mercury.

\*The repetition of some exercises in different sections is because some exercises pursue different goals and may be necessary to achieve one and unnecessary for another.

\*Removed items from the final list of requirements due to the low content validity ratio (CVR &lt; 0.49); not entering the Delphi stage.

\*\*Reviewed items returned to the experts due to the low content validity index (CVI &lt; 0.79) in the first stage. (The mentioned CVI is the final CVI after review).

\*\*\*Suggested items by some experts in the first stage which were sent to 10 experts in the review stage.

or re-stroke [69]. Therefore, it seems that, as patients receive other drugs at home and the drugs prescribed by the doctor, the critical training DDIs at the time of discharge must be done, which can prove especially beneficial in the form of a self-care software. Being familiar with DDIs can help patients and caregivers communicate quickly with their physician in case of any possible symptoms due to DDIs. According to the Cana-

dian Heart and Stroke Foundation [70], a great number of the side effects seen in people taking stroke medications can be easily controlled if they are reported to physicians by patients. Physicians can control these side effects by changing the dose of the drug, the time of taking the drug, or replacing the drug with a similar one. Therefore, knowing the side effects of the drug and reporting them to the physician immediately

can prevent serious complications. Hence, it is recommended that the functional requirements of the application include the side effects of the essential drugs prescribed for patients with stroke. In an interview with the patients, some caregivers stated that they were tired of continuing treatment after a while and did not continue. They stated that, in the educational material after discharge, it would be more beneficial to include the potential consequences of stopping treatment and encourage patients to continue their treatment, which was also approved in the Delphi stage. Considering that one out of every four stroke survivors experiences re-stroke during the first five years [71], from the physicians' point of view, treatment and control of the underlying causes of stroke (such as heart disease, hypertension, atrial fibrillation, hypercholesterolemia, and diabetes) are of particular importance, and drug treatment and lifestyle changes should be among the top priorities of these patients [72].

A similar study conducted by Smith and Pizzi [73] encourages patients to continue treatment, emphasizing that follow-up exercises in improving patient self-care is practical and necessary.

In a study using a stakeholder needs assessment, Suresh Kumar et al. [49] identified the functional requirements of a stroke care software application in four sections: more information about stroke, home exercises, functional skills training, and assistive devices. The main difference between this study and the present one is in their research methodology. In the present study, the Delphi technique was used with at least 25 experts in each group (53 in total) since probably a higher number of experts can increase the validity of the requirements. Although the generalities of the content presented in both studies seem somewhat similar, the functional requirements presented in the present study probably have a more detailed category. However, training in assistive devices was not approved by our experts for the reasons stated below.

### 4.3 | Some omitted requirements in the present study

The requirements that were not scored by the panel of experts include using splints and taking laxatives if constipation persists. The American Heart Association's scientific statement for post-stroke patients [34] recommends using laxatives to prevent and treat early constipation in patients. This item was not scored by the experts in our study and was removed from the list of requirements. According to some of the experts participating in the present study, patients with stroke use various medications and recommendations for laxatives due to other drugs may cause some DDIs. They stated that any laxatives should only be prescribed by a doctor and cannot be recommended to patients in a self-care application.

The US rehabilitation guideline for stroke [31] also recommends using splints to properly manage upper and lower limb spasms, a requirement that the expert panel of the present study rejected. Monaghan et al. [74] stated that the use of these splints as stretching interventions is suitable for limb rehabilitation

believing that the patient or therapist could use these splints. However, in a study conducted by Abzug et al. [75], it was found that poor and inappropriate splinting techniques are prevalent and occur in 93% of patients. Halanski et al. [76] also considered items such as skin damage, joint ankylosis, heat damages and burns, neurovascular hazards, and compartment syndrome as complications of incorrect splinting.

Moreover, in the present study, physicians considered performing instrumental interventions by patients or their caregivers as unacceptable due to the possibility of injuries resulting from improper use of splints for patients. It seems that splinting should be done by skilled therapists and under their supervision. The American Heart Association and American Stroke Association (AHA/ASA) [29] consider yoga and tai chi training to be helpful in improving one's balance and quality of life and reducing the fear of falling in patients with stroke.

Schmid et al. [77] also evaluated the use of yoga and Ding [78] stated the tai chi technique to improve patients' balance with stroke and found them to be useful. In the present study, these two techniques were not finally approved by experts and were thus excluded. Some experts participating in the present study argued that the reason for not approving these two techniques was the high complexity of the self-care application for users. Therefore, it can be said that although—according to experts—the existence of such techniques can help to improve balance in these patients, it may be helpful to address it in a separate and specific application.

### 4.4 | Limitations of the study

The main limitation of this study was related to the nature of patients with stroke. Some of the patients on our interview list died after being discharged from the hospital, who had to be replaced by patients with similar conditions. Moreover, some patients refused to attend the interview due to their circumstances. Instead of designing a long interview session, efforts were made to design multiple but shorter sessions where all of the patients' problems could be identified using targeted questions. Attracting the cooperation of experts was also only possible once an official letter was issued by the vice chancellor of research of the university.

## 5 | CONCLUSIONS

The highest number of approved functional requirements were related to the rehabilitation of patients' upper extremity to improve hemiparesis, ADLs performing, and their quality of life. According to the expert panel, support services for the mobile-based application, the possibility of providing alerts and reminders for patients, the possibility of communication between patients and therapists, and the possibility of receiving appropriate feedback from the therapist were added to the stroke mobile-based self-management application. Given that patients and their caregivers are the main target group for

such applications, it is recommended that a needs assessment of all stakeholders, especially the patient group, be performed in the software analysis phase. Finally, it is suggested that the stroke self-management application be designed according to the requirements stated in this study and then be implemented and evaluated using a clinical trial study. Comparison of patients' outcomes after the intervention can indicate the effectiveness of the application.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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