

Features and Quality of a Mobile Application Employed in a Speech-Language Therapy

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Abstract. This paper introduces *mLogoped*, a mobile application for delivering remote speech-language pathology (SLP) therapies. With an aim to examine quality of a *mLogoped* application, an empirical study was carried out. Participants in the study were parents of children diagnosed with SLP disorders. Data was collected with pre- and post-use questionnaire. Items in pre-use questionnaire were related to the participants' computer literacy, their experience in using mobile devices and applications, and their preferences with respect to attending online SLP therapies. After spending a week using the application, the study participants examined its quality by means of user version of Mobile App Rating Scale (uMARS) post-use questionnaire adapted to SLP domain. An analysis of collected data revealed to what extent *mLogoped* has met one subjective (perceived quality) and four objective (engagement, functionality, aesthetics, and information quality) facets of mobile quality.

Keywords: *mLogoped* · uMARS · Speech-language therapy · Mobile application · Quality evaluation · Empirical study

1 Introduction

New technologies are significantly reshaping healthcare sector and one of the fastest growing branches in Digital Health is *mHealth*, or mobile health, which denotes the practice of medicine and public health assisted by smartphones [18]. According to [9] the growth rate of use of *mHealth* smartphone applications is more than 42% in last two years with more than 259.000 applications available on the market in the year 2016. This growth is triggered by enabling mobile technologies, increasing number of smartphone users, and broad categories of applications aimed at healthcare professionals, patients and general public. While some applications are mobile versions of their printed or computer counterparts (e.g. mobile library of medical terms, mobile electronic health records), the other can assist in disease diagnosis, patient monitoring,

or provide an interface between sensors attached to the patient's body and a medical device that registers patient's health status.

Despite these encouraging numbers and trends, patients in Croatia with speech-language disorders have only a few opportunities to be digitally assisted in performing therapeutic exercises. Thus, in this paper we propose a model and architecture of a platform that enables delivery of a personalized video instructions to this specific target group. An application named *mLogoped* (abbreviation for a "mobile speech-language therapist") is developed for Android and iOS platform and is supported by RESTful [12] backend web service and web application for speech therapists. The main content of the applications are educational video lessons specifically designed in collaboration with speech therapists to help caregivers and children with pediatric speech sound disorder (dyslalia) or undeveloped speech in performing correct pronunciation of a particular sound.

The remainder of the paper is structured as follows. Brief overview of current advances in the field is offered in the next section. Evaluated mobile application is introduced in the third section. Employed research methodology is described in the fourth section. Study findings are presented in the fifth section. Concluding remarks with limitations of conducted study are provided in the last section.

2 Background to the Research

There is a broad range of health-related mobile applications which provide medical and healthcare support for health professional and everyday life: applications for medical providers; applications for medical education and teaching; specialty or disease-specific applications; applications for patients and the general public (including health and fitness applications), as well as other applications [2]. Among mHealth publishers, 56% of them identify chronically ill people as the main target group for developing disease-specific applications, followed by the health and fitness mobile applications (33%) [9]. Mobile health applications for patients and general public include wide range of domains and target groups, e.g. apps for diabetics, apps for asthmatic patients, apps for pregnant women, apps for psychiatric patients, apps for patients with speech disorders, to mention only a few.

Surprisingly, the results of the systematic mobile applications' characteristics review [19], show that tracking, although being a core function of most health applications, does not contribute to the user satisfaction as much as features that save time. Furthermore, Mendiola et al. found that users also value simple and intuitive applications which are aligned with Nielsen's findings on usability [20] and applications that provide structured information. Finally, users are keen on sharing their health data with chosen individuals. These characteristics presented the solid ground for the features of application *mLogoped* we describe in this paper.

Mobile applications for speech-language disorders also benefit from today's achievements in technology. According to Furlong [21] these applications can assist in speech therapy, increase practice time, give feedback on the accuracy of users' practice,

enhance families' engagement in therapy or strengthen the relationship between the patient and speech therapist. On top of that, children, as a specific and very vulnerable target group [23], especially benefit from often, effective and intensive therapy [22]. Furthermore, Furlong states that the use of mobile applications in an intervention can positively influence some of very important factors that affect therapy effectiveness: the therapy time could increase without the increase of time spent with therapist; practice could be performed in personal and relaxing settings; technology could increase enjoyment and motivation etc.; all of these leading to better and faster therapy results. Although there are studies confirming these hypotheses in other mHealth fields, Furlong states that evidence in using mobile applications in therapies of speech sound disorders is sparse [21].

A broad range of mHealth applications and specific domains they cover set out additional requirements regarding application development and its quality. While quality of mobile applications in general is assessed by star ratings and written feedback from the app users, those criteria are insufficient and uninformative [5]. Many researchers express concerns about the quality of health-related mobile applications, e.g. identifying poor reliability or accuracy of applications [6, 7]. Concern about the quality of mHealth applications is further underpinned by the fact that majority of mHealth publishers (51%) come from non-healthcare industries, e.g. IT and tech companies or app developers, while only 28% of publishers have healthcare background. However, 85% of developers consult to some extent (in-house or externally) with healthcare practitioners while building the mHealth applications [9].

A recent attempt to identify the most important criteria for evaluation of mobile health applications resulted in development of Mobile App Rating Scale (MARS) [8] that was later adapted to user version of Mobile App Rating Scale (uMARS) [1]. Mobile App Rating Scale was confirmed as a simple and reliable tool for assessing the quality of mHealth applications in four objective categories (engagement, functionality, aesthetics, and information quality), and one subjective category (perceived quality) dimensions of mobile quality [8]. It has also been applied to speech-language pathology (SLP) domain, in the quality assessment of the mobile apps for management of childhood speech sound disorders [21].

A mobile SLP application *mLogoped* described in this paper is developed with an aim to provide parents and their children easy, constant and accurate treatment of speech disorders at home. The application is adherent to web application *eLogoped* which was developed to evaluate the quality of video lessons employed in telerehabilitation of pediatric speech disorder (dyslalia) [4]. Video lessons were designed and developed according to the principles of Cognitive Theory of Multimedia Learning (CTML) and were further described in [3, 4, 10, 11]. Videos were implemented in a learning management system and tested with five children and their parents in the pilot study [4]. The perceived quality of video lessons was examined by a questionnaire, indicating that video artefacts were of very high quality and prepared professionally, with some less favorable aspects of the quality like visual appeal, quality of audio, or availability of video. Qualitative assessment and parent/child experience with video artefacts is described in [3].

Feedback received in our initial studies motivated us to design and develop *mLogoped* mobile application and further explore the scope of online remote speech-language treatments.

3 Mobile Application

In this section we will present a brief overview of requirements towards the functionalities of *mLogoped* platform. It will include specification of mobile application, web application and web services which stand for main software components. Software requirements presented in this section are excerpt from detailed specification which is aligned with IEEE's Software Requirements Specification Standard [13].

Purpose of the *mLogoped* platform is to enable speech therapist to deliver video lessons to their patients in a simple and convenient way. The usual procedure involves speech therapist demonstrating and explaining exercises that patients are supposed to repeat at home on a daily basis. However, patients may forget or misinterpret the given instructions and thus perform exercises in non-optimal manner. Thus, *mLogoped* is intended to ensure that instructions and explanations on exercises are delivered in a form of video lessons directly to the patients through the mobile application.

Our *mLogoped* platform is standalone and independent system. The only prerequisite is a stable internet connection necessary for mobile application to communicate with web service to fetch data and stream content. The system architecture is given in Fig. 1.

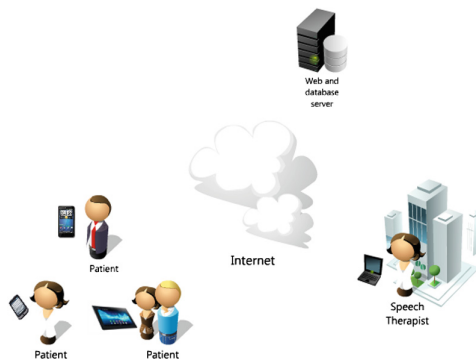


Fig. 1. *mLogoped* platform architecture

The core component of this platform is a set of web services located on the web server. These services accept and process requests from web and mobile applications, communicate with database and file servers and serve the clients with data and video streams. Web services form a *mLogoped* API (Application Programming Interface) which is based on RESTful architecture [15]. Having in mind different options of formatting the messages containing information exchanged between clients and web services [16, 17], we decided to use JSON (Eng. JavaScript Object Notation) notation

as it, in our particular case, has more advantages over other notations and formats. An excerpt from full API specification, specifying a service endpoint responsible for providing clients an information on a specific lesson is given in Fig. 2.

Method	URL
GET	api/1/lesson/{id}* *Required header attributes Authorization: Bearer {token}

Response

Status	Response
200	{ "status": 200, "data": {{ "id": 2, "title": "Lesson2", "description": "Lesson desc", "thumbnailPath": "www.url.com/thumbnail.png", "averageRating": 3.00, "videoPath": "www.url.com/video.mp4", "createdAt": "2014-11-11", }} }
404	{ "status": 404, "data": {{ }} }

Fig. 2. Excerpt from API specification

The overall functionalities of mobile and web applications, presented in the form of use cases (UCs) and their relationships is given in Fig. 3. This diagram, along with other diagrams in detailed specification is aligned with UML 2.5 specification [14].

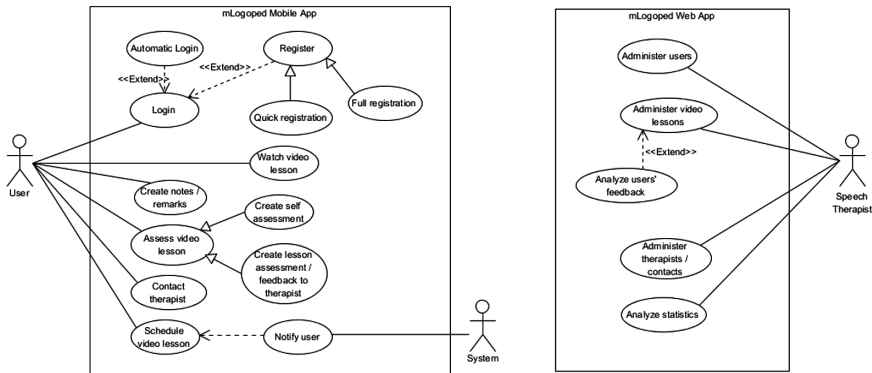


Fig. 3. Applications' use cases

Upon new video instructions or video lessons are published on the platform (UC: Administer video lessons), the users are automatically notified with pushed notifications (UC: Notify user). Through the native Android and iOS design, *mLogoped* provides users with the possibilities of registering and logging into the application (UC: Login + extension), searching, viewing and bookmarking available video content. Special attention is put on a design of functionalities available while the video lesson is being streamed and viewed (UC: Watch video lesson): users can put private remarks on the concepts presented in the lesson (UC: Create notes), can track and note their own progress (UC: Create self-assessment) and can give feedback on the lesson to their speech therapist (UC: Create lesson assessment). Finally, there are options of scheduling the lesson with automatic reminder within the application (UC: Schedule video lesson) and directly contacting the available speech therapists by phone (UC: Contact therapist).

On the other hand, apart from aforementioned UC of administering the video lessons, the speech therapist uses web application and can create, observe or block users (UC: Administer users), obtain detailed report on feedback the users gave to a particular lesson (UC: Analyze users' feedback), create or change a list of available therapists for direct contact (UC: Administer therapists) and get an insight to statistical data on lessons views (UC: Analyze statistics). However, speech therapist does not have the possibility to observe private notes or self-assessments made by users.

The screenshots representing the Android (Fig. 4) and iOS mobile application (Fig. 5) include several functionalities, namely list of available lessons, and options regarding viewing lessons and creating notes and feedbacks.

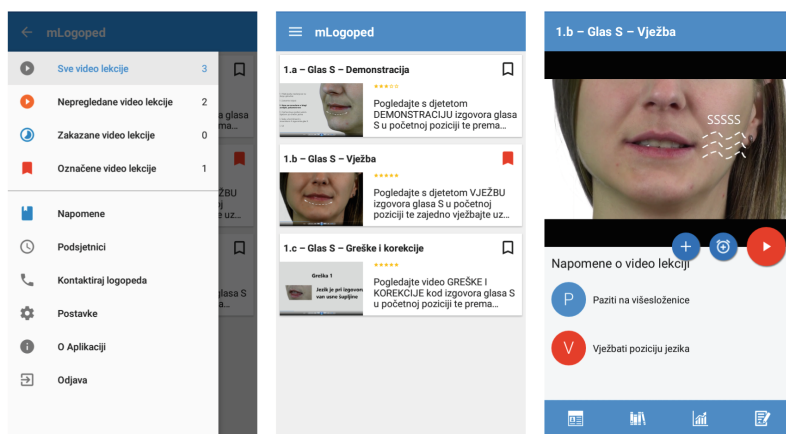


Fig. 4. mLogoped Android screenshots

According to the application classification presented in MARS questionnaire [8], above presented application directly targets and focuses physical health, while indirectly targets several categories: well-being, reducing negative emotions and stress, behavior change and goal setting. In terms of theoretical background, the following

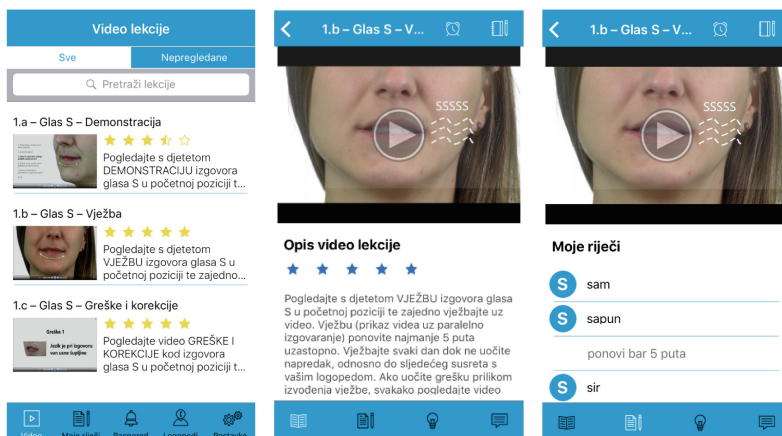


Fig. 5. mLogoped iOS screenshots

categories apply: assessment, feedback, information/education, monitoring/tracking, goal settings, advice and acceptance commitment therapy. Affiliation of the mobile applications is partially University and partially Speech Therapy Center. The platform is suitable to all age groups, although, the children under the age of 12 should be supervised when using the app. Finally, technical aspects of the application that apply include the following: password protection and login, app sends reminders, and app needs access to the Internet to function properly.

4 Methodology

Procedure. At the beginning of the study, the participants who attended speech therapy sessions with their children were informed about the quality evaluation procedure which was followed by brief introduction of a mobile application. Thereafter, the participants were asked to complete the pre-use questionnaire. The essential part of the study was interaction with a *mLogoped* mobile application designed for delivering SLP therapies in the form of educational video lessons. After spending a week using the application, the study participants examined its quality by means of the post-use questionnaire. An analysis of collected data uncovered to what degree *mLogoped* has met four objective (engagement, functionality, aesthetics, and information quality), and one subjective (perceived quality) dimensions of mobile quality.

Apparatus. Data was collected with two questionnaires. The first one was administered among participants before study took place. It was composed of 28 items related to computer literacy of respondents, their experience in using mobile applications and devices, and needs and preferences of SLP clients with respect to SLP therapies provided online. The second questionnaire was completed by study participants after their children spend one week in interaction with a mobile application. Items in the post-use questionnaire were adopted from uMARS [1] questionnaire and adapted for speech-language

application domain. It should be noted that original pool of items introduced in [1] was enhanced with an item related to the assessment of resolution and aesthetics of video artefacts and one item meant for measuring the added value of performing online SLP therapies by means of *mLogoped* mobile application. Responses to the post-use questionnaire items were modulated on a five point Likert scale (1 – strongly disagree, 5 – strongly agree).

5 Results

Participants. A total of nine parents of children diagnosed with at least one speech disorder were involved in the study. Majority (77.78%) of parents were female whereas most (66.67%) of the children were male. Respondents originated from 6 different Croatian counties where 44.44% of them were from Varaždin county. Children ranged in age from 5 to 9 years ($M = 6.22$, $SD = 1.394$). Regarding the information and communication technologies they are commonly employing, all of them are using smartphones, 55.56% is using desktop computers, 44.44% is using laptops, 33.33% is using a headset with a microphone and digital camera, 22.22% is using tablets, and 11.11% is using a microphone connected to the computer and a webcam. When frequency of using particular information and communication technologies is considered, majority (77.78%) of parents is employing computers up to one hour a day at home while 44.44% of them is using smartphones up to 2 h per day for both private and business purposes. As much as 88.89% of study participants are owners of Android-based smartphone for at least two years. Regarding the purpose of using their smartphones, 33% of study subjects are continuously sending and receiving messages via free services such as Viber and WhatsApp; 44.44% of them are often sending and receiving e-mails, reading news on various web portals and sites of interest, and taking photos; 44.44% of parents are neither rare nor often taking phone calls and making videos; 55.56% of participants are rarely using their smartphones for performing educational activities; 44.44% of respondents are rarely using short messaging service, watching podcasts on services such as YouTube and Vimeo, and employing applications for enhancing productivity such as calendar, reminders, calculator, navigation, and to-do list; 33.33% of subject is rarely playing games on their smartphones; 55.56% have never used their smartphone for the purpose of interaction on social network sites such as Facebook, Twitter, LinkedIn, and Instagram, online shopping on sites such as eBay and Amazon, internet banking, and listening to music. None of study participants has never used applications for monitoring and planning the diet (calorie counter, menu planning) nor other health-related applications. On the other hand, 44.44% of parents have rarely used applications for improving cognitive functions (brain teasers). In addition, 88.89% of respondents have never employed applications for measuring and monitoring physical conditions (e.g. weight, sleeping rhythm, etc.), applications for measuring and monitoring physical activities (e.g. heart rate, distance traveled on foot or by bicycle, etc.), applications for physical fitness improvement (workout applications), applications for assistance in correcting the health problem, and other applications as a supplement to SLP therapy. Finally, 77.78% of subjects have never used

applications for women's health and/or monitoring of pregnancy nor applications for improving the mental state (for relaxing, relieving stress, meditation, etc.).

All children were diagnosed with dyslalia disorder, 55.55% of them were visiting the speech therapist due to stuttering, and one child was diagnosed with delayed speech development disorder. A total of 44.44% of children attended SLP sessions in their hometown and additional 11.11% of patients were visiting a SLP therapist who is resident in another town of their county. Two respondents reported they were visiting two or more SLP therapists, one of whom is outside their hometown or county. Remaining 22.22% of children were attending a SLP therapist who was not resident in their home county. All parents expressed their readiness to include their children in online SLP sessions where 66.67% of them were interested to participate in it from time to time, while 33.33% of parents were interested to participate in it most of the time. Majority (77.78%) of parents were willing to include their children in online SLP sessions during and after completing the therapy. The same number of parents reported they would carry out SLP sessions by themselves and under the supervision of a speech therapist. Regarding the form of online SLP sessions, majority of respondents were interested in video demonstrations of certain speech exercises (88.89%), speech therapy exercises in the form of computer games that are available on the Web (88.89%) or can be installed on the smartphone or tablet (77.78%), and communication with the speech therapist via video link (55.55%). When the monitoring of child's progress in online SLP therapy is taken into account, all parents would like to have insight into assignments their child needs to do until the next appointment with a speech therapist, 44.44% of them would like to have an insight into therapies being carried out while 88.89% of parents would like to help in improving required skills of their child as well as employ computer games that monitor child's performance over a certain period of time.

Findings. According to the results of data analysis, 55.56% of respondents believe that *mLogoped* is moderately interesting mobile application because it was capable to engage children for up to 5 min. Since *mLogoped* has proved that it can entertain SLP patients for up to 5 min, 66.67% of study participants finds it moderately fun. As much as 44.44% of subjects reported that *mLogoped* allows basic customization of its features (e.g. sound, content, notifications, etc.). It was also discovered that 33.33% of parents think that *mLogoped* offers basic interactive features (e.g. reminders, sharing options, etc.) to function adequately. In addition, 77.78% of study subjects stated content of *mLogoped* in terms of visual information, language, and design is perfectly appropriate for targeted audience.

When performance of *mLogoped* is considered, 33.33% of parents reported that its responsiveness is timely and that it does not have technical bugs. Study findings indicate that due to its intuitiveness and simplicity, 88.89% of users was able to employ *mLogoped* immediately. It was also uncovered that 55.56% of respondents perceived *mLogoped* as easy to use and understand mobile application. Moreover, 66.67% of participants believe that gestural design is perfectly consistent and intuitive across all screens of evaluated mobile application.

Outcomes of data analysis indicate that 33.33% of subjects find *mLogoped* professional, simple, clear, orderly, and logically organized mobile application optimized to the device on which its content is displayed. Furthermore, 44.44% of study participants perceived resolution graphics and visual design of *mLogoped* as highly proportionate and stylistically consistent throughout. It was also found that 55.56% of parents believe that resolution and clarity of video artefacts offered by *mLogoped* is very high. Regarding the visual appeal, 55.56% of respondents think that *mLogoped* is, due to its seamless graphics, consistently and professionally designed mobile application.

Taking into account the quality of information, 44.44% of participants stated that *mLogoped* provides highly accurate description of its functionalities. The collected data also imply that 66.67% of parents perceived information offered by *mLogoped* as comprehensive and concise with links to more information and resources. A total of 77.78% of subjects reported that visual explanation of therapies through video artefacts is perfectly clear, logical, and correct. Regarding the credibility of evaluated mobile application, 77.78% of respondents agree that content it provides originates from legitimate and specialized source.

The data gathered from study participants revealed that 66.67% of them would recommend *mLogoped* to everyone who might benefit from its use. The same percentage of parents think that their children would use *mLogoped* at least once a month in the next one year. Study findings also revealed that 66.67% of study subjects mostly agree they would pay for using the *mLogoped*. It was also discovered that 55.56% of respondents reported that *mLogoped* is one of the better applications they have used.

A total of 44.44% of study participants strongly agree that *mLogoped* increases awareness of the importance of conducting online SLP therapies. Results of data analysis revealed that 55.56% of parents think that *mLogoped* increases extent of knowledge with respect to performing online SLP therapies. Similarly, 55.56% of respondents believe that employment of *mLogoped* encourages the creating of positive attitude towards the implementation of online SLP therapies. The same percentage of study subjects reported that using the *mLogoped* increases the level of motivation in addressing SLP disorders. It was also found that 44.44% of parents mostly agree that employment of *mLogoped* encourages users to ask for further assistance (if required) in resolving SLP disorders. In addition, study findings indicate that 66.67% of parents agree that using the *mLogoped* increases the frequency in conducting online SLP therapies. Finally, 55.56% of respondents mostly agree that employment of *mLogoped* enhances efficiency in addressing SLP disorders.

6 Concluding Remarks

The aim of this paper was two-fold: to present functionalities of mobile application *mLogoped* developed to assist in the treatment of pediatric speech disorder and to explore quality of *mLogoped* mobile application as perceived by its users. The application *mLogoped* provides parents and their children easy, constant and accurate treatment of pediatric speech disorders at home. Since the application is available anytime anywhere, it enables quick and easy access to video instructions needed to

perform accurate exercise. Furthermore, video content also demonstrates typical mistakes in position of speech apparatus, so the user (parent) can recognize them and learn how to avoid them, which accelerates a progress during treatment. Finally, a parent is more confident in performing the exercises with a child when instructions are always accessible.

By building on a basis of identified valuable characteristics of mHealth applications, along with identified important features of applications targeting speech-language and speech-sound disorders, we designed, developed and presented in this paper the architecture and functionality of *mLogoped* platform. It has three main components, consisting of web service endpoints connected to database and file servers, mobile applications for Android and iOS platform and web application for speech therapists.

Consequently, an empirical study was conducted during which data on users' experience in interacting with mobile devices and applications was collected with pre-use questionnaire whereas data on facets of perceived mobile quality was gathered by means of post-use questionnaire. The analysis of data collected with post-use questionnaire revealed pros and cons of *mLogoped* mobile application. In particular, we found that advantages of *mLogoped* are related to the appropriateness of provided content, easiness of use, clarity of visual information and credibility of offered content. On the other hand, identified disadvantages are mostly associated with some technical issues, customizability of features and lack of functionalities that would further facilitate interaction between user and application which indicated that there is still room for improvement.

As with all empirical studies, some limitations which require further examination have to be noted. The first one deals with the homogeneity of participants. Although children diagnosed with at least one SLP disorder are a representative sample of *mLogoped* users and thus their parents convenient sample of respondents in our study, outcomes of perceived quality assessment might vary if it would be evaluated by more heterogeneous group of users. The second limitation is that the findings cannot be generalized to all types of mobile applications designed for providing remote therapies except to the one involved in the study. Keeping the aforementioned in mind, study results should be interpreted with caution.

Considering there is a lack of studies on implementing SLP therapies in the form of mobile applications in general and the assessment of their quality in particular, we believe that findings presented in this paper significantly add to the extant body of knowledge thus establishing a foundation for further theoretical and empirical advances in the field. However, to draw generalizable sound conclusions and to examine the robustness of reported findings, further studies should be carried out.

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