



OPEN | I speak Tele outlines the design of a digitized dysarthria assessment

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Stroke is a leading cause of disability worldwide, leaving many survivors with chronic neurological deficits that restrict their daily activities. Telerehabilitation offers an opportunity to improve access to care, reducing travel burdens and fostering ongoing therapy in diverse settings. Speech and language telerehabilitation specifically benefits those with communication disorders such as dysarthria. However, widespread reliance on manual, paper-based documentation and subjective evaluations remains a significant challenge for remote speech and language therapy. To address this, we identified the specific requirements of various stakeholders and employed a user-centred design approach to develop a digital tool that integrates note-taking, time measurement, and audio/video recording within a single interface. By prioritizing the needs of speech-language pathologists (SLPs), researchers, and IT specialists, the resulting prototype streamlines common tasks, enhances data consistency, and delivers high usability. In testing, SLPs reported a reduction in assessment times from 50 to 35 min, while the average System Usability Scale score exceeded industry benchmarks, indicating strong acceptance. By enabling automated scoring, data export, and potential interoperability with healthcare systems, this tool fosters more comprehensive patient monitoring. Future iterations will incorporate a secure backend and support for additional assessments, potentially transforming remote speech and language therapy.

Keywords Stroke, Rehabilitation, Telemedicine, Speech therapy, Dysarthria, Speech-Language pathology

Stroke remains the second leading cause of death worldwide and is a major driver of disability¹. With demographic changes leading to an aging population, its incidence is projected to rise significantly in the coming decades¹. Although acute stroke treatments have advanced, many survivors face chronic neurological deficits that substantially affect their independence and quality of life². Patients with significant functional impairments typically receive intensive multidisciplinary rehabilitation, including speech and language therapy, in specialized neurorehabilitation clinics³.

Telerehabilitation, using communication technologies to deliver remote rehabilitation, tackles challenges such as travel logistics, high costs, and restricted access to quality care⁴. This approach enables therapy continuation after hospital discharge and supports patients in rural or remote regions⁵. Speech and language telerehabilitation, a subtype of telerehabilitation, can be administered synchronously, asynchronously, or via a hybrid model⁶. Evidence suggests that these remote interventions are feasible, safe, and can match in-person outcomes while boosting overall therapy doses^{7,8}.

Around 30–60% of stroke survivors develop communication disorders⁹. Conditions such as aphasia, apraxia, dysphagia, and dysarthria disrupt daily activities and well-being^{10,11}. Dysarthria, affecting between 26 and 44% of stroke survivors, compromises respiration, phonation, resonance, articulation, and prosody^{12–15}. Speech-language pathologists (SLPs) target various facets—articulation, voice, fluency, and swallowing—to improve function¹⁶. Yet, SLPs face critical hurdles in remote monitoring, mainly due to subjective evaluations and manual, paper-based documentation^{17,18}.

A pressing need exists for technology-driven tools that not only standardize speech and language assessments but also address the practical challenges faced by SLPs^{19–21}. In many clinical settings, evaluations rely heavily on subjective judgments and manual data entry, which can lead to inconsistencies, extended assessment times, and increased workload²². The absence of robust automated systems—capable of providing real-time, objective

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scoring and seamless data capture—restricts the ability of clinicians to monitor patient progress effectively and make evidence-based decisions²³. Although language analysis has benefited from resources such as TalkBank, the lack of analogous comprehensive databases for pathological speech means that SLPs are missing critical benchmarks for assessing and tracking patient performance²⁴. By integrating automated scoring and digital data management tools, clinicians can reduce manual tasks, minimize documentation errors, and tailor interventions more precisely, ultimately enhancing patient outcomes and workflow efficiency²⁵.

Recently developed digital tools all migrate traditional speech-language assessments online, offer automated scoring or analytics, and demonstrate initial validation across diverse age groups^{26–30}. However, none of these platforms specifically target post-stroke dysarthria: they lack specialized modules for articulatory precision, real-time motor speech control assessments, and stroke-adapted task designs needed for objective dysarthria evaluation in stroke survivors^{31,32}. Furthermore, established digital tools often suffer from critical limitations: many provide for only cumbersome user experience, limited remote assessment capabilities, lack integrated automated scoring, or force clinicians to navigate multiple disjointed platforms^{19,33–35}. Data fragmentation across multiple platforms further hampers remote speech-language pathology, leading to inefficiencies and lost opportunities for integrated care^{35–37}. These weaknesses translate into extended documentation times, inconsistent data capture, and ultimately lack of uptake in daily clinical practice. To combat this, our study aims to develop a digitized assessment tool that automatically captures assessment data. By minimizing manual entry and siloed record-keeping, we seek to reduce documentation workload and improve data consistency. Simultaneously, a needs-based interface designed to shorten assessment time and enhance usability is proposed. Automated summaries of assessment scores will streamline SLTs' workflows and cut reliance on manual calculations, while voice-recording options will enable future data analytics for deeper clinical insights^{38,39}.

To achieve these objectives, this study adopted a user-centred design (UCD) framework. UCD involves ongoing user participation throughout development to ensure that final products align with real-world requirements. We investigated the key stakeholder requirements on a remote speech and voice assessment tool, addressing two sub-questions:

What features and functionalities do SLPs and other stakeholders require?

How do stakeholders perceive the tool's usability, effectiveness, and overall utility?

By answering these questions, our work aims to advance innovative tools that enhance the accessibility and quality of speech-language therapy—particularly crucial for stroke survivors and others with significant communication needs.

Methods

User centred design methodology

This formative user study followed the ISO 9241 – 210:2019 User-Centred Design (UCD) framework^{40,41} augmented by an additional prototype development phase to facilitate iterative user involvement. The five core phases were:

- Understand and Specify the Context of Use.
- Specify the User and Organizational Requirements.
- Produce Design Solutions.
- Develop Prototype.
- Evaluate Prototype Against Requirements.

All procedures adhered to relevant guidelines and regulations. The study was juristically verified by the Ethics Commission of Northwestern and Central Switzerland (EKNZ; Req-2024-00103). All participants provided written informed consent, including consent for publication of de-identified data. The sample size followed ISO Ergonomics of human-system interaction and classical empirical research guidelines^{42–45}.

Participants and setting

Study participants included six speech-language pathologists (SLPs) with experience in online or inpatient neurorehabilitation, one SLP researcher specializing in telerehabilitation, two clinical IT specialists, and two lay users. SLPs were required to be actively delivering rehabilitation services, researchers to be employed in telerehabilitation-oriented institutions, IT experts to be engaged in clinical support or telehealth solutions, and lay users to not be engaged in SLP practice or research. Detailed demographic information is presented in Table 1.

Participants	Region	Age (Mean +- Std) / Range	Gender	Field of Work	Work experience (years)
Speech and language pathologists (<i>n</i> = 6)	Europe (5) Arabic Peninsula (1)	38.5 +- 12.9	5 Females, 1 Male	Online Neurorehabilitation <i>n</i> = 5 Inpatient Neurorehabilitation <i>n</i> = 1	Mean : 9.8, Range 5–25
Researcher (<i>n</i> = 1)	Australia (1)	52	1 Females	Investigations into remote rehabilitation spanning various domains of speech-language pathology	20
IT-specialists	Europe (2)		2 Males	Clinical IT	Range 5–9
Lay users	Europe (2)	Range 34–45	1 Female, 1 Male	Health Research, other than speech and language pathology	

Table 1. Participant characteristics. SLP – speech and language pathologist; IT – information technologist.

Data collection and analysis

Sampling strategy

A purposive sampling method was employed, predicated on the assumption that each participant would offer unique insights⁴⁶. Because participants' roles were not interchangeable, sample size was guided by data saturation rather than statistical power analysis⁴⁶.

Qualitative data collection

Qualitative data

To capture user needs and workflows for a tele-SLP application, data were gathered through:

- Focus Group Interview (1 h): Three online SLPs discussed online assessment challenges, device preferences, and usability issues.
- Individual Interviews (1 h each): One SLP researcher (requirements for data collection, collaboration features) and two clinical IT professionals (integration, compliance, performance, cost).
- Work Shadowing (two sessions): Observations with one online SLP and one clinical SLP focused on internet stability, audio/video quality, and ancillary tools used.

All sessions were audio-recorded and transcribed; relevant themes were extracted using MAXQDA to identify user, organizational, and technical needs.

Development process

Understand and specify the context of use

Focus group and expert interviews, both of one hour duration, were conducted via Microsoft Teams, recorded with noScribe (an AI-based, open-source transcription tool), and analysed in MAXQDA. Work shadowing sessions were conducted via customized Telerehab applications and onsite in a neurorehabilitation clinic, each lasting three hours. We identified user goals, tasks, resources, and environment constraints, then mapped current (“as-is”) and potential (“to-be”) processes with Business Process Model and Notation (BPMN). User goals, tasks, resources, and environment constraints were identified and then mapped as current (“as-is”) and potential (“to-be”) processes using BPMN. Three online SLPs participated in the focus group, one researcher and two IT professionals in the single expert interviews, and one online plus one clinical SLP in the work shadowing sessions.

Specify the user and organizational requirements

User needs tagged in MAXQDA were converted into structured user requirements (e.g., “The <user group> needs to know <information>...”). Functional vs. non-functional requirements were established by evaluating feasibility and importance. Needs met by existing systems or beyond the prototype’s scope were excluded; remaining requirements formed use cases defining tasks and expected outcomes.

Prototype design

A mid-fidelity mock-up was developed in Figma, incorporating key features. Iterative feedback from an online SLP and two lay users addressed usability issues and refined the interface.

Develop prototype

Building upon the developed Figma design, an initial web application prototype was implemented using *React.js*, with *Node.js* and *npm modules* managing dependencies. Our web application uses *React.js*, a popular library for building user interfaces. It relies on *Node.js* to run JavaScript on the server side and *npm modules*—small, reusable code packages—to add extra features. Git version control was integrated to track development progress and facilitate collaboration. The prototype followed a component-based architecture, *leveraging React hooks*, simple functions that let different parts of the page keep track of data and respond to changes for local state management and a context provider for global state sharing. To ensure accessibility and continuous feedback from stakeholders, the production build was deployed on *GitHub Pages*, enabling rapid updates and broader accessibility.

Evaluate prototype against requirements

The iSpeak-Tele prototype was evaluated through a structured three-stage process aimed at verifying essential functionality, identifying usability gaps, and assessing overall user satisfaction. The first stage, *Use Case Testing*, ensured that core features—such as ID format validation, note saving, and audio/video recording—functioned correctly and aligned with predefined requirements. Secondly, *Lay User Testing* was conducted with two lay users, who explored the prototype freely to identify interface ambiguities and potential usability issues; minor text and interface adjustments were made based on their feedback.

Finally, *Expert User Testing* involved five SLPs over two iterative cycles (four tested version 1.0; all five tested version 1.1). Participants received a customized questionnaire, patient information (English/German), a user manual, and a usability test form. SLPs completed real or simulated patient sessions, providing qualitative and quantitative feedback through open questions and ratings on 5 point Likert scales (1 = strongly disagree, 5 = strongly agree), focusing on general usability, features & functionalities, the FDA-2 assessment, and patient interaction, and filling out the System Usability Scale (SUS) (suppl Tables 1, and 2)⁴⁷. In one instance, an SLP compared the time required to assess a patient with and without the prototype, indicating possible efficiency gains.

Results

Understand and specify the context of use

Focus groups, individual interviews, and work-shadowing sessions revealed a predominance of manual, paper-based workflows among SLPs. Commonly cited challenges included:

- Long Assessment Times: Manual documentation and scanning of notes.
- Connectivity and Privacy Issues: Unstable internet disrupting online sessions, legal constraints on recording.
- Tool Fragmentation: SLPs often used multiple, disjointed platforms for therapy tasks.

SLPs, researchers, and IT professionals converged on the need for streamlined documentation, a user-friendly interface, and robust data-security measures.

Specify the user and organizational requirement

A total of 34 user needs emerged, showing minimal overlap across groups:

- 7 needs from IT professionals.
- 9 from the researcher.
- 15 from SLPs.
- 2 overlapping between researcher and SLPs.
- 1 overlapping between researcher and IT professionals.

Six were excluded (five already covered by existing systems, one deemed technically infeasible), leaving 28 needs (supp.Table 3). From these, the team derived 40 functional requirements—20 of which were deferred to future iterations due to data dependency, low priority, additional backend demands, frontend-only constraints, redundancy, security concerns, assessment validity issues, or data retention policies. The remaining 20 functional requirements are summarized in Table 2, alongside seven non-functional requirements (Table 3). These informed

Req. ID	UN. ID	Title / Area	Description	Feasibility	User priority	Total score (feasibility + user priority)
FREQ1	UN8	patient data register	With the system, the SLT can input the patient ID and case ID at the beginning of a session.	4	4	8
FREQ2	UN8	patient data register	With the system, the SLT gets an error when the inputted patient ID does not have seven characters.	4	4	8
FREQ3	UN8	patient data register	With the system, the SLT gets an error when the inputted case ID does not have seven characters.	4	4	8
FREQ4	UN13	additional patient information	With the system, the SLT can input additional patient information before the beginning of the assessment.	4	3	7
FREQ7	UN5	take notes	With the system, the SLT can input his notes during the assessment.	4	4	8
FREQ8	UN5	take notes	With the system, the SLT can input general notes independent of the assessment.	4	4	8
FREQ10	UN3	multiple windows	With the system, the SLT can open a separate window during the session, specific to display to the patient.	4	3	7
FREQ11	UN3	multiple windows	With the system, the SLT can place this separate window on a different screen during the session so that only one of them can be shared with the patient.	4	3	7
FREQ12	UN10	scoring	With the system, the SLT can select a score [a, b,c, d,e,] (in the case of FDA-2) during the assessment.	4	4	8
FREQ13	UN7	time measurement	With the system, the SLT can select a timer during the session.	3	3	6
FREQ14	UN7	time measurement	With the system, the SLT can start the timer when the timer has been selected.	3	3	6
FREQ15	UN7	time measurement	With the system, the SLT can stop the timer when the timer once it has been started.	3	3	6
FREQ16	UN7	time measurement	With the system, the SLT can see the time elapsed between start and stopping the timer, after pressing the stop button.	3	3	6
FREQ17	UN7	time measurement	With the system, the SLT can save the measured time in the notes.	3	3	6
FREQ18	UN2	recording	With the system, the SLT can press a button to record speech samples from users anytime during the session.	2	4	6
FREQ19	UN1	recording	With the system, the SLT can press a button to record speech samples from users during the assessment.	2	4	6
FREQ20	UN1	recording	With the system, the SLT can press a button to stop recording when the recording is running.	2	4	6
FREQ24	UN27	store data locally	With the system, the data (video, scoring, etc.) can be saved on the local device after finalizing the assessment.	3	4	7
FREQ26	UN32	data transfer	The system must be capable of creating a CSV-format, containing Case ID, patient ID, date, and scores.	4	4	8
FREQ35	UN11	visualization	The system can automatically generate a graph depending on the scores inputted by the SLT.	3	4	7

Table 2. Functional requirements.

Req. ID	UN-ID	Area	Description
NFREQ1	UN3	usability	a non-distracting patient view: no bright colours
NFREQ2	UN3	usability	the ability to work on a desktop computer/laptop with two screens.
NFREQ3	UN34	usability	can be used for android and apple users
NFREQ4	UN16	usability	only for the use together with a SLT (synchronous)
NFREQ5	UN17	usability	clear, high quality instructions
NFREQ6	UN22	validity	assessment should involve spontaneous speech and should be standardized
NFREQ7	UN33	compliance	comply with data security and data protection regulations for health data

Table 3. Nonfunctional requirements.

UCNr	Name	Short description	Trigger	Precondition	Outcome	Steps	UN-Nr.	Functional requirements
UC1	recording assessment	The system must be able to video record the patient during assessment.	The SLT wants to do an assessment.	The SLT has started the application and has selected the patient and the topic.	The recording is made and can be replayed for the scoring purpose.	1. press a button to start 2. press the same button to stop	UN1	FREQ19, FREQ20
UC2	recording session	The system must be able to video record the patient anytime during the session.	The SLT wants to do a recording of a spontaneous speech.	The SLT has started the application and has selected the patient.	The recording is made and can be replayed in a later session.	1. press a button to start 2. press the same button to stop	UN2	FREQ18
UC3	multiple windows	The system supports multiple windows to be opened, with different a view for the patient and SLT.	The SLT want to share his screen in order to show something to the patient.	The SLT has started the app, entered the patient's data and started the assessment.	The SLT has two windows open, one where the SLT makes notes and the other one to share with the patient.	1. click on a button "patient view" 2. a second screen opens with the same assessment information but without the SLT's notes	UN3	FREQ10, FREQ11
UC4	take notes during assessment	The system must allow the user to take notes specific to an assessment task.	The SLT wants to add a note to the assessment.	The SLT has started the app, entered the patient's data, started the assessment.	The note is saved for the specific task.	1. click on a button "notes" 2. write the note 3. click save	UN5	FREQ7, FREQ8
UC5	take notes during session (independent of assessment)	The system must allow the user to take notes specific for an assessment task.	The SLT wants to add a note to the session.	The SLT has started the app and entered the patient's data.	The note is saved for the patient.	1. click on a button "notes" 2. write the note 3. click save	UN5	FREQ7, FREQ8
UC6	measure time	The system must allow the user to measure the time for a specific assessment task.	The SLT wants to measure the time the patient needs to complete a task.	The SLT has started the app, entered the patient's data, started the assessment and selected a task.	The SLT can see the time required, the time is saved in the notes.	1. click on the timer 2. start the timer with "start" 3. stop the timer with "stop" 4. save	UN7	FREQ13, FREQ14, FREQ15, FREQ16, FREQ17
UC7	measure time	The system must allow the user to measure the time anytime during the session.	The SLT wants to measure the time.	The SLT has started the app and entered the patient's data.	The SLT can see the time required and the previous time measurements of the patient, the time is saved inside the notes.	1. click on the timer 2. start the timer with "start" 3. stop the timer with "stop" 4. save	UN7	FREQ13, FREQ14, FREQ15, FREQ16, FREQ17
UC8	additional patient information	The system has fields (true/false) for additional information, which can be filled an the beginning of the session.	The SLT wants to add any information that can affect the assessment process.	The SLT has started the app and entered the patient's data.	The fields are selected and the data is sent to the dashboard with the notes.	1. click checkbox for "hearing" 2. save	UN13	FREQ4
UC9	input patient's data	The system has the fields Case-ID and Patient-ID where Case-ID and Patient-ID can be entered and checked for length.	The SLT wants to start a session with a patient.	The SLT has the Case-ID and Patient-ID from the hospital available.	Case-ID and Patient-ID can be entered and checked for correctness of length.	1. enter the Case-ID 2. enter the Patient-ID 3. press start 4. if correct: the session has started 4. if incorrect: show "error: length not correct."	UN8	FREQ1, FREQ2, FREQ3

Table 4. Use cases defined for final tests of the functional requirements.

nine use cases (Table 4), each aligning with the prototype's initial design objectives. These furthermore informed the decision on the digitized assessment. SLPs preferred a web based synchronous application over a tablet based or asynchronous solution. The FDA-2 was chosen due to the inclusion of free-speech tasks, its wide distribution, and therapist-administered format⁴⁸.



Fig. 1. Figma page design for FDA-2 cough reflex task with instruction text, grading, and navigation menu reflecting SLP feedback on its clear layout and high usability.

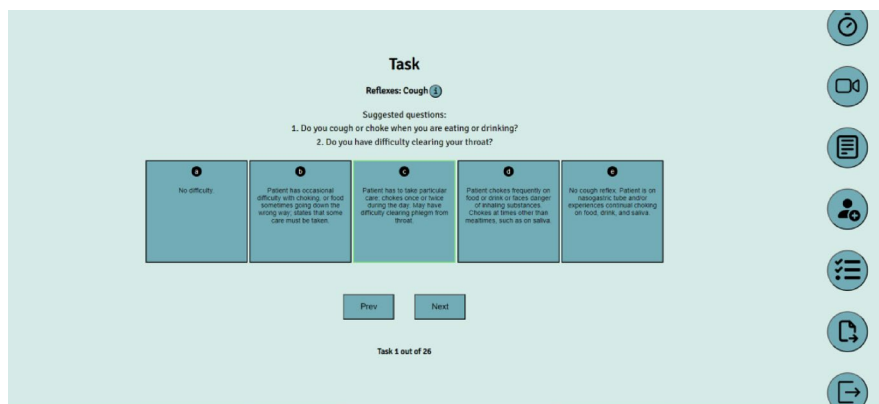


Fig. 2. React Prototype of FDA-2 cough reflex task with instruction text, grading, and navigation menu demonstrating the intuitive feature design.

Produce design solution

Based on the refined requirements, a Figma mock-up was created (Fig. 1). A fixed sidebar provided constant access to tools (stopwatch, recording, note-taking) across all pages, supporting key tasks:

- Patient Data Information (patient/case IDs).
- Influencing Factors (FDA-2-specific variables).
- Task Layout for FDA-2 (main assessment flow).
- FDA-2 Intelligibility Task (patient speaks, SLP interprets).
- Patient Window (plain display for patient prompts).
- Note-Taking (sidebar module).
- Stopwatch (timing tasks).

The clickable prototype underwent two feedback cycles. Early feedback led to adjustments in logo placement, hover icon information, and instruction text structure (on-page vs. info button). The intelligibility task was revised to include a short training phase (two words) before the primary 10-word set, with the option for SLPs to edit entries afterward. Having resolved minor design issues, the team proceeded to the development stage (Figs. 1 and 2).

Develop prototype

A front-end-only React.js application was built to store user input locally and enable end-of-session data exports (PNG, CSV, WAV, WEBM). This offline approach addressed immediate privacy concerns and simplified early deployment.

Component-based architecture

The application was divided into modular React components (Fig. 2), illustrated in UML diagrams and the application workflow (supp.figure 1, 2, and 3), meaning each part of the page is a self-contained, reusable piece that makes development faster and more reliable. Key component groups included Layout & navigation, session setup & patient data, assessment execution, and utility tools & data export.

This architecture also facilitates easy updates to assessment-specific texts (e.g., FDA-2) and supports multilingual functionality. With a focus on accessibility, the website is designed to be fully responsive for both desktop and laptop users.

Deployment and documentation

To facilitate testing in clinical environments, the application was containerized using Docker, ensuring secure local hosting and easy integration into existing IT infrastructures. A README file, including a concise user guide, assisted developers and testers in configuring and navigating the application. Given that typical SLP hardware setups favour desktop usage, full mobile optimization was not prioritized.

Evaluate prototype against requirements

Testing overview

After verifying use-case functionality (e.g., ID format checks, note saving, AV recording), two lay users tested the prototype without identifying major bugs. Minor wording and button-placement changes were adopted prior to expert user testing. Expert users (SLPs) received a reference manual and completed a questionnaire after their sessions. A temporary adjustment was also made to accommodate variable ID lengths (use case 9). Patients did not participate during since only SLPs interact with the front end at this stage.

Expert user testing cycles

First Cycle (v1.0).

- Participants: Four online SLPs testing for ~48 min each. One used a real clinical patient (offline), the others simulated an online session with a stand-in patient.
- Issues & Requests ($n = 31$): Backend needs (e.g., pausing assessments, longitudinal comparisons), single-screen or mobile adaptation, additional language options, layout adjustments (e.g., graph contrast), missing or unclear app or user manual details, recording compatibility issues on Firefox, and text reduction (deferred for assessment validity).
- Implemented: “Download All” button, stopwatch-to-notes integration, an intelligibility-task restart button, minor assessment-flow tweaks.

Second Cycle (v1.1).

- Participants: Five SLPs (two repeated from v1.0 for direct comparison).
- Issues & Requests (16): Ongoing backend needs (file storage, pausing, analysis integration), expanded assessment support, text reduction requests (still pending SLP consultation).
- Implemented: Task counter, recording pause function, .wav encoder (Praat compatibility), various minor bug fixes (e.g., window-size display issues).

User ratings

Mean ratings for meeting expectations rose from 4.25 in V1.0 to 4.8 in V1.1, while design appeal and navigation both improved from 4.25 to 4.6. Core features—stopwatch, note, recording, and patient window—were rated highly useful (4.6–5.0) and intuitive (4.0–5.0) in V1.1. The FDA-2 assessment workflow remained easy to use (4.6 vs. 4.75) and preference for the digital version increased from 4.25 to 4.6, supporting the prototype’s promise for streamlined, efficient assessments (Table 5).

SUS results

Four SLPs tested v1.0 (mean SUS: 87.5) and five tested v1.1 (mean SUS: 82.5), for a combined 84.7, which is above the standard benchmark of 68 (supp.Tables 1, and 4), and highlighted by the following exemplary quote from one SLP:

Keep most of it. It is clean and easy to use.

Minor score differences likely reflect sample size rather than true changes in usability, given minimal workflow alterations between versions.

The SLPs reported a reduction in total assessment time from 50 min (without the app) to 35 min (with the app). Though the sample size is limited, this suggests potential efficiency gains, which is highlighted by an example quote from one SLP:

Clear instructions, only stuff that you need is shown, all options are useful, graphs are made automatically and can be saved so I can upload it into patient system - huge timesaver!

Discussion

This study tackled the lack of digitized, standardized tools for remote speech and language assessments—a pressing issue given the growth of telerehabilitation and the persistent reliance on manual, paper-based methods^{17,18,35,37}. We found that SLPs require intuitive, integrated functionalities (e.g., time measurement,

	The app met my expectations	The design of the app (colors, fonts, layout) was appealing and professional.	The navigation within the app was easy and logical.	The stopwatch is a useful feature.	The note is a useful feature.	The recording is a useful feature.	The patient window is a useful feature.	The stopwatch was intuitive to use.	The note was intuitive to use.	The recording was intuitive to use.	The patient window was intuitive to use.	The assessment of FDA-2 was easy and logical with the application.	I prefer the digital version of the FDA-2 to the analog version of FDA-2.
v1.1	4.8	4.6	4.6	4.8	4.8	5	4.8	5	4.8	4	4.4	4.6	4.6
v1.0	4.25	4.25	4.25	4.75	5	4.75	5	4.75	4.75	4	4	4.75	4.25

Table 5. Expectations, design properties, core-features. Assessment workflow and user preferences measured (1 = strongly disagree, 5 = strongly agree).

note-taking, automated scoring) while researchers and IT professionals emphasize secure data handling and interoperability. Overall, stakeholders perceived the prototype as highly usable and effective—reflected in its strong SUS rating—indicating that a carefully tailored, user-centred solution can meet the demands of remote speech assessment.

By developing a frontend application focused on the FDA-2 assessment, we addressed core functional requirements such as patient data register, take notes, time measurement, recording, store data locally, data transfer, and visualization, alongside key use cases like recording assessment, recording session, multiple windows, and input patient's data that emerged from our user-centred design (UCD) process. Specifically, the application supports synchronous online therapy by enabling SLPs to record audio/video, measure time, and maintain concise session notes, thereby reducing manual documentation. Thus, the prototype represents an advance at various levels in rapidly evolving speech and language telerehabilitation, particularly regarding its synchronous and integrated approach. These outcomes align with the global push to improve the quality of life for stroke survivors through accessible telerehabilitation^{1,4}.

A core strength of our study is the rigorous UCD approach, directly informed by the diverse needs of SLPs, researchers, and clinical IT professionals. Iterative input from clinicians led to design features such as error checks for patient data (patient data register), a separate window for patient display (multiple windows), and one-click recording at any time (recording). These integrated functions helped reduce assessment time from 50 to 35 min and yielded a mean System Usability Scale (SUS) of 84.7—well above the industry average of 68 and indicative of high usability—highlighting both efficiency gains and high user acceptance. This echoes prior calls for integrated digital solutions that streamline remote speech therapy while maintaining effectiveness^{19,33–36,49,50}.

SLPs consistently emphasized time measurement, note taking, and automated scoring (under scoring) as central to easing their workload. By combining these in a single interface, the prototype demonstrably improved workflow efficiency—one SLP recorded a 15-minute reduction in assessment time. Although further validation with larger sample is needed, these indications suggest that digitized tasks can significantly reduce administrative overhead, which is especially valuable in tele-SLP settings^{7,8}.

Meanwhile, researchers highlighted the importance of automated scoring, data anonymization, and exchangeability to support broader analyses, while IT specialists prioritized secure data handling compliant with health-data regulations. Although the current prototype takes into account many security issues by storing data locally on the device, a robust backend is crucial for real-time data processing, comprehensive interoperability, and adherence to regulatory requirements^{23,24,51}. This will allow data to flow seamlessly to clinical systems, safeguarding patient information under frameworks like GDPR, MDR, and ISO 27,001/27,002^{5,17}. Furthermore, those needs indicate the potential for data ecosystem to serve as a connection and analysis hub, integrating various data streams and supporting clinical decision making⁵¹. They likewise indicate the potential for seamless data sharing with electronic health record (EHR) systems and national rehabilitation platforms, enabling clinicians to access patient progress directly within their healthcare workflows.

To support a wider range of speech and voice disorders, additional language options, further visualisation features and expansion to other assessments beyond FDA-2 have been requested^{9,12,37}. In addition, amassing labelled audio data over time could lead to robust pathological speech datasets, advancing automated diagnosis models and complementing existing linguistic repositories such as TalkBank^{24,38,39,52,53}.

Although participants typically preferred synchronous, supervised sessions, future iterations might incorporate semi-supervised or self-assessment modes for less complex patient needs, especially where mobility or scheduling is limited⁵⁴. Given that user requirements evolve, ongoing multi-stakeholder collaboration—including potential early engagement with policy-makers—remains pivotal for balancing advanced features (e.g., full automation, broader assessment coverage) with practical clinical and regulatory constraints. Future iterations will include tests with people with stroke dysarthria to gain more ecologically valid insights from their perspective, while their involvement was kept minimal at this development stage since only therapists interact with the application. Furthermore, future iterations may include a wider selection of possible assessments. For the first iteration the FDA-2 was chosen based on users preferences and the existing gap in digitized assessments, specifically the inclusion of free-speech tasks, its wide distribution, and therapist-administered format^{31,32}.

This formative evaluation involved six SLPs—sufficient for early-stage usability debugging but under-powered for hypothesis-driven statistics. In the next development cycle we will introduce a secure backend for data storage and user management, add automated scoring and objective voice-analytics that return phenomenon's, fluency and other speech metrics, and then conduct a powered confirmatory study with 20–25 SLPs and information on patients specific conditions and dysarthria severity when those are included in testing. That trial will test pre-specified hypotheses on diagnostic accuracy, efficiency gains and user satisfaction. Consistent with ISPOR ePRO migration guidance, we did not repeat a reliability study here because the underlying scoring algorithm remains manual and unchanged;⁵⁵ formal equivalence testing is planned once automated scoring is implemented.

Conclusion and outlook

In summary, our UCD-driven, frontend-first prototype successfully meets critical requirements for patient data capture, timekeeping, recording and note-taking, among others, thereby reducing the administrative burden for SLPs and achieving high acceptance scores in remote speech therapy settings. The next decisive step is integrating a secure backend to support real-time data analysis, automated scoring, and seamless interoperability with existing healthcare systems. Such enhancements will help overcome the fragmentation in patient data, promote evidence-based decision-making, and foster a more robust ecosystem for speech pathology research^{24,36,37}. Ultimately, expanded, digitized assessments stand to improve tele-SLP services for an aging population of stroke survivors and other individuals who depend on accessible, high-quality speech therapy^{1,2}.

Data availability

The code and data is available from the corresponding author upon a reasonable request.

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Author contributions

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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