# Usability Assessment of a Mobile Application for Patients with Chronic Pulmonary Diseases during Home-Based Exercise Care

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Submitted to: JMIR Human Factors
on: April 29, 2024

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# Usability Assessment of a Mobile Application for Patients with Chronic Pulmonary Diseases during Home-Based Exercise Care

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## *Abstract*

**Background:** Digital health tools have demonstrated promise for treating and self-managing chronic diseases while also serving as an important medium for reducing the workload of healthcare professionals and enhancing quality of care. However, these tools often merely undergo large-scale testing or enter the market without undergoing rigorous user experience analysis in the early stages of development, leading to frequent instances of low usage or failure.

**Objective:** This study aimed to assess the usability of and satisfaction with a mobile app designed for the clinical monitoring of patients with chronic obstructive pulmonary disease undergoing pulmonary rehabilitation at home.

**Methods:** This study employed a mixed methods approach, focusing on two key stakeholders - patients and healthcare professionals - with direct involvement in three phases: (i) design of mobile app mockups, (ii) development of a usability test for the two groups, and (iii) evaluation of satisfaction regarding the usability of the app.
Participants were selected through non-probability convenience sampling and divided into two groups: healthcare professionals (n = 12) and patients (n = 18). Each participant was provided with a tablet containing mockup designs, and usability tests were conducted through interviews. Audio recordings of the participants were transcribed anonymously and analyzed using NVivo12.0 software, with the focus being on mockup characteristics and usability test fragments. Task difficulty was assessed on a scale from 1 (very easy) to 5 (very difficult); task non-completion was considered a critical mistake. Satisfaction with usability testing was evaluated using a 5-point Likert scale ranging from 1 (totally disagree) to 5 (totally agree).

**Results:** Perceptions of app difficulty varied significantly between the two groups of participants; while 66.7% of healthcare professionals described most tasks as "very easy", only 22.2% of patients thought this was the case. Note that no participants made critical mistakes or withdrew from the experiment during the trial. In terms of usability variables, both groups reported high satisfaction levels. On average, the healthcare professionals completed their assigned tasks in approximately 20 minutes, whereas the patients required around 30 minutes to complete the patient-specific tasks.

**Conclusions:** For most healthcare professionals, the application was intuitive and easy to use; however, for most patients, operating the app alone and navigating tablet interfaces were challenging. Nevertheless, both groups reported high satisfaction levels in usability surveys. The patients expressed willingness to learn and would recommend the app to others. These positive usability evaluation outcomes, derived from satisfaction surveys and qualitative data analysis, contribute to a deeper understanding of the usage patterns of mobile healthcare applications. Additionally, with design adjustments, these applications have the potential for enhanced utilization in home care settings. Clinical Trial: IRB NO. 202200070B0

(JMIR Preprints 29/04/2024:60049)
DOI: https://doi.org/10.2196/preprints.60049

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qualitative data analysis, contribute to a deeper understanding of the usage patterns of mobile healthcare applications. Additionally, with design adjustments, these applications have the potential for enhanced utilization in home care settings.

## 1. Introduction

Chronic pulmonary diseases severely impair the respiratory system and impact the daily activities of sufferers[1-4]. With approximately 3 million deaths annually, chronic pulmonary diseases rank among the top three global causes of death[5, 6]. Chronic obstructive pulmonary disease (COPD) is a major subset, with nearly 36% of patients developing comorbidities such as hypertension and cardiovascular diseases[7]. Globally, one person succumbs to COPD every 10 seconds; in Taiwan, over 5,000 deaths are attributed to COPD annually[8]. Severe cases of COPD may lead to systemic manifestations, emphasizing the urgency of intervention[9, 10]. Patients, particularly the elderly, often struggle with dyspnea and thus suffer from a diminished quality of life[11]. Depressive symptoms also commonly arise[12, 13]. The significant impact of chronic pulmonary diseases on respiratory function and overall well-being highlights the urgency of addressing this issue. COPD presents with three major symptoms - cough, sputum production, and wheezing – and is therefore often mistaken as symptoms of the common cold[14, 15]. Coupled with low awareness of obstructive lung diseases among the public, individuals frequently underestimate the condition, leading to a delayed diagnosis and treatment as well as significantly elevating the risk of deterioration[16, 17].

Exercise is recognized as one of the most effective therapies for chronic pulmonary diseases[18]. It serves to alleviate respiratory symptoms, enhance cardiorespiratory function, improve quality of life, and consequently, increase the overall well-being of patients[19, 20]. Statistics indicate that individuals with COPD face a reduced life expectancy of 6 to 10 years[21, 22]. In Taiwan, the one-year mortality rate after the first hospitalization for obstructive lung diseases is as high as 20%[23]. To prevent recurrent hospitalizations due to acute deterioration in pulmonary function, post-discharge priorities for patients with chronic pulmonary diseases include maintaining regular exercise habits and receiving precise exercise prescriptions tailored to their conditions[24, 25]. This approach aims to train and enhance pulmonary capacity, thereby extending life expectancy[20, 26]. To ensure that home-based pulmonary exercise rehabilitation meets clinical requirements, digital health (e-health) tools are considered potential aids in the treatment of chronic diseases, given their facilitation in self-managing their condition[27, 28]. Simultaneously, these tools can provide real-time assistance to patients, caregivers, and healthcare professionals in achieving the vision of individual disease management and monitoring[29, 30]. Moreover, e-health tools serve as optimal instruments for healthcare professionals to provide real-time guidance to patients at home in developing healthcare skills and managing chronic diseases, especially during circumstances when in-person treatments are challenging (such as during the Covid-19 pandemic)[31]. Research confirms that the application of e-health tools not only effectively reduces incidence rates, disease exacerbation, and recurrent hospitalizations but has also proven to be an efficient means of alleviating the clinical workload of healthcare professionals[32, 33].

Chronic diseases are a primary driver of the global increase in healthcare and caregiving expenditures[33, 34]. In this context, e-health tools could benefit various stakeholders (including healthcare professionals, patients, and caregivers) by offering a

[35, 36]. However, these tools often face challenges in achieving seamless operation among those involved, leading to outcomes below expectations[37]. Consequently, patients post-discharge exhibit low adherence to using these tools, hindering the comprehensive realization of their intended benefits[38, 39]. Therefore, the design of e-health tools should prioritize a methodology centered on user experience[33, 40, 41].

For the reasons above, this study conducted a user experience-based evaluation of the usability of a home-based pulmonary rehabilitation app. The assessment focused on operational proficiency, information comprehension, interface design, and system acceptance among discharged patients and healthcare professionals. User feedback and results were collected, and based on the survey findings, design modifications were implemented post-trial to enhance the effectiveness and user adherence to the e-health tool. The objective was to ascertain the usability and satisfaction of the mobile application in tracking home-based exercise therapy for users.

## 2. Materials and methods

This study was a non-pharmacological clinical trial that utilized a questionnaire-based interview approach to evaluate the operational usability of a mobile application designed for remote healthcare delivery. The evaluation involved two key groups: healthcare professionals and patients. The insights gained from this assessment will be utilized as a reference for refining the design of e-health tools, ensuring their applicability for both clinical and home-based remote healthcare. The study received approval from the Institutional Review Board of Chang Gung Medical Foundation prior to execution [Registration Number: 202200070B0]. Prior to this study, the researchers conducted a survey on the construction requirements of a home-based pulmonary rehabilitation system. The aim was to establish the fundamental elements of system design based on user experience and needs. Building upon the outcomes of the preliminary research, two applications were developed: one for healthcare professionals to clinically monitor exercise activities and another for patients or caregivers to execute prescribed exercises at home. This study concentrated on assessing the usability of these applications for the two participant groups. The survey results of this study will contribute to refining the design of the home-based pulmonary rehabilitation application. The research investigation comprised the following two stages: (i) observing and recording user interactions to understand the ease of use regarding system functionalities and (ii) conducting usability tests through application operations to elucidate user satisfaction with the design of the application. The study was conducted at Chang Gung Hospital in Taiwan with convenient sampling. The healthcare professionals group consisted of respiratory care and pulmonary professionals, including physicians, therapists, and nurses (n=12), who (i) were aged 25 or above with at least one year of experience in respiratory or pulmonary disease care, (ii) had provided care for patients with chronic pulmonary diseases in the past three years, and (iii) had experience in tracking patient rehabilitation. The patient group comprised patients with chronic pulmonary diseases (n=18) who (i) were aged 58 or above, (ii) had been diagnosed for three or more years with a history of hospitalization and experience in pulmonary rehabilitation, (iii) willingly participated and signed an informed consent form, and (iv) possessed the ability to express themselves independently.

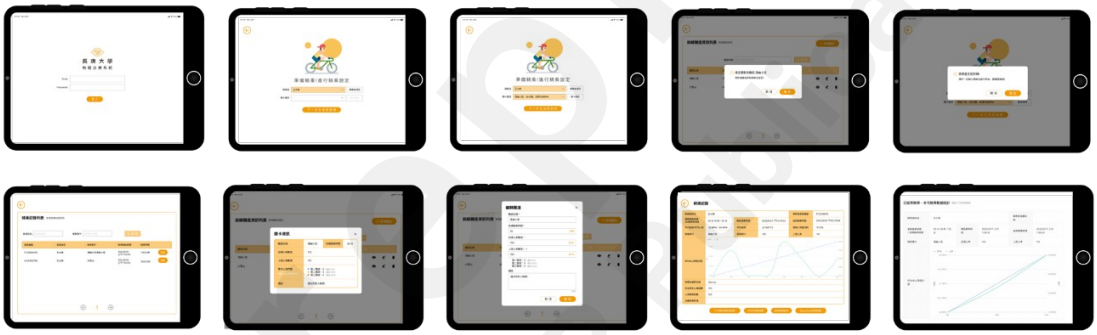
Considering the relatively advanced age of the participants in this study, the questionnaires were administered and filled out by the trial executor. Fig. 1 illustrates the main functionalities of the app and the information distribution on each screen. Usability tests were conducted on the 10 key functional pages of the app, representing the most crucial functions of the system. The details of these tasks are outlined in Table 1. Throughout the testing process, when participants encountered notable operational challenges, the researcher proactively inquired about their difficulties or potential consideration for discontinuation. If participants successfully accomplished a task, it was documented as "operation success" on the questionnaire. Conversely, if participants failed to complete a task in three consecutive attempts without adhering to instructions, the researcher categorized it as "operation failure." Irrespective of participants' success, post-task feedback was collected, and a Likert scale was utilized to evaluate task difficulty, using the following ratings: 1 = Very easy, 2 = Easy, 3 = Moderately easy, 4 = Difficult, and 5 = Very difficult. To evaluate app usability satisfaction, a survey was developed by adapting and modifying validated questionnaires from previous studies to align with the objectives of this research. Regarding the satisfaction of app usability, the survey comprised 10 questions each for healthcare professionals and for patients (Table 2). Responses were assessed on a 4-point Likert scale, ranging from 1 (totally disagree) to 4 (totally agree).

Additionally, to ensure the accuracy of participants' feedback, the entire experimental process was recorded, with meticulous time control to ensure that each participant completed the interview within the designated timeframe (approximately 50-60 minutes). Participants had the opportunity to express their perspectives, opinions, and experiences regarding the tasks during the experiment (such as difficulties or simplicity). Subsequently, this information underwent verbatim transcription analysis, with relevant usability keywords marked. Detailed information on participants' sociodemographic and clinical characteristics can be found in Table 3. Furthermore, the quantitative data of this study were analyzed using the statistical software SPSS (version 22.0).

a. App functional interface for healthcare professionals


Interface for Healthcare Professionals: Professionals can prescribe exercise regimens based on the patient's condition, adjusting them dynamically by referencing clinical data and psychophysical states. This aids in facilitating the self-management of post-discharge patients at home.

b. App functional interface for patients



Interface for Patients: The interface for the home pulmonary rehabilitation app guides patients through lung exercises at home using visualizations, encompassing features such as exercise prescription reception, activity tracking, and progress monitoring.

**Fig. 1 Usability tests mockups**

**Table 1 Usability Test Items**

| Task No. | Usability test for app functionality for healthcare professionals | Usability test for app functionality for patients |
|---|---|---|
| 1 | Create an account | Log in |
| 2 | Log in | Select Personal Information to view individual details |
| 3 | Patient Information Management: including entering or adding patient name, age, sex, contact number, and a brief description of the patient's physical condition. | Generate a pairing code to connect with the hospital end |
| 4 | Prescription Management: Set patient prescriptions and transmit them to the patient's end. | Retrieve exercise prescription |
| 5 | Record Review and Analysis: View the patient's exercise history records, including visualizing graphs showing trends in clinical signs. | Review exercise prescription details |
| 6 | Clinical Monitoring: Monitor patient cycle variations, including checking safe heart rate and heart rate variability. | View personal exercise history records (including visualizing graphs showing trends in clinical signs) |
| 7 | Remote Monitoring: Establish a connection and pair with the patient's end for online monitoring of the patient's exercise status. | Pause exercise (can be paused at any time if discomfort is experienced) |
| 8 | Consultation and Reporting: View exercise outcome reports and conduct online consultations. | Examine exercise cycle variations, including checking safe heart rate and heart rate variability. |
| 9 | Prescription Adjustment: Online adjustment of exercise | Receive remote connection requests for online consultations |

| | | |
|---|---|---|
| | prescriptions, including intensity and difficulty. | |
| 10 | Record Management: View, edit, or delete member records. | Complete online questionnaires (e.g., Borg Scale self-assessment) |

**Table 2 Usability Satisfaction Assessment for App**

| | Questions for healthcare professionals | Questions for patients |
|---|---|---|
| 1 | Overall, this app is user-friendly. | Overall, this app is user-friendly. |
| 2 | The app interface is well-designed and aligns with clinical information needs. | The app has a simple and easy-to-understand interface. |
| 3 | Based on patient-generated data, the graphs are easy to interpret. | The app facilitates easy recall of exercise prescription information at home. |
| 4 | The app substantially assists clinical care professionals. | The app comprehensively records the entire exercise process, ensuring no loss of vital information. |
| 5 | The app facilitates monitoring the home-based exercise rehabilitation of post-discharge patients. | When encountering issues, I can easily resolve them. |
| 6 | Would you recommend colleagues to use a similar app? | Virtual reality contributes to my increased focus and enjoyment during rehabilitation. |
| 7 | The operations of the app are straightforward and easy to remember. | I intend to continue using this app. |
| 8 | The actions performed, whether online or offline, are straightforward to me. | Even without assistance, I can operate the app on my own. |
| 9 | The app design is comprehensive, with no missing or incorrect information. | I feel safe using this app at home. |
| 10 | I believe that it is safe for patients to use at home. | I find some features a bit complex. |

## 3. Result

This study collected data from two groups: healthcare professionals (n = 12) and patients (n = 18). The majority of healthcare professionals were respiratory therapists (8/12, 66%) with an average age of 46 years (± 5 years). They had over 1 year of experience in respiratory care within the past 3 years. The majority of chronic lung disease patients were male (16/18, 88.8%) with an average age of 66 years (±5 years). They had a history of chronic lung disease for over 3 years and had undergone pulmonary rehabilitation for at least 3 years. Detailed information regarding the sociodemographic and clinical background of these two participant groups can be found in Table 3.

**Table 3 Sociodemographic of participants.**

| **Health care professionals N=12** | | | **Patients N=18** | | |
|---|---|---|---|---|---|
| **Variable** | **n** | **Percent (%)** | **Variable** | **n** | **Percent (%)** |
| **Gender** | | | **Gender** | | |
| **Male** | 3 | 25% | Male | 16 | 88.9% |
| **Female** | 9 | 75% | Female | 2 | 11.1% |
| **Age (SD)** | 46 years (± 5 years) | | **Age (SD)** | 66 years (± 5 years) | |
| **Job title** | | | **Education level** | | |
| Respiratory Therapist | 8 | 66.7% | Elementary | 10 | 55.5% |
| Thoracic surgeons | 1 | 8.3% | High School | 3 | 16.7% |
| Physiotherapist | 1 | 8.3% | Bachelor | 3 | 16.7% |

| | | | | | |
|---|---|---|---|---|---|
| Pulmonary rehabilitation specialists | 2 | 16.7% | Bachelor's degree or higher | 2 | 11.1% |
| **Experience in caring for chronic respiratory diseases** | | | **Duration of illness** | | |
| 1–3 years | 3 | 25% | 1–3 years | 5 | 27.8% |
| > 3 years | 9 | 75% | > 3 years | 13 | 72.2% |

### 3.1 User Operations and Usability Perception Interview Survey

Following user interaction with the system app, this study conducted one-on-one, semi-structured interviews to gather insights into operational experiences. Participants described any difficulties encountered as well as their feelings when executing tasks. The entire interview process was recorded, transcribed verbatim, and then subjected to qualitative analysis using NVivo12.0 software for content analysis and synthesis.

Among healthcare professionals, 66.7% (8/12) acknowledged the need for a brief transitional period to familiarize themselves with the software interface and functionalities. During the transformation of data into graphical representations, more diverse visualizations were preferred. Specifically, 58.3% (7/12) expressed a preference for observing changes in heart rhythm and having graphical representations illustrating cyclic patterns to aid in explaining the progression of pulmonary function in patients.

Moreover, 83.3% (10/12) of healthcare professionals emphasized from a hospital standpoint the concern regarding patients' inadequate self-health management post-discharge, especially considering that these patients belong to a high-risk demographic, and reported that prioritizing safety should be a top consideration. Therefore, it is recommended that the fundamental design of the application incorporate an emergency cessation mechanism or a real-time notification feature upon detecting physiological abnormalities, aligning with the fundamental requisites for medical

applications.

Within the patient participant group, 83.3% (15/18) of respondents reported a sense of complexity during their initial exposure to the application. Among them, 61.1% (11/18) indicated an inability to operate the application independently; this challenge was attributed to the advanced age of the majority of participants (mean age 66±5 years) and their inherent skepticism regarding their own operational capabilities. Despite the user interface of the patient-side application being menu-based and devoid of text input requirements, it was still perceived as challenging. Moreover, 44.4% (8/18) expressed difficulty in discerning or comprehending the information presented on the screen, contributing to feelings of unease and tension; 61.1% (11/18) believed that understanding the operational procedures of the application without guidance was challenging. Notably, the majority of patients (12/18) specifically highlighted difficulties encountered during the initial step of entering email and password information to log into the system. Lastly, 38.8% (7/18) conveyed an inability to comprehend the numerical representations in the post-exercise feedback reports, expressing curiosity or confusion regarding the meaning of the graphs. Table 4 presents detailed feedback from participants.

### 3.2 Evaluation of User Operational Difficulty

During the assessment of the usability of the app’s function, healthcare professionals encountered minimal challenges in tasks such as setting up user and patient accounts as well as modifying patient information using tablets. Specifically, 8 out of 12 participants (66.7%) rated these tasks as "very easy." More than half of the healthcare providers (7 out of 12, 58.3%) found it easy to set and transmit prescriptions to the patient's end. Additionally, the majority (9 out of 12, 75%) found it relatively straightforward to access patient exercise histories and visualize health status charts, although some recommended potential enhancements.

Concerning the online monitoring of changes in patient physiological readings, the majority of healthcare professionals found it not difficult. Specifically, 9 out of 12 individuals (75%) perceived the interface to be clear and easy to understand, with operations being very straightforward. However, when establishing connections, most participants found it somewhat difficult initially. Nevertheless, after becoming familiar with the

process, they regarded it as relatively simple (8 out of 12, 66.6%).

While tasks like adjusting online prescriptions and conducting remote consultations were found easy by most healthcare professionals (75% or 9 out of 12), 7 out of 12 expressed that accessing patient information and engaging in online consultations were comparatively complex, requiring more time for comprehension.

Managing patient information was deemed straightforward by 10 healthcare professionals (83.3%). They noted that the clear interface facilitated easy access and deletion. Screen delays were reported by only 41.6% (5 out of 12) of participants, classifying this issue as "moderate" (Table 5a). Importantly, no task was rated as "difficult" or “too difficult."

In contrast, the patient group experienced substantial challenges during system login. Most patients initially struggled to understand how to use the tablet. After reminders and demonstrations, 44.4% (8/18) of patients eventually considered the login process as "easy", while 27% (5/18) found it challenging. When viewing personal information, 6 individuals (33.3%) expressed that it was relatively simple, despite requiring some time for searching and consideration.

Regarding receiving pairing codes and connecting to the hospital end, most patients could input the pairing code to establish a connection; however, 33.3% (6/18) still encountered difficulties due to a lack of familiarity and the absence of assistance from caregivers. Despite some patients expressing confusion regarding the functionality on the screen to receive prescriptions from healthcare providers, 6 (33.3%) and 3 (16.7%) patients respectively found it very simple and simple.

Additionally, concerning viewing exercise prescriptions and accessing personal exercise history records (including visualized charts displaying clinical symptom trends), the majority of patients (11 participants, 61.1%) considered these tasks relatively simple. When experiencing discomfort, 66.7% (12/18) knew which button to press for pausing and considered this step as "very easy".

Regarding viewing personal physiological information, 7 patients (38.8%) found it relatively easy; however, 8 (44.4%) patients expressed uncertainty about how to initiate online consultations. Nonetheless, although participants within the patient group encountered operational difficulties,

none described the tasks as "too difficult" in questionnaire interviews (Table 5b).

### 3.3 Usability testing of system task accomplishment

In usability testing with healthcare professionals, system tasks were assessed, such as setup, login, exercise prescription, and remote connectivity. None of the tasks were completely successful on the first attempt. However, login and clinical monitoring tasks showed a higher success rate, reaching 83.3% (Table 6a). In the testing process, each participant was given five opportunities for operation. The majority of healthcare professionals (62%) required some time to adapt to and familiarize themselves with the system application. About 41.6% committed one to two errors during operations, while 25% made three or more errors. Nevertheless, 58.3% ultimately succeeded in completing the tasks within the specified time limit. Healthcare professionals attributed these errors primarily to unfamiliarity with the interface and occasional accidental presses. However, they noted that the design of the system was not overly complex, and the inclusion of a 'back' mechanism allowed for quick error correction.

Conversely, the majority of patients (66.7%) were able to complete tasks with assistance. However, tasks such as 'Pairing for connection' and 'Request online consultations' remained challenging for many, with failure percentages of 66.7% and 77.8%, respectively. Among these patients, 44.4% made one to two mistakes, while 38.9% made three or more errors on the test (Table 6b).

During the study, the main reason for errors among patients was their relatively advanced age, which may have affected their ability to operate the tablet as we would have liked. Note that patients achieved a 100% success rate in Task 10, 'Completing questionnaires online', primarily because this functionality was operated by healthcare professionals at the current stage, thereby encountering fewer issues in operation.

Note also that the experiment was conducted in a medical setting; as a result, none of the participants in either group made critical mistakes.

**Table 4 Operational Challenges: Semi-Structured Interview Findings**

| Participants | Participants' Feedback | Pain Points |
|---|---|---|
| Healthcare professionals (HCPs) | Um... Honestly, at first, without any instructions, I was a bit unsure where to start, but luckily, I quickly found the "+" sign to create an account. (HCPs 6) | The "+" symbol for account creation might not be very clear, but fortunately, it was quickly resolved. |
| | I found it easy to fill in basic patient information, but prescribing medication is more challenging for me since I'm not a doctor. (HCPs 1) | Different backgrounds may entail different responsibilities. |
| | I'm not sure if it's just me being unfamiliar with the system, but currently, while the screen displays patient heart rate and related data well, for clinical staff, besides linear charts illustrating historical backgrounds, it would be helpful to have icons indicating categories or different charts displaying changes in various physiological values for clarity. (HCPs 11) | Clinical staff require more varied graphical representations or symbols to express the significance of diverse clinical data. |
| | I'm not sure if it's a network issue or a system problem, but I feel the screen updates a bit slowly. (HCPs 4) | It is essential to ensure data conversion speed and the ability to promptly provide accurate information. |
| | Perhaps there's some network delay; when I modify prescriptions, the patient's | |

| | | |
|---|---|---|
| | screen doesn't always match what I intend to prescribe. (HCPs 12) | |
| | Hmm... Typically, it takes some time to accumulate clinical data to see the effectiveness. At this stage, although the feature exists, there might not be enough data to discern changes. (HCPs 1) | A vast amount of data is required for clinical efficacy to be evident in the system. |
| | I'm afraid I might accidentally delete a patient's record. (HCPs 5) | There is a lack of mechanisms for recovery or compensating for errors. |
| **Patients (Ps)** | I can't read, and I can't see what's written on the screen. (Ps 8 & 17) | Patients who are elderly, have lower levels of education, or have poor vision may not be comfortable with operating the app alone. |
| | I can use a tablet, but I don't know how to type. (Ps 17) | In addition to typing, other input functions and voice commands need to be added. |
| | I don't really understand what these numbers mean... And what is pairing connection... Do I just press it, or do I need to input something? (Ps 5, 9, & 12) | The connection mechanism poses a challenge for both the elderly and caregivers. |
| | I often accidentally press the pause button... I don't know how to get back to the exercise screen... It makes me very anxious. (Ps 13) | There are too many function keys on the screen, making it difficult for users to navigate. |

| | |
|---|---|
| I see my heartbeat and heart rate... I don't quite understand them, so it would be better if there were colors or lines to remind me when to slow down. (Ps 10) | The interface should be more user-friendly in order to avoid excessive use of numbers and scientific charts and should make good use of patterns, icons, or voice commands. |
| I received a message asking to connect and to input numbers. I find this very difficult. (Ps 8) | Text may be difficult to understand; replacing it with diagrams or call-in features might be easier to comprehend. |
| This thing is too advanced; I can't figure it out. (Ps 7) | The digital divide is a significant barrier for many rural and elderly populations. |

**Table 5 Perceived difficulty of participant operations**

**a. Healthcare professionals (HCPs) (N=12)**

| Task | Very easy n (%) | Easy n (%) | Moderate Difficulty n (%) | Difficulty n (%) | Very Difficulty n (%) |
|---|---|---|---|---|---|
| **T1. Create an account** | 8(66.7) | 3(25) | 1(8.3) | 0(0) | 0(0) |
| **T2. Log in** | 8(66.7) | 3(25) | 1(8.3) | 0(0) | 0(0) |
| **T3. Patient Information Management** | 8(66.7) | 4(33.3) | 0(0) | 0(0) | 0(0) |
| **T4. Prescription Management** | 4(33.3) | 7(58.3) | 1(8.3) | 0(0) | 0(0) |
| **T5. Record** | 3(25) | 9(75) | 0(0) | 0(0) | 0(0) |

| | | | | | |
|---|---|---|---|---|---|
| **Review and Analysis** | | | | | |
| **T6. Clinical Monitoring** | 2(16.7) | 9(75) | 1(8.3) | 0(0) | 0(0) |
| **T7. Remote Monitoring** | 2(16.7) | 8(66.6) | 2(16.7) | 0(0) | 0(0) |
| **T8. Consultation and Reporting** | 3(25) | 9(75) | 0(0) | 0(0) | 0(0) |
| **T9. Prescription Adjustment** | 3(25) | 4(33.3) | 5(42) | 0(0) | 0(0) |
| **T10. Record Management** | 2(16.7) | 10(83.3) | 0(0) | 0(0) | 0(0) |

**b. Patients (Ps) (N=18)**

| Task | Very easy n (%) | Easy n (%) | Moderate Difficulty n (%) | Difficulty n (%) | Very Difficulty n (%) |
|---|---|---|---|---|---|
| **T1. Log in** | 4(22.2) | 8(44.4) | 1(5.6) | 5(27.8) | 0(0) |
| **T2. View Personal Information** | 5(27.8) | 6(33.3) | 3(16.7) | 4(22.2) | 0(0) |
| **T3. Pairing for connection** | 4(22.2) | 3(16.7) | 5(27.8) | 6(33.3) | 0(0) |
| **T4. Retrieve** | 6(33.3) | 3(16.7) | 4(22.2) | 5(27.8) | 0(0) |

| | | | | | |
|---|---|---|---|---|---|
| **exercise prescription** | | | | | |
| **T5. Review prescription details** | 6(33.3) | 11(61.1) | 1(5.6) | 0(0) | 0(0) |
| **T6. View past exercise history** | 6(33.3) | 11(61.1) | 1(5.6) | 0(0) | 0(0) |
| **T7. Pause exercise** | 12(66.7) | 6(33.3) | 0(0) | 0(0) | 0(0) |
| **T8. Examine cycle variations** | 5(27.8) | 7(38.9) | 4(22.2) | 2(11.1) | 0(0) |
| **T9. Request online consultations** | 1(5.6) | 2(11.1) | 7(38.9) | 8(44.4) | 0(0) |
| **T10. Complete questionnaires online** | 3(16.7) | 15(83.3) | 0(0) | 0(0) | 0(0) |

**Table 6 Success rate of participants' operations**

b. Patients (Ps) N=18

| Task | Yes | | No | |
|---|---|---|---|---|
| | Frequency | % | Frequency | % |
| **T1. Logging in** | 8 | 44.4 | 10 | 55.6 |

| | | | | |
|---|---|---|---|---|
| **T2. Viewing personal information** | 9 | 50 | 9 | 50 |
| **T3. Pairing for connection** | 6 | 33.3 | 12 | 66.7 |
| **T4. Retrieving exercise prescription** | 9 | 50 | 9 | 50 |
| **T5. Reviewing prescription details** | 11 | 61.1 | 7 | 38.9 |
| **T6. Viewing past exercise history** | 13 | 72.2 | 5 | 27.8 |
| **T7. Pausing exercise** | 16 | 88.9 | 2 | 11.1 |
| **T8. Examining cycle variations** | 10 | 55.6 | 8 | 44.4 |
| **T9. Requesting online consultations** | 4 | 22.2 | 14 | 77.8 |
| **T10. Completing questionnaires online** | 18 | 100 | 0 | 0 |

### 3.4 Mobile Application Satisfaction Survey

Regarding the satisfaction survey, over half of the healthcare professionals expressed satisfaction with the functionality design of the application, finding it relatively satisfactory with minimal operational issues. A substantial proportion, constituting 75% (9/12), perceived the application as highly user-friendly, and 66.7% (8/12) expressed considerable satisfaction with the design of the interface. Moreover, the healthcare professionals could promptly access patients' physiological information in real-time through the application, with 58.3% (7/12) indicating such capability. However, satisfaction levels slightly declined when monitoring patients' physiological conditions through online connectivity. Only 33.3% (4/12) perceived this function as comprehensive, while 16.7% (2/12) expressed concerns regarding the inability of the current connection quality to facilitate real-time monitoring. Furthermore, 25% (3/12) suggested that a more stable network connection would enhance safety. Lastly, the extraction of information and the generation of graphical representations were considered crucial by the majority of healthcare professionals. In this study, 41.7% (5/12) and 33.3% (4/12) expressed extreme satisfaction and satisfaction, respectively, with the design of this

application. Respondents anticipated that these functionalities would aid healthcare professionals in assessing patients' physical conditions and prescribing medical treatments.

In the patient group, satisfaction with operational aspects notably lagged behind that of the healthcare professionals across functions such as operation, information retrieval, connectivity, and message access. Only 22.2% (4/18) of patients perceived the interface design of the app as user-friendly, with nearly 33.3% (6/18) unable to provide a proper evaluation. This is attributed to significant operational challenges faced by patients, with 50% of users unable to comprehend each interface function (Neutral-27.8%, Disagree-11.1%, Strongly Disagree-11.1%). Moreover, a high percentage (72.2%) were unaware of how to connect remotely, and 38.9% (Neutral-11.1%, Disagree-22.2%, Strongly Disagree-5.6%) were unsure of how to access historical rehabilitation exercise records. Additionally, 61.1% were uncertain about accessing personal messages, and over a quarter (27.8%) expressed confusion about the significance of real-time values. Nonetheless, 61.1% (Strongly Agree-33.3% and Agree-27.8%) expressed willingness to recommend and continue using the app.

**Table 7 App Satisfaction Survey**

**a. Healthcare professionals (HCPs) (N=12)**

| Task | Strongly Agree n (%) | Agree n (%) | Neutral n (%) | Disagree n (%) | Strongly Disagree n (%) |
|---|---|---|---|---|---|
| 1. **Easy to use** | 9(75) | 2(16.7) | 1(8.3) | 0(0) | 0(0) |
| 2. **User-friendly interface** | 8(66.7) | 3(25) | 1(8.3) | 0(0) | 0(0) |
| 3. **Well-designed patient information management** | 6(50) | 3(25) | 1(8.3) | 2(16.7) | 0(0) |
| 4. **Effective real-** | 7(58.3) | 4(33.3) | 1(8.3) | 0(0) | 0(0) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **time patient data access and analysis** | | | | | |
| 5. | **Effective online health monitoring functionality** | 4(33.3) | 4(33.3) | 2(16.7) | 2(16.7) | 0(0) |
| 6. | **Clear medical information and graphics** | 5(41.7) | 4(33.3) | 1(8.3) | 2(16.7) | 0(0) |
| 7. | **Well-implemented connectivity features** | 4(33.3) | 4(33.3) | 1(8.3) | 3(25) | 0(0) |
| 8. | **Data aiding decision on rehabilitation prescription** | 3(25) | 4(33.3) | 3(25) | 2(16.7) | 0(0) |
| 9. | **Easy online prescription setup and adjustment** | 4(33.3) | 5(41.7) | 1(8.3) | 2(16.7) | 0(0) |
| 10. | **Convenient record retrieval** | 4(33.3) | 5(41.7) | 1(8.3) | 2(16.7) | 0(0) |

**b. Patients (Ps) (N=18)**

| Task | Strongly Agree | Agree n (%) | Neutral n (%) | Disagree n (%) | Strongly Disagree |
|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| | | n (%) | | | | n (%) |
| 1. | **User-friendly interface** | 4(22.2) | 3(16.7) | 6(33.3) | 4(22.2) | 1(5.6) |
| 2. | **Easy access to personal information** | 5(27.8) | 3(16.7) | 4(22.2) | 4(22.2) | 2(11.1) |
| 3. | **Understanding of each feature on the interface** | 4(22.2) | 5(27.8) | 5(27.8) | 2(11.1) | 2(11.1) |
| 4. | **Easy-to-use connectivity features** | 2(11.1) | 3(16.7) | 5(27.8) | 4(22.2) | 4(22.2) |
| 5. | **Convenient access to historical records** | 7(38.9) | 4(22.2) | 2(11.1) | 4(22.2) | 1(5.6) |
| 6. | **Well-designed personal prescription collection and execution** | 5(27.8) | 4(22.2) | 4(22.2) | 4(22.2) | 1(5.6) |
| 7. | **Implementation of security mechanisms** | 6(33.3) | 5(27.8) | 2(11.1) | 4(22.2) | 1(5.6) |
| 8. | **Personal exercise variations incorporated** | 5(27.8) | 3(16.7) | 5(27.8) | 3(16.7) | 2(11.1) |
| 9. | **Complete personal message records** | 3(16.7) | 4(22.2) | 6(33.3) | 4(22.2) | 1(5.6) |

| | | | | | | |
|---|---|---|---|---|---|---|
| **10.** | **Willingness to recommend this app** | 6(33.3) | 5(27.8) | 4(22.2) | 3(16.7) | 0(0) |

*** The percentages are calculated to the first decimal place and rounded to the nearest whole number; therefore, the sum of individual percentages may result in a value other than 100%**

## 4. Discussion

The study has revealed a dichotomy in app operation and satisfaction levels between the participating healthcare professionals and patients. Both groups exhibited a demand for adapting to the app, with the majority of healthcare professionals potentially acquiring app operation skills and understanding its functions through learning and adaptation. Conversely, some participants in the patient group found it challenging to utilize tablets for assisting in rehabilitation programs. Overall, there exists a correlation between operational capability and satisfaction levels. Although both groups of participants provided suggestions for the app, they all recognized that the usage of this app would contribute to personal health management and remote home health monitoring. Additionally, the results of the usability tests and the suggestions provided will aid us in devising improvements to the design of the mobile application.

### *4.1. Considering Human Factors for Enhancing Healthcare App Usability Design*

Technological advancements offer various methods to enhance healthcare service quality. Despite the longstanding application of digital technology in medical facilities and home care, the practical implementation and user acceptance of e-health tools remain limited[42]. A key reason is the absence of user-centric interface design[43]. A 2024 study underscores the importance of considering all stakeholders' perspectives and needs in product, system, and service design. However, that study also noted the significant challenge posed by the lack of user-centric interface design in successfully implementing digital healthcare technology[33]. In other words, through this design survey research, it has been revealed that the usability of software not only directly impacts the smooth delivery and execution of healthcare products, systems, or services, but it also determines users' operational capability, acceptance, and satisfaction[44].

Our research indicated that the principle of user-centric design can be further refined to tailor designs to different stakeholders. Regarding the app interface proposed in this study, some healthcare professionals required a short period of time to learn and adapt to the app in order to assess whether its functionalities met their needs or required improvement. Similarly, many patients appeared to lack the skills and

abilities to sufficiently manage e-health technology; therefore, they were possibly unable to provide effective evaluations on functionality evaluations or suggestions for improvement or even determine the potential of the app for future home use. Previous research has emphasized that the challenges arising from implementing home care often stem from overly complex, expensive, or bulky equipment[45]. This study builds upon current literature and suggests that the technology used at home could pose challenges for elderly patients[45]. One challenge is attributed to issues with interface design between software and hardware, which negatively impact performance[46]. Thus, home care devices and equipment could be perceived as unhelpful, and introducing such technology into patient rehabilitation at home could be rendered futile. Consequently, interface design should prioritize not only the capabilities and preferred modes of communication of application users but also how the information is transmitted and visually displayed. For instance, considering the educational level of the elderly and unfamiliarity with consumer electronics, graphical representations should be favored over text and clickable options preferred over dropdown menus[47].

### *4.2. Feasibility of Digital Technology in Home Healthcare*

The benefits of digital technology alleviate the workload of clinical personnel in addition to providing more precise references for clinical decision-making[48]. An immediate assessment of patients' current physiological status and a prediction of their needs can be derived from the data generated by user interaction behavior[49]. However, effective information communication and exchange rely on the capabilities of both parties. Therefore, a well-designed user interface becomes a crucial element in message transmission and is also a reason for users to accept, trust, and rely on technology[50].

Calvin et al. explored technology acceptance among patients with early-stage disease, with a primary focus on factors relevant to older adult populations[51]. The authors suggested that patients are more likely to adopt technologies if they perceive them as useful or are satisfied with the recommendations provided by healthcare professionals through technological assistance. Conversely, users may reject or discontinue communication with healthcare professionals when they fail to recognize the benefits of technology, struggle to understand its significance due to

technological barriers, or experience negative emotions such as increased anxiety, uncertainty, or fear.

The feasibility and acceptance of technology for managing chronic diseases among the elderly entail key considerations, primarily due to potential limitations in perceptual abilities[52]. Factors such as diminished cognitive function, tactile sensitivity, and visual acuity may hinder the utilization of technology, consequently impacting the efficacy and acceptance of using applications. Research findings indicate significant challenges among most elderly individuals in navigating touch screen controls alongside difficulties in comprehending textual information displayed on screens. Hence, presenting relevant information through visual representations or incorporating voice prompts better caters to the needs of the elderly.

On the contrary, both patients and healthcare professionals with higher education levels and tablet familiarity preferred utilizing visual aids instead of text to illustrate patient recovery progress. Additionally, they advocate for longer data cycles and consider them instrumental in enhancing the accuracy of medical decisions and influencing patient recovery results and timelines. As irreversible conditions, chronic lung diseases necessitate long-term monitoring and health management, making home rehabilitation and health management an inevitable trend for patients. The use of digital technology not only benefits healthcare professionals but also closely relates to the health of patients with chronic disease. However, the benefits of digital technology can only be realized by leveraging its functional advantages, which allows all parties involved to benefit from and consequently accept e-health tools. The usability tests conducted in this study revealed that despite numerous suggestions and challenges encountered by both groups of participants in using the app, there was still a high level of satisfaction with the intervention method. Importantly, the majority of participants expressed willingness to adopt this approach as a future method of health management.

### *4.3. Recommendations for app design based on the results of usability testing*

The usability study revealed challenges for older adults in using tablet or other touchscreen interfaces[53]. In addition to lower-than-expected tactile responses, their limited visual acuity and cognitive abilities may hinder

their understanding of on-screen information[54]. Some studies have suggested that presenting information in visual formats is an effective method to alleviate communication barriers and enhance comprehension, particularly benefiting older adults[55]. Those with limited tactile perception may require additional aids such as auditory cues or styluses.

Both participant groups in this study recommended that designs be easily understandable and advocated for presenting clinically relevant graphical data in a simple and intuitive manner. Furthermore, during the trial period, some patients struggled with input commands (e.g., dropdown menus) due to unfamiliarity with tablet touchscreen interfaces, leading to feelings of helplessness or confusion. Consequently, such input interfaces may not be suitable for the elderly, and alternatives are required to meet their needs, for example, click-based interactions coupled with imagery, which are widely used pain assessment tools.

In terms of operational capability, most healthcare professionals encountered few issues in tasks such as account creation, login, accessing patient information, online prescription management/adjustment, and monitoring patient dynamics. However, some healthcare professionals expressed concerns about the impact of connection quality on delivering medical services. Unstable connections could lead to message asynchrony as well as screen delays and lagging. While some healthcare professionals considered this a normal occurrence due to data processing and screen updates, others believed that it might affect the effectiveness of medical services.

In contrast, patients could face more challenges in operation. Research observations have indicated that the primary reason that most patients can operate technology smoothly is due to assistance from caregivers. However, as the interface of this app is primarily displayed in Chinese, caregivers whose native language is not Chinese likely require additional explanations and perhaps training to understand the app. To address this issue, future improvements could consider using icons to replace textual instructions for broader user adaptation.

To enhance patient privacy and security, the application implemented a bidirectional online consultation feature. However, this feature may not be user-friendly for patients, as many of them are unfamiliar with how to input pairing connection values via touch screens on tablets. Consequently,

even if the hospital sends a request message, patients may struggle to comprehend or operate this feature. To address this issue, it is suggested that a simpler approach be adopted, such as using a basic incoming call icon as a prompt for physician calls or serving as a signal for connection.

Our findings demonstrate that placing human-centered design at the forefront is paramount. Considering the abilities, cognition, and perceptions of different stakeholders will aid in improving the design, usability, and acceptance of e-health applications. Throughout the study period, no critical mistakes, such as incomplete tasks, were reported by patients and professionals. Moreover, a high degree of satisfaction was expressed. Despite significant operational challenges faced by patients, they indicated willingness to learn to use the app and recommend it to others. This suggests that such a model has the potential to enter home care; however, further considerations in design details are necessary.

This study involved two participant groups and aimed to assess from their perspectives the usability, cognition, and acceptance of e-health interfaces. The study included a total of 30 participants, comprising 12 healthcare professionals and 18 patients; this met the required sample size for such studies. Nielsen (2000) suggested that five participants are typically adequate to identify most issues[56]; however, the actual sample size may vary depending on different categories, which has also been noted by numerous related studies. The findings of the present study are consistent with those of other investigations evaluating the usability of e-health technology tools. Nonetheless, there is a need for further refinement, particularly in simplifying the communication hardware and application interfaces used by patients. Tablets may not be the most suitable medium for older adults, and other alternative solutions, such as voice calls instead of text input, should be considered.

## 5. Conclusions

The survey results of this study indicated that the majority of healthcare professionals found the app intuitive and easy to use, while most elderly patients found it challenging to operate independently. Nevertheless, both groups of participants exhibited a high level of satisfaction in the usability satisfaction survey. It is imperative for us to focus more on discussing and addressing the difficulties and dissatisfactions encountered by participants during app usage to enhance the potential for future home-based

applications. By examining errors during actual operations, conducting usability satisfaction surveys, and analyzing qualitative data, we can gain a better understanding of the usage of mobile health applications during testing. The results from user testing aided in comprehending the actual functioning of mobile applications and served as a basis for design modifications. Moreover, our usability tests underscore the importance of tailoring app designs to accommodate contextual factors and user characteristics, such as age, education, and functional conditions, especially in populations with chronic diseases like COPD. Addressing these variables is pivotal for ensuring the effective adoption and acceptance of digital technologies in healthcare settings.

## Author Contributions

S.Y. Chien contributed to the study design, data analysis, and drafting of the manuscript. H.C. Hu and H.Y Cho contributed to the study design.

## Funding

This study received support from the National Science and Technology Council (NSTC) through grant number 111-2222-E-182-02-MY2.

## Institutional Review Board Statement

This research has been approved by the Research Ethics Committee of the Chang Gung Medical Foundation (IRB NO. 202200070B0).

## Informed Consent Statement

Before the experiment began, we obtained consent from all participants, who were also required to sign the necessary documents to give informed consent.

## Data Availability Statement

The datasets utilized in the present study are not publicly accessible due to the need to safeguard participants' personal data. However, interested parties may obtain access to the datasets by contacting the corresponding author and making a reasonable request.

## Declaration of Competing Interest

The authors declare that they do not have any known financial interests or personal relationships that could have influenced the work presented in this paper.

## Acknowledgments

We sincerely thank all participants for their valuable contributions to this study. Special appreciation goes to the Respiratory Therapy Department at Chang Gung Memorial Hospital for their invaluable clinical support.

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# Supplementary Files