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Patients, caregivers, and healthcare professionals' needs when designing the content of a mobile application for the clinical monitoring of patients with chronic obstructive pulmonary disease and home oxygen therapy: A user-centered design

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ABSTRACT

Background: Patients with chronic respiratory diseases require oxygen supply in a considerable amount to reduce their symptoms and increase their survival. The development of abilities for the self-management of chronic diseases has been shown to be essential to decrease exacerbation of symptoms. Therefore, the design and development of health mobile applications (apps) that aid in educating and training for disease self-management are cost-effective strategies.
Objective: The purpose of this research was to describe the main characteristics that, according to final users, should be included in a mobile application for monitoring patients prescribed home oxygen therapy.
Methods: A participative-qualitative design was used, involving direct participation of patients, caregivers, and healthcare professionals. Focus groups were conducted to identify the needs and perspectives related to the app. A card sorting method was used to determine the contents and basic architecture of the app.
Results: By means of the focus groups, we could identify nine basic functions of the app for the clinical monitoring of patients under home oxygen therapy. For both profiles, the app structure was determined by identifying the most frequent contents among participants.
Conclusions: The implementation of a user-centered design allowed for the detection of the functions, contents, and basic architecture of the app by identifying healthcare professionals and patients' needs and preferences regarding the self-management and monitoring of home oxygen prescriptions.
Trial Registration: The study is registered in ClinicalTrials.gov: NCT04820790.

1. Introduction

E-health technologies have become notable support tools to reduce healthcare gaps associated with limited access because of geographical conditions or to streamline healthcare. They represent a way of collecting and accessing clinical data (Korpershoek et al., 2020; Kooij et al., 2021). Currently, patients with chronic respiratory diseases require considerable oxygen supply in order to ensure their survival and decrease their symptomatology, especially dyspnea (Branson, 2018). Moreover, the ability to self-manage chronic diseases has been proven to be essential to reduce exacerbation. In this sense, designing and developing health mobile apps to provide education and training regarding disease self-management are cost-effective strategies (Turchioe et al., 2019; Spielmanns et al., 2020).

It is worth mentioning that, according to the World Health Organization, chronic obstructive pulmonary disease (COPD) is the third cause

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of death worldwide and has become a public health concern (Caballero et al., 2008; Naranjo-Rojas et al., 2021).

In Colombia, spirometry yielded a global COPD prevalence of 8.9 % in 2008. Regarding the increase in home oxygen therapy prescription during the initial phases of treatment, it has been reported that approximately 3176 patients have been enrolled in home care programs. However, the data has not been updated based on new epidemiological studies (Naranjo-Rojas et al., 2021).

The use of oxygen supply in patients with chronic respiratory diseases, such as COPD, requires monitoring to ensure compliance with the medical prescription and equipment handling (Spielmanns et al., 2020). Because this need becomes especially relevant in the domiciliary context, wherein the care visits by healthcare professionals are shorter, this task is delegated to the patients or their caregivers (Santos et al., 1991). These situations evidence the need for technological tools (Zhou et al., 2019; Farias et al., 2019), so that healthcare professionals can monitor patients through the collection of clinical data supporting the interventions and streamline healthcare and enhance the use of home oxygen therapy equipment. Moreover, healthcare can be programmed based on patients and caregivers' needs and the latter can learn to identify alarm signs (Farias et al., 2019; Deng et al., 2020; Marcano Belisario et al., 2013).

Boer et al. (2019), conducted research to compare the efficacy of a mobile app as opposed to an action plan based on printed records and educational material for the self-management of patients diagnosed with COPD. Participants were interested in the support function of the app, suggesting that this technological tool can be useful for patients with COPD.

According to some authors (Marcano Belisario et al., 2013; Boer et al., 2019), five stages must be fulfilled in order to develop a health app: (i) conceptualization, (ii) definition, (iii) design, (iv) development, and (v) publication. In addition to these stages (Rodríguez Hermosa et al., 2020; Graham et al., 2019; Berlanga et al., 2017), to avoid low adherence to these tools, they showed that the opinions and experiences of the final users (patients, healthcare professionals, etc.) should be the focus of the design process so that functionality, ease of use, safety, and cost can be determined (Torres-Mallma et al., 2018; Arnhold et al., 2014; Biediger-Friedman et al., 2016). In this sense, it has been evidenced that excluding users from the design and development process is the main reason why these technological strategies have failed when used in therapy (Molina-Recio et al., 2020; Molina-Recio et al., 2021).

Some research publications (Wang and Qi, 2021; Bardus et al., 2019; Lindqvist et al., 2020; Thirumalai et al., 2018a, 2018b), have proposed a design process centered on users, with a participative approach in the development of mobile apps. The need for including focus groups has also been highlighted to correctly assess the situation, design the architecture of the data offered by the apps, and offer a higher-usability resource. As other authors suggest (Molina-Recio et al., 2020; Molina-Recio et al., 2021), although these strategies could be used to obtain successful results, designs centered on final users are scarcely implemented. In short, it seems evident that identifying the needs and perspectives of the parties involved in the design and development of a mobile app to monitor home oxygen therapy and prevent and control exacerbations in patients with COPD may be an adequate approach to offer a functional and highly satisfactory app with a high level of adherence.

The purpose of this research was to describe the main characteristics that a mobile app should have according to the opinions and experiences of the final users (patients, caregivers, and healthcare professionals) to monitor patients prescribed home oxygen therapy in Colombia by applying quantitative techniques (focus groups).

2. Methods

This study is part of a project for a randomized, non-pharmacological clinical trial (Naranjo-Rojas et al., 2021), to assess the efficacy of a mobile app in the clinical monitoring of patients under home oxygen therapy (the study is registered in ClinicalTrials.gov: NCT04820790). The mobile app will have different user profiles: one for healthcare professionals and the other one for patients and caregivers. As a result, each profile shall include the expectations and needs of its final users, which will be different for each user. For this reason, based on the methodology proposed by Molina-Recio et al. (2021), we applied a participative-qualitative design with the direct participation of patients, caregivers, and healthcare professionals. Focus groups were conducted to identify the needs and perspectives related to the app, which included comprehensive group interviews (García Calvente and Mateo Rodríguez, 2000; Amezcua, 2003). One of the advantages of focus groups is the possibility of working with small groups, which allowed for seamless interaction between users. For these reasons, it is considered that this type of methodology can allow the needs and perceptions of end-users to be recognised. However, there is no consensus on the recommended sample size. Between 5 and 15 participants per focus group have usually been suggested (Buss Thofehrn et al., 2013; Gil Flores et al., 1994; Silveira Donaduzzi et al., 2015). Based on recommendations made by previous studies (Ploderer et al., 2018; Thirumalai et al., 2018a, 2018b), a sample of 12 participants (5 patients with their careers and 7 health care professionals) was established and selected through non-randomized convenience sampling. During this stage, discussion topics were proposed, which included participants' prior experience using health mobile apps and aspects related to the clinical monitoring of patients under home oxygen therapy.

Given the date on which the research was initiated, the healthcare professionals performed their activities virtually, consistent with the COVID-19 lockdown. Informed consent was obtained through an online survey before each session. The second group received domiciliary visits, and participation acceptance was obtained by signing an informed consent form. The primary caregiver of each patient accompanied the researchers during the home visit.

The following inclusion criteria were applied to select participants: (i) subjects older than 18 years; (ii) respiratory therapists and/or physiotherapists working for a domiciliary healthcare company; (iii) >1 year of domiciliary healthcare experience; (iv) patients prescribed home oxygen therapy for >1 year; (v) caregivers of patients under home oxygen therapy for >1 year; and (vi) having signed an informed consent form before participating. Exclusion criteria: (i) patients with mechanical ventilation.

Three activities were performed to explore the contents and basic structure of the mobile app (Fig. 1): (1) focus groups: identification of background and expectations regarding clinical monitoring of patients with COPD under home oxygen therapy through a mobile app; (2) function list: identification of categories and functions described as important by participants; and (3) definition of the contents and basic architecture of the mobile app through a card sorting method (Optimal Workshop, 2021). Firstly, two focus groups were held to learn about needs, previous experiences in mHealth and expectations (session 1) and establish the list of desired functionalities in the app (session 2). These sessions were followed by a third one which made it possible to define the content and architecture of the mobile application; for this session, researchers applied the card sorting method through the online software Optimal Workshop.

2.1. Focus groups: needs, categories, and function list

The focus group meetings lasted for approximately 1 h. Initially, the topics were approached in a general manner, asking if healthcare professionals had used or would use mobile health (mHealth) apps in clinical practice as part of treatment. Likewise, the patients were asked about what they knew about the disease and the use of mHealth apps. Subsequently, three categories were established: (1) experiences before mHealth, (2) clinical monitoring of patients under home oxygen therapy through an app, and (3) expectations. Each category included questions

Fig. 1. Exploring the contents of the mobile app according to the final users.

aiming at identifying the ways in which a technological tool could improve treatment, monitoring of the patients' respiratory process, and self-management when identifying symptoms such as dyspnea. Finally, questions about participants' preferences regarding the contents and architecture of the app design were asked (Table 1). Subsequently, a list of functions described as necessary by participants was established for their inclusion in the mobile app. All sessions were recorded and transcribed, and the participants remained unidentified. The anonymous transcriptions were analyzed, highlighting those parts of the focus groups about users' preferences regarding specific characteristics of the app. The research team reviewed each of these preferences in order to accept them and selected those consistent with the purposes of the study.

2.2. Content grouping of the mobile app

In order to determine the contents of the app, the card sorting technique was used (Optimal Workshop, 2021). This is one of the most popular methods in user-centered design and is considered reliable and economical (Boream, n.d.). It is used to determine the way in which the contents of a digital product should be organized or grouped based on users' opinion. In this case, a hybrid card sorting approach was used (Beerlage-de Jong et al., 2020; Wentzel et al., 2016a, 2016b; Hassan Montero and Martín Fernández, 2004), wherein participants could create new categories based on their needs aside from creating predefined groups or categories to classify the cards,. Each card was given a name associated with the functions identified in the focus groups by the final users. Optimal Workshop software was used to apply this method (Optimal Workshop, 2021; Candamil Llano and Guevara Hurtado, 2008; Wentzel et al., 2016a, 2016b), which generates two graphic results: similarity matrices and dendrograms. Similarity matrices show dark blue squares representing those card combinations grouped in closely related pairs, in addition to the highest similarity percentages. Likewise, cards that were not grouped together by participants were represented by white squares, suggesting no similarity at all, which is why their analysis should focus on content organization (based on the frequency by which participants placed a card next to the other). Similarity

Table 1
Questions asked in the focus groups.

Experiences before mHealth
▪ *Have you ever used mobile health apps?*
▪ *What do you think about mobile health apps?*
▪ *Do you trust mobile health apps?*
▪ *Do you think an app for patients under home oxygen therapy would be useful?*
▪ *Would you use an app for patients under home oxygen therapy?*
▪ *Are you familiar with the reasons why your physician prescribed home oxygen therapy? Could you mention them?*
▪ *How do you find answers to your questions about home oxygen therapy?*
Clinical monitoring of patients under home oxygen therapy through an app
▪ *Do you think that an app might be useful for monitoring home oxygen therapy?*
Expectations
▪ *Do you think that an app would be useful for solving the difficulties associated with home oxygen management? How?*
▪ *Do you think that an app for home oxygen monitoring would reduce your decision-making time?*
▪ *Do you think that an app could measure acute exacerbations associated with oxygen therapy?*

Questions based on the recommendations by Molina-Recio et al. (2020).

Table 2
Socio-demographic characteristics of participants.

Health care professionals			
Variable		Frequency	Percentage (%)
Sex	Female	6	86
	Male	1	14
Health care professional	Physiotherapy	3	43
	Respiratory therapy	4	57
Home care experience	<1 year	0	0
	1–3 years	7	100
	>3 years	0	0
Experience in home care	<1 year	0	0
	1–2 years	1	14
	>2 years	6	86
Experience in the management of patients with domiciliary oxygen	Yes	7	100
	No	0	0
Accepts to participate as an expert	Yes	7	100
	No	0	0
	Median	**IR**	
Age(years)	36	12	

Patients			
		Frequency	Percentage (%)
Sex	Female	4	80
	Male	1	20
		Median	**RIC**
Age(years)		86	28
Time in home care program with oxygen support (years)		3	1

IR: interquartile range.

matrices allowed for the identification of the contents that should be grouped together in the mobile app. As a reference, high content similarity was considered when cards were grouped together by >60 % of participants. Once the way in which information should be grouped was defined, a visual dendrogram analysis was used to identify the contents that should appear in the same mobile app section or screen.

(Saparamadu AADNS et al., 2021; Schnall et al., 2016; Birkhoff and Smeltzer, 2017).

3. Results

Importantly, two data collection groups were formed: respiratory care professionals and physiotherapists (n = 7) and patients and their carers (n = 5). The professionals showed a median age of 36 (interquartile range – IR – 12 years), with a female majority and home care experience of more than two years in 80 % of cases. The patient group was predominantly female, with a median age of 86 years (IR 28). More detailed information on the socio-demographic and clinical characteristics of the participants can be found in Table 2.

Perceptions expressed in the focus groups allowed for the identification of the basic functions that the mobile app should have for the clinical monitoring of patients under home oxygen therapy. Therapists remarked the need for including graphs, behavior trends of vital signs over the last few visits, clinical status classifications, and practical and specific information about patients. Patients and caregivers mentioned the importance of having an educational app, which helps them to identify alarm signs in an easy, comprehensible, and accessible manner. For instance, they believed that the app should indicate when oxygen use is necessary and that it should include information regarding their medical prescription and vital signs, such as their respiratory rate and oxygen saturation. Moreover, they highlighted the importance of providing information that favors the monitoring and management of home oxygen therapy. Table 3 includes some of the participants' preferences regarding the functions of the app.

In this way, we could identify nine basic necessary functions, with six categories for the therapist's profile and four categories for the patient's and caregiver's profile. The categories for the therapist's profile were established as follows: (1) clinical signs registry, (2) data presentation as simple graphs, (3) assessment of compliance with the home oxygen prescription, (4) descriptions of management plans or changes in the home oxygen therapy, (5) identification of the number of hospitalizations over the last month, (6) maintenance of oxygen supplies. The categories for the patient's and caregiver's profile were defined as follows: (1) education, (2) self-report, (3) management of oxygen therapy equipment, (4) medical prescription.

3.1. Basic architecture of the mobile app

Content grouping of the app was defined by studying similarity matrices. As mentioned above, the combinations of grouped cards with the highest similarity percentages according to participants were considered. In the therapist's profile, as Fig. 2a shows, 100 % of participants grouped the “respiratory rate” and “heart rate” cards together, which means that they thought that both are closely related. The same was observed for the “low oxygen flow systems” and “high oxygen flow systems” cards, which yielded 85 % similarity. Unlike the cases mentioned above, the “heart rate” and “high oxygen flow systems” cards were not grouped together, which suggests that professionals did not see a relationship between them. Likewise, in the case of the patient's and caregiver's profile, Fig. 2b shows that 100 % of patients grouped the “heart rate” and “temperature” cards together and the “videos” and “audio files” cards together, whereas the “time of use of oxygen therapy” and “respiratory rate” cards were not grouped together. This allowed for the identification of the most meaningful combinations for participants and determination of the content structure for each profile. Table 3 describes the highest similarity scores.

In contrast, the dendrogram results in the therapists' group (Fig. 3a) show that, consistently with the findings of other studies and based on a 57 % cut-off percentage.

(Boream, n.d.; Beerlage-de Jong et al., 2020), participants' grouping resulted in three general categories: (1) oxygen therapy, (2) classification of the patient's state, and (3) clinical data. Non-grouped variables were included in the groups that showed the highest correlation. Likewise, the dendrogram results in the patients' and caregivers' group (Fig. 3b), with a 60 % cut-off percentage (Boream, n.d.; Beerlage-de Jong et al., 2020), resulted in three groups: (1) self-assessment, (2) help,

Table 3
Participants' preferences regarding the functions of the mobile app.

Participants	Participants' statements	Proposed topics
Healthcare professional [HP]	*“I think it should have… I don't know, some kind of sequence, show average oxygen saturation levels, so I can tell if the patient's blood oxygen is decreasing. I should be able to measure saturation levels today, tomorrow, the day after tomorrow, in order to determine the patient's average saturation.” [HP3]*	Prior experience mHealth
	“Yes, this app may be useful because you can monitor your patient, his or her status… It should include graphs. Also, therapists who share patients could have readily available information about changes in their symptoms or about the disease itself in an easy and clear manner.” [HP5]	
	“This app could be used as some kind of triage, similar to the ones used in emergency services, so that we can determine if patients need priority care by healthcare professionals based on their signs and symptoms and a short questionnaire.” [HP7]	Needs and expectations regarding the clinical monitoring of patients under home oxygen therapy through an app
	“First, this app should have patients' names and diagnoses, and second, it should have a memory, so that each time we visit patients, we can record their saturation, signs, and dyspnea state.” [HP1]	
	“I think this app would allow us to make quick decisions when it comes to oxygen management…we could assess oxygen needs, measure use time, and based on clinical data, link information to make therapeutic decisions… I think it's an interesting idea”. [HP6]	
Patients and caregivers [PC]	*We would use the app when in doubt, when we don't know how to use the oxygen devices, or if we are following the physician's instructions correctly…We would also feel as if the therapist was there, with us, we would feel supported through when completing our tasks.” [PC2]*	Medical prescription indications for requiring home oxygen.
	“This app would be really good because it could teach us to measure and manage oxygen saturation when the patient cannot breathe and we could have an idea about the patient's lungs and health state.” [PC4]	
	“We would like to see warnings about oxygen excess and misuse, as well as record vital signs and when he or she [the person] cannot breathe. In addition, I think that including us in oxygen therapy is a really good idea.” [PC1]	Home oxygen self-management and control aspects through an app.
	“We would like to see questions explaining what the physician said, such as connecting the oxygen when she [the patient] cannot breathe… Using videos or something of the sort, something easy to understand. I would like it to be simple, with simple drawings.” [PC3]	

and (3) medical information. In this way, the app structure of both profiles was determined by establishing the closest relationships between contents for participants, reflected by similarity matrices. Moreover, the dendrogram analysis facilitated the grouping of contents into categories, which suggests the organization of possible sections of the mobile app. Content grouping by profiles is shown in Table 3.

Once the results of the card sorting method (Optimal Workshop, 2021), were correlated and analyzed using dendrograms and similarity matrices, the research group met and studied the conformation of logical groups that could represent the structure of the mobile app on a screen. Thus, the healthcare professional's profile was divided into three main screens, whose contents are included in Fig. 4a, whereas the patient's and caregiver's profile consisted of three screens, whose contents are included in Fig. 4b.

4. Discussion

The main findings of this research are that the mobile application will have two user profiles, one for healthcare professionals and one for patients and their carers. Each profile will respond to different needs depending on the end-user's context. Both healthcare professionals and patients and their carers agreed on the importance of developing a user-friendly app with a simple design for handling and interpretation. Therapists expect to have fluid communication regarding the management and changes of treatments to control patients diagnosed with COPD and home oxygen support. They also highlighted the relevance of

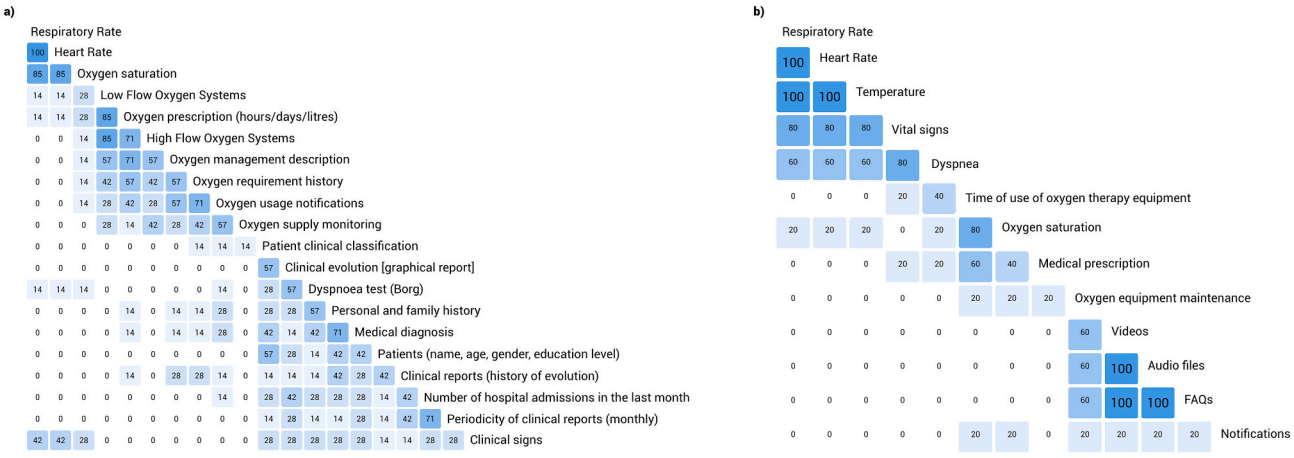

Fig. 2. Similarity matrices.

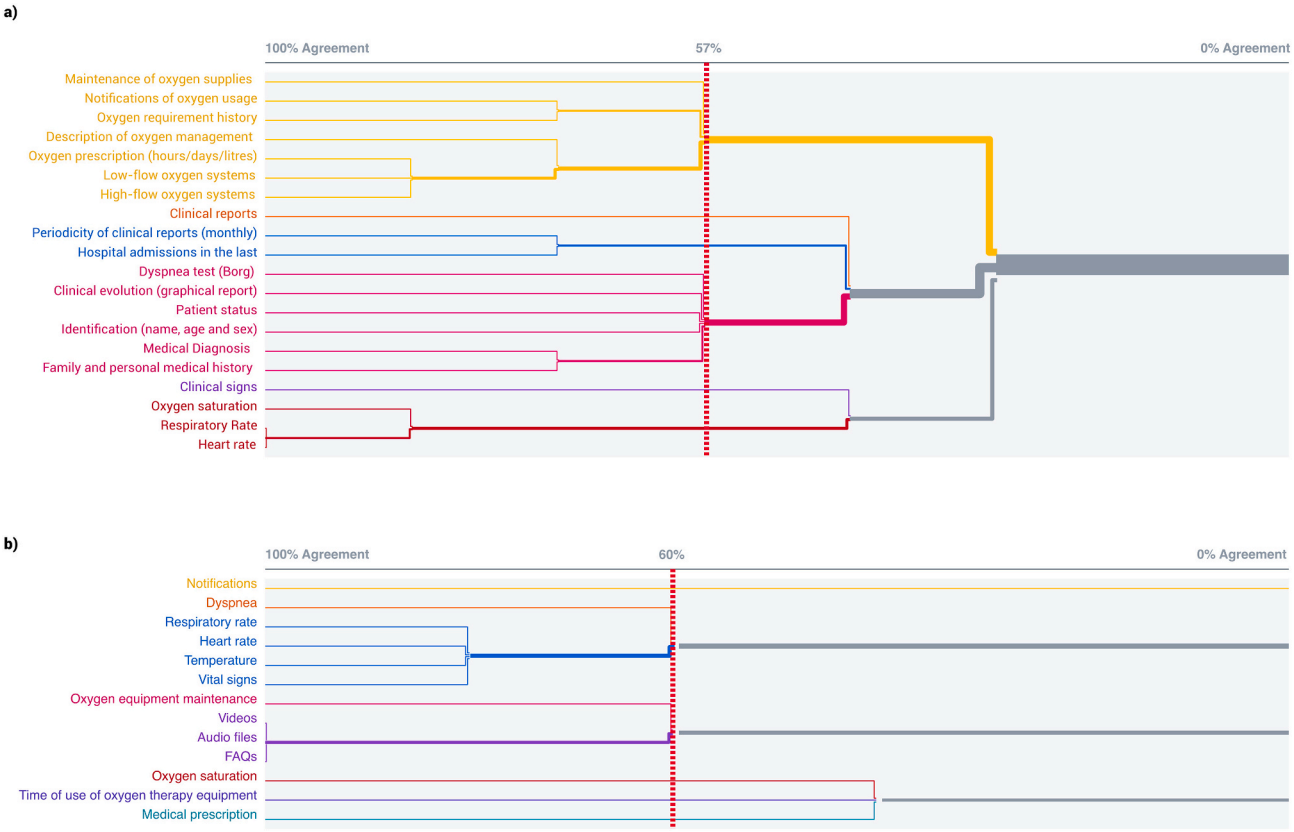

Fig. 3. Dendrograms.

displaying accurate information that allows them to make decisions with data taken in real-time. On the other hand, patients and caregivers expressed the need for a mobile application that includes videos, tutorials and images that allow them to quickly and easily interpret the basic behaviors to be performed while the professional in charge is not at the patients' home.

Regarding the needs mentioned by professionals, patients, and caregivers, the results of our research are consistent with a study performed by Ledel Solem et al. (2020), who also highlighted that ease of use and a simple design should be the key characteristics of mHealth apps (Peng et al., 2016; Paea and Baird, 2018; Wentzel et al., 2014).

The research conducted by Lyles et al. (2016), provided results that

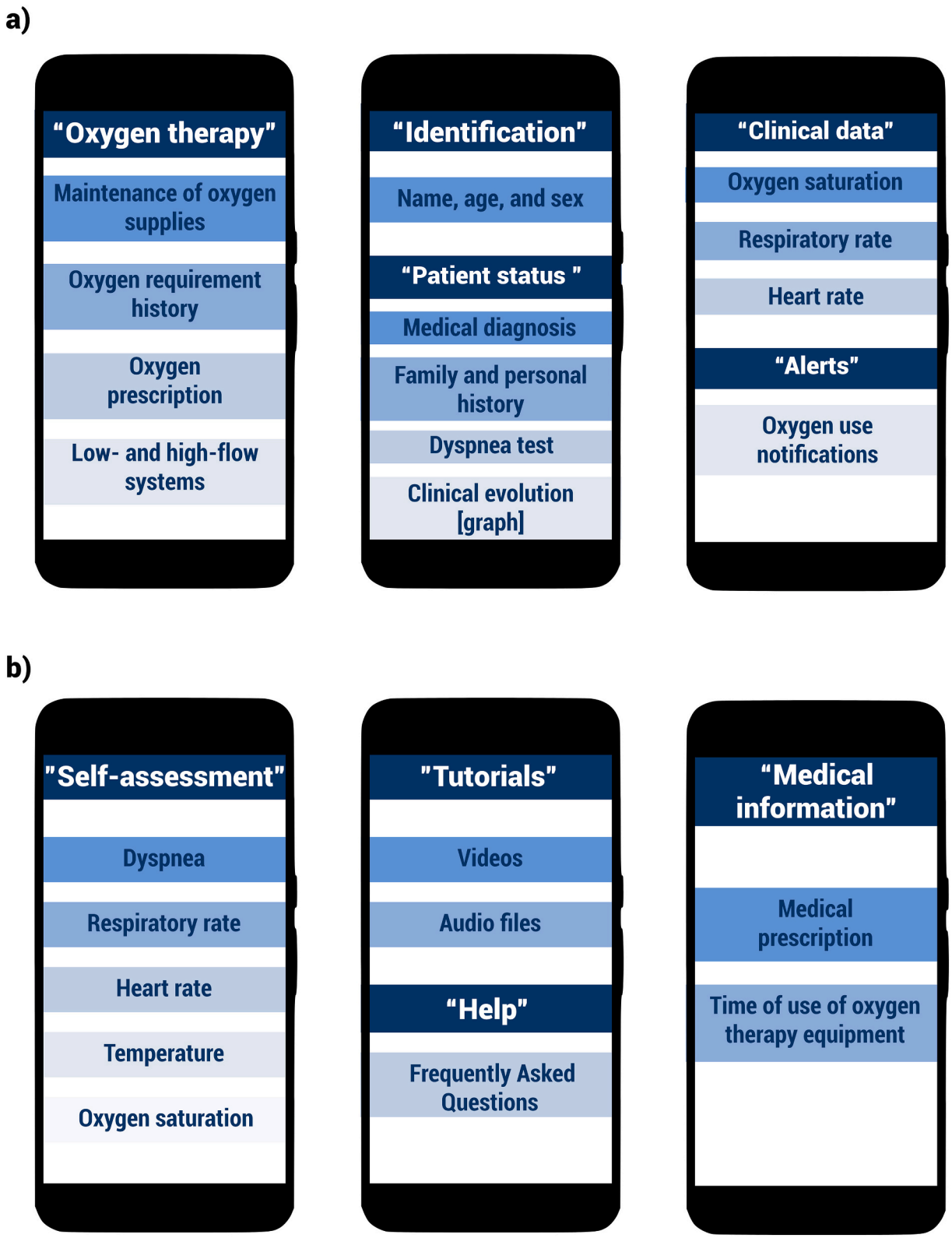

Fig. 4. Screen structure of the app.

are consistent with those of this study because users also highlighted that mobile apps should be accessible and simple upon execution, their contents should be mostly explained pictorially, the texts should be short, and educational aspects should be included.

Moreover, this research is consistent with the research conducted by Korpershoek et al. (2018), regarding two aspects: first, the participants also highlighted the importance of a simple mHealth intervention, and second, both studies provided information based on participants' mind maps as possible organization ideas for the contents of an mHealth intervention (2005).

Ferrucci et al. (2021) mentioned the importance of healthcare professionals sharing information with their colleagues through a mobile app. This aspect was also highlighted by all therapists who participated in this research, who explained that the app should provide them with seamless and constant communication with both colleagues and patients when assessing changes and behaviors regarding oxygen supply use.

Likewise, patients said that the mobile app could be helpful during moments of uncertainty, when professionals are not physically available, which has also been pointed out by Williams et al. (2014).

In their investigation, Hardinge et al. (2015), developed a mobile app to support the self-management of patients with COPD and highlighted the self-management and support contents or modules. These contents are similar to those included in this research - "self-assessment" and "help." Another investigation in which similarities were observed is the one performed by Wiecha et al. (2015), who highlighted the importance of including educational material from their website, such as self-management and respiratory disease management guidelines. In contrast, Farmer et al. (2014), included a module for the assessment of patients' quality of life by employing St. George's Respiratory Questionnaire. This type of information was not requested by users in this study.

Likewise, the structure suggested for this research is consistent with that suggested for the study performed by Olaya et al. (2020), who designed two profiles so that users could log in and enter clinical information: a professional's profile and a patient's profile.

However, unlike what was reported by Olaya et al. (2020), this study did not evidence the need for including a section to upload diagnostic imaging.

By contrast, in the revision of mobile apps for the self-management of hypertensive subjects, Hui et al. (2019), highlighted that the most common content or function organization is divided into categories such as clinical data registry, monitoring with graphic records, and advice through videos about disease management. This structure is consistent with the findings of our study.

Finally, the ideas about content grouping by screen proposed in this research are similar to the design of the mobile app EPOCuídate (n.d.), which has a main screen with general contents: symptoms journal, medical information, tutorials, and patient's profile, which are consistent with the architecture proposed in this study for the patient's and caregiver's profile. Moreover, and similarly to our results, content organization of the main screen of the mobile app Chronic Obstructive Pulmonary Disease Assessment App and FVL Siempre – telemonitoreo (Apkpure.com, 2021; Google.com, 2021), include modules for self-assessment, vital signs registry, and history of vital signs behavior.

4.1. Limitations

The number of participants in this study was small. However, this is a recommended sample size. As mentioned above, the literature indicates that this type of methodology is appropriate for working with limited population groups. Furthermore, although there is certainly no consensus on the recommended sample size, between 5 and 15 participants per focus group are suggested (Buss Thofehrn et al., 2013; Gil Flores et al., 1994; Silveira Donaduzzi et al., 2015). Other authors have used similar sample sizes in projects with similar designs to those used in this research (Ploderer et al., 2018; Thirumalai et al., 2018a, 2018b). It is important to note that this study will continue with the graphic design (which will include the user experience/user interface - UX/UI) and the programming of the mobile application using an iterative process by prototyping, where new participants will increase this sample size. The results of this research are comparable with those of other studies in terms of needs, organization, and data structure in technological tools. However, these findings should not be generalized to all healthcare areas because one of the main features of this app is oxygen monitoring in a home-based environment and within the context of Colombian healthcare.

4.2. Future work

Future work related with this research will focus on developing the app (graphic design and programming) based on the same approach centered on final users; thus, usability testing with preliminary assessments of efficacy will be necessary. Subsequently, the launch version will be implemented in a non-pharmacological clinical trial (Naranjo-Rojas et al., 2021), over a period of 6 months (ClinicalTrials.gov: NCT04820790), in which remote monitoring and self-management of patients under home oxygen therapy and its effects on their clinical situation and quality of life will be assessed.

4.3. Conclusions

The focus groups allowed for exploring the needs and expectations of the study population as future users. In addition, this methodology gave the research group a more holistic view of what the end-users wanted to find in the application. Initially, the authors intended to design a mobile application with more information and a single user profile. However, at the end of the focus groups, the vision of a mobile health application designed from the context of the end-user allowed us to identify: (i) the organization and architecture based on the needs of the end-user, (ii) the importance of reducing the amount of information included in the app, and (iii) the need to create a profile for patients or their carers and another for health professionals. Professionals highlighted the need for an app that records clinical data, which can be interpreted using graphs and shows patients' clinical behavior trends, and aims at improving communication between colleagues in order to make timely decisions and that includes useful information to assess patients' compliance with the oxygen prescription. Conversely, patients and caregivers mentioned the need for an app that teaches them how to measure and record vital signs and that includes support at the time of checking oxygen use. Moreover, they mentioned the importance of participating in the control and verification of the correct use of home oxygen.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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