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ORIGINAL RESEARCH

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Evaluation of m-Health-rehabilitation for respiratory disorders: A systematic review

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Abstract

Background and Aims: Chronic respiratory diseases are prominent causes of morbidity worldwide that impose significant social and economic burdens on individuals and communities. Pulmonary rehabilitation is one of the main aspects of medical rehabilitation. Nowadays, mobile health apps deliver pulmonary rehabilitation support via smartphones. This article presents a systematic review of the literature on m-Health apps used in respiration disorders rehabilitation.

Methods: A systematic search was performed on MEDLINE (through PubMed), Web of Science, and Scopus in May 2021 without any date limitation. This study was using a combination of keywords and MeSH terms associated with pulmonary rehabilitation. Relevant studies were selected by two independents and were categorized studies results. The inclusion criterion was m-Health apps for pulmonary rehabilitation and exclusion criteria mobile-based interventions, by voice call or short message service and cardiopulmonary articles.

Results: Searching scientific databases yielded 161 relevant articles. Then, 27 articles were included in the study with a complete evaluation of the articles. Sixty percent of them were related to patients with chronic obstructive pulmonary disease (COPD). Rehabilitation aiming to improve the quality of life, promote self-management, encourage physical activity, and reduce the symptoms as the most common goals of pulmonary rehabilitation using m-Health apps; 89% of these studies showed that m-Health apps can be effective in improving pulmonary rehabilitation. In addition, 37% of studies reported high usability and acceptance. However, the results of some studies show that adherence to apps decreases in the long run.

Conclusion: Our study shows that m-Health pulmonary rehabilitation apps are effective in improving the quality of life, self-management, and physical activity. According to the results, it seems that using the m-Health apps for pulmonary rehabilitation can be useful in the COVID-19 pandemic and help reduce respiratory disorders in patients with COVID-19 disease.

KEYWORDS

COVID-19, mobile health, pulmonary, rehabilitation, respiration disorders

1 | BACKGROUND

Chronic respiratory diseases (CRD), as a major public health issue worldwide, impose significant social and economic burdens on individuals and communities.[1] According to the Global Burden of Diseases Study (GBD), in 2017, the prevalence of CRD was 545 million people of all ages, of which about 50% were due to chronic obstructive pulmonary disease (COPD) and about 50% due to asthma. Due to the rapid aging of the population, CRD is becoming a more prominent problem in the world.[2]

Pulmonary rehabilitation is a comprehensive therapeutic intervention for patients with respiratory disorders,[3] which is effective in improving their quality of life.[4] Pulmonary rehabilitation is defined as "a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include but are not limited to, exercise training, education, and behavior change designed to improve the physical and psychological condition of people with chronic respiratory disease and promote the long-term adherence to health-enhancing behaviors."[5] The benefits of pulmonary rehabilitation do not last over time and gradually disappear between 6 and 12 months after the end of pulmonary rehabilitation. Lack of commitment to rehabilitation seems to be one of the possible reasons for losing these benefits. Therefore, developing effective strategies to increase adherence to such interventions is key to maintaining the effects obtained after pulmonary rehabilitation.[5]

On the contrary, one of the greatest challenges of humanity in the 21st century is the coronavirus (COVID-19) epidemic. The severity of the disease varies from moderate to severe, and with any severity, it requires pulmonary rehabilitation. Therefore, physiatrists should investigate effective management plans for COVID-19 survivors with extrapulmonary involvement.[6] In patients with COVID-19, the goal of pulmonary rehabilitation is to improve the symptoms of shortness of breath, relieve anxiety, reduce complications, minimize disability, maintain function, and improve quality of life.[7] Due to its high speed of transmission, remote control, and management of this disease have become important.[8,9]

In this regard, the importance of using information and communication technology (ICT) as a tool for motivation and human interaction from afar has been emphasized.[10,11] ICT can be useful to increase access to health services.[12,13]

m-Health apps are one of the ICT that can be used for health care.[12,14] m-Health is defined by the World Health Organization (WHO) as "the function of medical and public health supported by mobile devices such as cell phones, patient monitoring devices, personal digital assistants and other wireless devices."[15] Today, the use of smartphones has increased, and m-Health uses smartphones as a complement to medical health care because some of its benefits extend beyond specific barriers to clinical health care.[16,17] m-Health apps offer new opportunities for access to health care, learning, self-management, and communication.[18,19] Based m-Health apps enhance self-management outcomes by providing support (e.g., information, education, and reminders) to patients.[20,21]

Various systematic reviews have been conducted on m-Health apps for COPD and asthma patients, but questions remain about the effectiveness of mobile use for pulmonary rehabilitation in various respiratory disorders. According to the COVID-19 epidemic, identifying effective studies in pulmonary rehabilitation using m-Health apps can be useful for the development of m-Health apps to reduce the complications of respiratory disorders after COVID-19. Therefore, this review addresses the following research questions: (1) How effective are m-Health apps in improving pulmonary rehabilitation?, (2) What are the objectives of using m-Health apps in pulmonary rehabilitation?, (3) How is adherence to m-Health apps in pulmonary rehabilitation?, (4) What are the capabilities and functions of apps?, and (5) What are the evidence and outcomes about the acceptability and usability of m-Health apps in pulmonary rehabilitation? By answering these questions, we achieve our aim of assessing the efficacy of mobile health in pulmonary rehabilitation.

2 | METHODS

2.1 | Literature search

The current systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist to ensure the inclusion of relevant studies.[22] A systematic search was conducted through MEDLINE (through PubMed), Web of Science, and Scopus in May 2021 without any date limitation. In this study, a combination of keywords and MeSH terms related to pulmonary rehabilitation have been used to retrieve studies (Table 1). A flow chart of search results is presented in Figure 1.

Articles were retrieved based on this search strategy. The inclusion criterion was m-Health apps for pulmonary rehabilitation. Exclusion criteria were (1) mobile-based interventions by voice call or short message service (SMS), (2) cardiopulmonary articles, and (3) thesis, book chapters, letters to editors, short communications, technical reports, reviews, or meta-analyses.

2.2 | Data extraction

After retrieving the articles based on the search strategy, S. A. and S. K. reviewed all the titles and abstracts to find relevant articles. Then,

TABLE 1 Keywords and search strategy

Keywords	Mobile health, m-Health, rehabilitation, lung, respiration disorders, pulmonary, chest therapy, breathing exercises
Search strategy	(["m-Health" OR "mobile health") AND (rehabilitation OR "breathing exercises" OR "chest therapy"]) AND (lung OR "respiration disorders" OR pulmonary)

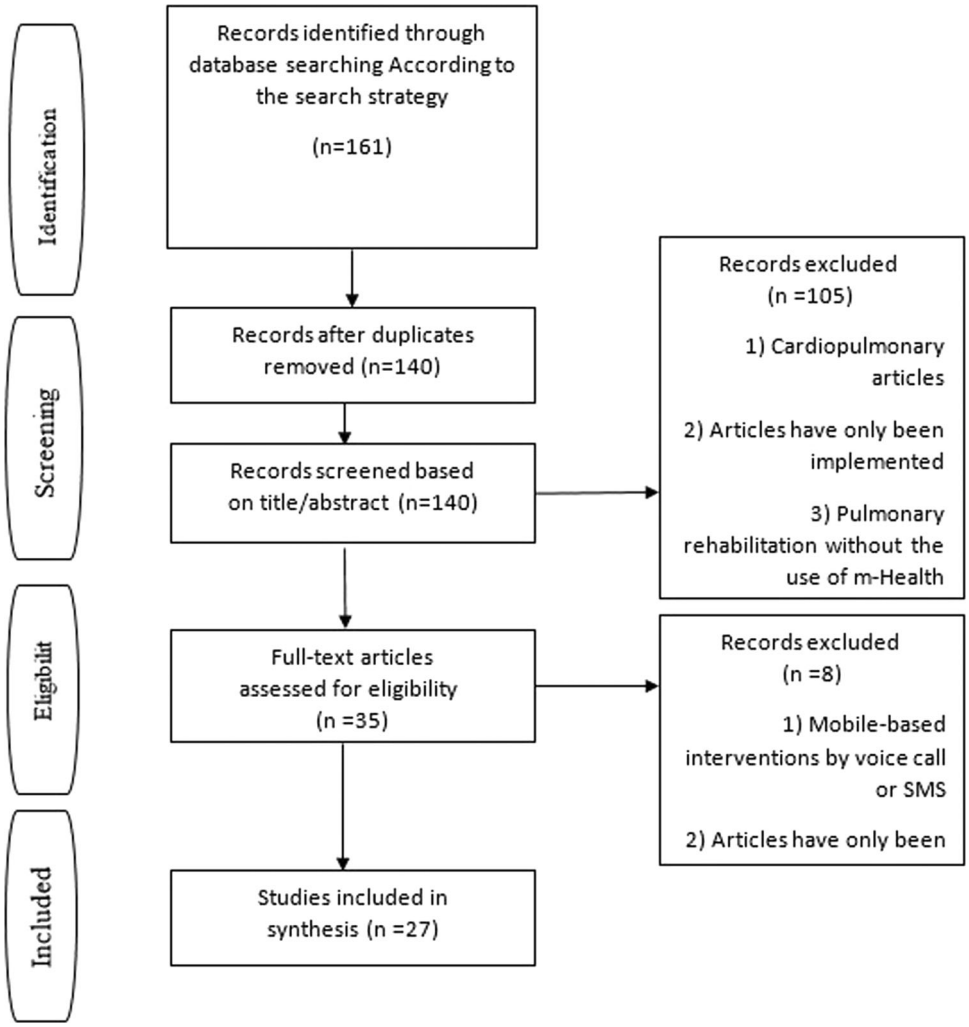

FIGURE 1 The flow diagram for the identification, screening, and eligibility of studies based on PRISMA

the articles that met the inclusion criteria were selected for full-text review. Subsequently, the full text of the relevant articles was fully evaluated by S. A. and S. K. If there was disagreement between the authors in the selection of the relevant articles, the final decision was made by A. Y. Specific categories were considered for the classification and analysis of related articles. The extraction forms were designed by researchers to manage and investigate the obtained information. The two authors (S. A. and S. K.) independently extracted the features of the articles by category. The next author (A. Y.) evaluated and confirmed the extracted information. EndNote software X9 was used to manage resources. Synthesis and analysis were performed using SPSS v25.

3 | RESULTS

Searching scientific databases retrieved 161 relevant articles. The initial evaluation was based on the title and abstract of the articles then, 27 articles were included in the study with a complete evaluation of the articles. The procedure of screening articles based on the PRISMA method is displayed in Figure 1.

From selected studies 16 articles related to patients with COPD,[5,23–37] three articles related to asthmatic patients,[18,38,39] six articles about cancer patients,[3,40,41] and lung transplantation[42–44] and one related to cystic fibrosis (CF)[45] and the last to patients with acute respiratory diseases.[46] The frequency of studies according to respiratory disorders is shown in Figure 2.

Most studies have focused on COPD, and few studies have examined the role of comorbidity in acute respiratory disease.

The objectives, functionality, and outcomes of each study are presented in Table 2. According to the literature review, the following categories were extracted to respond to research questions and achieve the objectives:

3.1 | The effectiveness of using m-Health apps in pulmonary rehabilitation

As a response to the first question, we concluded that in 89% of the selected studies, the use of m-Health apps in pulmonary rehabilitation was effective in improving the quality of life, self-management,

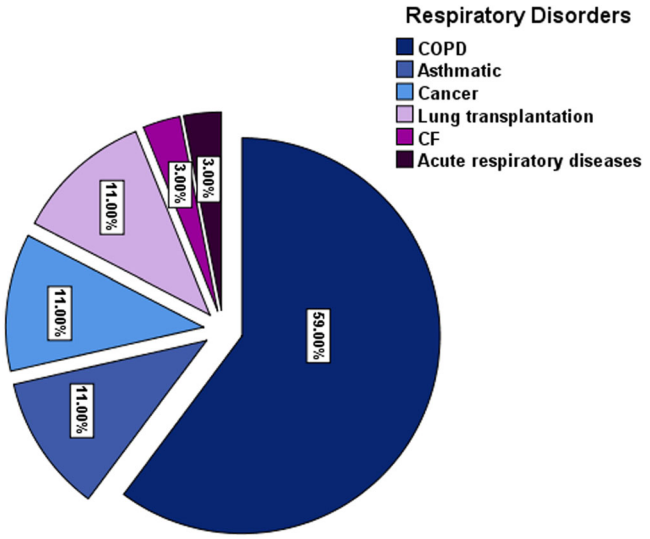

FIGURE 2 Frequency of studies according to respiratory disorders

and physical activity. In addition, patients whit respiratory disorders often experience long-term impairments in physical function and mental health including symptoms of depression and anxiety, which reduce the quality of life[46] and increase the complexity of treatment management,[28] some articles have also examined the impact of m-Health apps on mental health. Results showed that m-Health apps improved access to mental health care.[28,35,40,46,47]

3.2 | Objectives of using m-Health apps in pulmonary rehabilitation

Pulmonary rehabilitation is an interdisciplinary and patient-centered intervention, including exercise training and behavioral interventions aiming to strengthen self-management. Pulmonary rehabilitation refers to the systemic effects of chronic respiratory disease, including physical ventilation, symptoms of anguish and depression, and inconsistent behaviors such as sedentary lifestyles and poor adherence to treatments.[48] In response to the question of what the objectives of using m-Health apps in pulmonary rehabilitation are, we concluded that the most common objectives of pulmonary rehabilitation were to improve the assessment quality of life, promote self-management, improve physical activity, and the patient symptoms. This will be explained more in the following section:

3.2.1 | Self-management

Self-management is defined as an individual's ability to manage the symptoms, treatment, physical, psychological, and social consequences of chronic disease.[49] The results of the study showed a significant positive change in self-management that is associated with patient empowerment and participation in treatment.[29,30,35,36,38–40,42,43,45]

3.2.2 | Improvement of physical activity

Physical activity aims to improve or maintain physical fitness and health.[50] A significant body of evidence shows that improving exercise capacity leads to increased physical activity and reduced respiratory-related hospitalizations. So physical activity is important in rehabilitation interventions.[25] From selected studies, 12 studies focused on physical activity. The studies used sensors such as pedometers, mobile sensors, accelerometers, and so forth, to evaluate physical activity. Some of these apps also had an alert (if not using the apps for a long time), a motivational message, or a reminder to improve physical activity. The results showed that m-Health apps can improve health and physical activity.[5,23–25,30,32–34,37,40,44,47]

3.2.3 | Improvement of patient symptoms

Symptoms are defined as the manifestations of the respiratory system in diseases of the respiratory system.[51] Exacerbation of symptoms significantly affects patient health status. Exacerbation of symptoms in COPD and asthma leads to worsening respiratory conditions.[26] On the contrary, lung cancer causes many symptoms such as shortness of breath, fatigue, anxiety, depression, and pain. Reducing these symptoms improves the survival of patients with lung cancer.[3] Therefore, proper management of symptoms is very important for patients with respiratory disorders. According to the results of the present study, collecting and sending patients' respiratory symptoms to physicians through m-Health apps leads to improving symptoms of the disease.[3,18,23,25,38–40,47]

3.2.4 | Assessment quality of life

Quality of life is a general concept that reflects concern about improving life traits.[52] One of the goals of using the m-Health apps was to improve the quality of life in patients with respiratory disorders. In some studies, patients' quality of life was assessed using various instruments such as health-related quality of life (HRQoL), quality of life (QoL), COPD test assessment (CAT), St. George's Respiratory Questionnaire (SGRQ), and more. Hence, it seems that m-Health apps play an effective role in improving the quality of life.[3,5,23,25,30,31,38,39,47]

3.3 | Adherence to rehabilitation pulmonary m-Health apps

To find the response to the third research question, we examined the degree of adherence to pulmonary rehabilitation m-Health apps. Lack of adherence to rehabilitation intervention seems to be one of the possible reasons for the loss of health benefits and creating effective strategies to increase adherence to such apps is key to maintaining the effects of pulmonary rehabilitation.[5] Some studies have examined

TABLE 2 Studies in the field of respiration disorders and their characteristics

	Study objectives						Functionality			
Authors/year	Self-management	Improvement of physical activity	Improvement of patient symptoms	Assessment quality of life	usability/acceptability evaluation	Respiratory disorders	Notification (alert and reminder)	Sensor	integration with electronic healthcare systems	Outcome
Kooij (2021)[36]	✓					COPD	NM	NM	NM	They concluded that the use of a self-management app after discharge from the hospital is possible for a small number of patients.
Diamond (2021)[44]		✓			✓	Lung transplant	NM	NM	NM	The results showed that the m-Health app enhanced motivation to engage in rehabilitation.
Bentley (2020)[34]	✓	✓				COPD	NM	Fitbit wearable activity tracking device	NM	The results showed that the m-Health app helps people with COPD in self-management and affects physical activity.
Khusial (2020)[39]	✓		✓	✓	✓	Asthma	NM	An inhaler adapter, an indoor air-quality monitor, a physical activity tracker, a portable spirometer, a fraction exhaled nitric oxide device	NM	Using the myAirCoach improves asthma control and quality of life. Users also reported positive attitudes towards the app.
Parker (2020)[46]					✓	Acute respiratory failure survivors	NM	NM	NM	The results showed that the app was usable and acceptable and that the self-government application might be valuable in increasing motivation.
Wang (2020)[30]	✓			✓		COPD	NM	NM	NM	The m-Health app was effective in improving quality of life and self-

(Continues)

TABLE 2 (Continued)

Authors/year	Study objectives					Respiratory disorders	Functionality			Outcome
	Self-management	Improvement of physical activity	Improvement of patient symptoms	Assessment quality of life	usability/ acceptability evaluation		Notification (alert and reminder)	Sensor	integration with electronic healthcare systems	
										management behavior in patients with COPD.
Henshall (2020)[40]	✓	✓	✓			Lung cancer	NM	NM	NM	This app has shown its value as a manageable self-management tool.
Jiménez-Reguera (2020)[5]		✓		✓		COPD	Medication reminder	NM	NM	The results showed that an integrated health care app could create a more active and responsible attitude towards self-care and commitment.
Colombo (2020)[31]		✓	✓			COPD	NM	Pulse oximeter	NM	MyDA was a practical and valuable solution to motivate the elderly to continue rehabilitation at home
Morita (2019)[18]	✓				✓	Asthma	medication reminder via email	NM	connecting to the TELUS Health Space	People with asthma report good usability and high levels of satisfaction with using the m-Health app.
Park (2019)[47]		✓	✓	✓		Lung cancer	Provides a warning about taking medication, doing rehabilitation exercises, and visiting the clinic as scheduled	The portable pulse oximeter, thermometer	NM	Pulmonary rehabilitation based on the m-health app was reported effective.
Ji (2019)[3]			✓	✓		Lung cancer	NM	Wearable pulse oximeter	NM	The m-health app can improve the improvement of physical activity, dyspnea, and quality of life.

TABLE 2 (Continued)

Authors/year	Study objectives					Respiratory disorders	Functionality			Outcome
	Self-management	Improvement of physical activity	Improvement of patient symptoms	Assessment quality of life	usability/ acceptability evaluation		Notification (alert and reminder)	Sensor	integration with electronic healthcare systems	
Ding (2019)[23]	✓		✓	✓		COPD	Monitor symptoms	Internal motion sensors in smartphones	NM	MH-COPD provides evidence of the effectiveness of using the m-Health app to improve COPD care.
Rudolf (2019)[45]					✓	CF	Customizable medication reminders, including barcode scanner help and a voice reminder system.	NM	NM	Most of the patients did not want to continue using the app after the study period. Only a few CF-specific aspects of weighted life satisfaction were possibly stabilized by the m-Health app; clinical parameters were not affected. Adaptation of the functions to adolescent-specific needs could improve the long-term use and thus positively affect the disease course.
Boer (2019)[26]	✓					COPD	NM	Pulse oximeter, thermometer	NM	This study did not show the beneficial effects of an m-Health app on exacerbation-free time, health status, self-efficacy, self-management behavior, and health care utilization compared with the use of a paper action plan.
Whelan (2019)[28]					✓	COPD	NM	Pulse oximeter with Bluetooth	NM	Monitoring of anxiety and depression symptoms was feasible.
	✓		✓	✓		Asthma	NM	NM	NM	

(Continues)

TABLE 2 (Continued)

	Study objectives						Functionality			
Authors/year	Self-management	Improvement of physical activity	Improvement of patient symptoms	Assessment quality of life	usability/acceptability evaluation	Respiratory disorders	Notification (alert and reminder)	Sensor	integration with electronic healthcare systems	Outcome
Fedele (2018)[38]										Results measure changes in family management of asthma, quality of life and self-efficacy for asthma management, and feasibility, acceptance, and use of AIM2ACT throughout the RCT.
Loeckx (2018)[24]		✓			✓	COPD	Audio reminder to record and send counter data	Step counter	NM	The intervention was well accepted and feasible for patients and their coaches.
Kwon (2018)[25]		✓		✓		COPD	NM	Wearable pulse oximeter	NM	A mobile rehabilitation app could complement or replace traditional rehabilitation programs and improve the disease.
Vorrink (2016)[31]		✓		✓		COPD	Automated persuasive messages an emoticon	Accelerometer	NM	Compared to usual care, no differences were observed in physical activity, functional exercise capacity, HRQoL outcomes, or BMI.
Vorrink (2016)[32]		✓		✓		COPD	Real-time feedback on daily physical activity (DPA)	NM	NM	mobile phone is known as a suitable and practical interface for eHealth intervention.
Shellmer (2016)[42]	✓				✓	Solid organ transplant patients	Text message for drug dose	NM	NM	All adolescents were interested in using TPP for monitoring medications and satisfaction with the

TABLE 2 (Continued)

Authors/year	Study objectives					Respiratory disorders	Functionality			Outcome
	Self-management	Improvement of physical activity	Improvement of patient symptoms	Assessment quality of life	usability/ acceptability evaluation		Notification (alert and reminder)	Sensor	integration with electronic healthcare systems	
										automatic messaging between adolescent and caregiver versions of the app. Adolescents unanimously found TPP easy to use.
Rosenberger (2016)[43]	✓					Lung transplant recipients	Drug alerts and reminders	NM	NM	Self-monitoring was associated with a reduced risk of mortality. Although Pocket PATH did not have a direct impact on long-term outcomes early improvements in self-management facilitated by Pocket PATH may be associated with long-term clinical benefits.
Hoaas (2016)[35]					✓	COPD	NM	Pulse oximeter	NM	Patients were generally satisfied with the technical components of the telerehabilitation intervention.
Pereira (2016)[33]	✓	✓				COPD	Exchange messages with other users, professionals, and healthcare providers	Pulse oximeter	NM	Patients recognized the usefulness of monitoring their disease using the Exercit@rt m-Health app. this app can help patients contribute to their quality of life and autonomy, enabling them to perform respiratory exercises

(Continues)

TABLE 2 (Continued)

Authors/year	Study objectives					Respiratory disorders	Functionality			Outcome
	Self-management	Improvement of physical activity	Improvement of patient symptoms	Assessment quality of life	usability/acceptability evaluation		Notification (alert and reminder)	Sensor	integration with electronic healthcare systems	
										and daily life physical activities.
Hardinge (2015)[29]	✓				✓	COPD	Personal alert threshold generation was used for symptom score, oxygen saturation, and pulse rate.	Pulse oximeter	NM	The m-Health self-management app was feasible and acceptable to patients
Williams (2014)[27]	✓					COPD	NM	Pulse oximeter	NM	They showed that interventions using a m-Health app improve patients' self-management.

Abbreviations: BMI, body mass index; CF, cystic fibrosis; COPD, chronic obstructive pulmonary disease; HRQoL, Health-Related Quality of Life; NM, not mentioned in the article; RCT, randomized controlled trial; TPP, teen pocket PATH.

adherence apps;[5,35,45] which their results show adherence to apps has decreased in the long term.

3.4 | Functionality

To respond to the fourth question, we considered the sensors, integration with electronic health care systems (e.g., electronic health records [EHR]), alerts, and reminders. According to Table 2, the sensors can be roughly divided into two categories: (1) physical activity sensors, which included accelerometers, mobile sensors, wearable trackers, and so forth. (2) blood oxygen level sensors, which were most used. Ten studies used pulse oximeter sensors to measure blood oxygen saturation levels.[24,25,27–29,35,37,47] In just one study, the m-Health app was integrated with the EHR through TELUS Health Space, the local version of Microsoft HealthVault (a web-based personal health record created by Microsoft).[18]

3.5 | Assessment usability/acceptability apps

An important factor for the successful implementation of the electronic intervention is the involvement of users in the design process. Design defects can affect the ease of use usability, and acceptability of the system. That may reduce the user's willingness to use these technologies for interventions.[32] The purpose of usability testing is to identify performance problems, observe user performance and determine user satisfaction.[53] Therefore, to answer the fifth question, we evaluated the results of studies that examined usability and acceptability. Ten studies examined the usability of m-Health apps in pulmonary rehabilitation and reported the use of high usability and acceptability.[18,24,28,29,35,39,42,44–46]

4 | DISCUSSION

Studies showed that pulmonary rehabilitation improves the quality of life, self-management, physical activity, mental health, adherence to the m-Health apps, and symptoms. In the following part, the effectiveness of m-Health apps in pulmonary rehabilitation is described based on the pulmonary disorder:

4.1 | COPD

The kinds of literature about rehabilitation COPD patients with m-Health apps are plentiful (Table 2). According to our review, 16 studies of 27 research for the rehabilitation of patients with COPD reported the positive efficacy of the m-Health apps.[5,23–25,28–30,32–37] COPD requires integrated care and management. The management of this chronic disease has shifted from acute treatment of symptoms to a prevention strategy. Recently, various approaches have been used to manage this disease, including pulmonary rehabilitation using m-Health. Pulmonary rehabilitation has been shown to improve quality of life, exercise tolerance, shortness of breath, and improve symptoms in patients with COPD.[54] Also, the benefits of pulmonary rehabilitation are such that they have been compared to other strategies such as optimal drug treatment in terms of cost-effectiveness.[5] The mentioned materials can be the reason for the interest of the research community in this population. For example, Ding et al. proposed an innovative m-Health app (MH-COPD) to improve self-management for COPD patients. They evaluated the results of COPD symptoms and quality of life using the CAT, SGRQ, and modified Medical Research Council (mMRC) questionnaires; MH-COPD provided evidence of the effectiveness of using the m-Health app to improve COPD care in the community.[23] Jiménez-Reguera et al. developed and evaluated HappyAir app. They used three different (CAT, SGRQ, Euro QOL-5D) self-report questionnaires to assess the quality of life. The results of this study showed that adherence to the app improves if the use of the app is accompanied by patient awareness and participation.[5] Kwon et al. developed the Efil Breath app. A well-user interface mobile rehabilitation application for monitoring and managing patients with COPD can supplement or replace traditional center-based rehabilitation intervention and achieve improved patient health outcomes. They used CAT and mMRC questionnaires.[25] Wang et al. evaluated the effectiveness of an m-Health app in terms of self-management on the quality of life, self-management behavior, exercise, and smoking cessation behavior in patients with COPD. To assess self-management behavior, the authors used the COPD self-management scale (CSMS) that includes five domains (symptom management, daily life management, emotion management, information management, and self-efficacy). They assessed the HRQol app using the CAT questionnaire. This application was effective in improving the quality of life and self-management behavior in patients with COPD.[30] However, three studies did not show the beneficial effects of m-Health. For example, Vorrink et al. evaluated the effectiveness of a previously developed m-Health app intervention to stimulate physical activity in COPD patients after pulmonary rehabilitation. They examined the HRQoL app. Compared to usual care, no differences were observed in physical activity, functional exercise capacity, HRQoL outcomes, or BMI in patients with COPD, using this intervention.[31] Boer et al.'s study did not show the beneficial effects of an m-Health app on exacerbation-free time, health status, self-efficacy, self-management behavior, and health care utilization in patients with COPD, compared with the use of a paper action plan.[26]

4.2 | Asthma

According to three studies, m-Health apps help asthma control and management.[18,38,39] For example, Morita et al. designed and developed a multipurpose platform, a collaborative self-management m-Health app for asthma patients, based on the clinical content of international evidence-based guidelines, using the user-centered design process. In their study, people with asthma reported a high

level of satisfaction. This app enables self-management through instant access to the app, display of environmental conditions, and air quality reduction messages. Also, they examined usage patterns in the context of known patient characteristics and linked increased use to physician supervision, email reminders, and age 50 and older.[18] Khusial et al. evaluated the clinical effectiveness and technology acceptance of myAirCoach-supported self-management on top of usual care in patients with asthma using inhalation medication. The results showed using the myAirCoach app improved asthma control and quality of life.[39]

4.3 | Cancer

Based on three studies performed on cancer patients, m-Health apps were involved in improving the management of symptoms and quality of life in these patients.[3,40,47] For example, Park et al. evaluated the effectiveness of smartphone apps on exercise capacity, symptom management, and quality of life in patients with non-small cell lung cancer undergoing chemotherapy. They used the questionnaires for measuring QoL, distress, including anxiety (generalized anxiety disorder-7 [GAD-7]) and depression (Patient Health Questionnaire-9 [PHQ-9]), symptom (the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-C30 [EORTC QLQ-C30]), and pain (numeric rating scale [NRS]). m-Health apps for pulmonary rehabilitation were effective in patients with advanced lung cancer who were undergoing chemotherapy.[47]

4.4 | Transplantation

Three studies have been performed on transplant patients, and the effectiveness of the m-Health apps in improving self-management in these patients has been expressed.[42–44] Two of these studies used the Pocket PATH app. Pocket PATH is one of the few m-Health app interventions on self-management for lung transplant recipients who have undergone a rigorous process of development, pilot testing, and formal evaluation. Its features include alerts and reminders about taking immunosuppressants, customized data recording and graphing apps for tracking health indicators and symptoms, and decision support to guide the patients about when to seek clinical assistance.[43] For example, Rosenberger et al. examined the association between Pocket PATH exposure during one year and long-term clinical outcomes- mortality and bronchiolitis obliterans syndrome (BOS). In this study, all adolescents were interested in using the app for monitoring medications and satisfaction with the automatic messaging between adolescent and caregiver versions of the application. Adolescents unanimously found the app easy to use. Self-monitoring was associated with a reduced risk of mortality.[43]

According to the results of the studies, adherence to m-Health apps is a prerequisite for changing positive behavior and improving health outcomes. User-centric design is important to increase adherence. The purpose of this type of design is to create and maintain a certain level of adherence.[18] Despite the high level of ease of use and satisfaction of m-Health apps, the actual use of these apps decreases over time. According to studies, the following solutions can help improve adherence to apps:

- Reduce duplicate content and eliminate heavy inputs.
- Automatic alerts and motivational messages via app notifications.
- Consideration of factors such as age, technology experience, level of education, and possible comorbidities when developing m-Health programs.
- Interact with patients, especially the elderly, in designing and testing to ensure ease.
- Providing support and advice (counseling is divided into two categories: social support and technical support).

The functionality review of apps shows that spirometry has been considered. Measurement of lung function is the cornerstone of pulmonary diagnosis, treatment evaluation, and prognosis. Without access to pulmonary function tests, many patients will not be properly diagnosed or treated incorrectly. The use of spirometry seems to be because studies have shown that daily home spirometry is an effective tool for diagnosing the progression of idiopathic pulmonary fibrosis and is involved in the early diagnosis of infection.[55] Also, in some patients, such as those with asthma, repeated measurements of pulmonary function at home can help assess symptoms and thus better control.

In addition, we examined the integration of apps with other health systems. In just one study, the app was integrated with EHR. While this issue should be given more attention. The EHR provides information about an individual's health status in a computer-processable manner to professionals, enabling real-time access to clinical records. EHR systems reduce errors through allergy alerts, access to laboratory data.[56] The collection and effective use of clinical information is essential for the provision of quality healthcare services. HER data can be used for this purpose. Patients' data collected through EHR can be used in research and provide an opportunity to study diseases and extract clinical knowledge.[57] Integrating EHR with other systems and software, including mobile apps, can further enhance its potential benefits. When apps are integrated with the EHR, they fully optimize its efficiency.[58] Features such as secure messaging and features such as viewing, downloading, and transferring data to the EHR facilitate the exchange of patient data with specialists. But other EHR costs such as resources, internet connection, staff training, and system support should also be considered. Our study showed that m-Health apps can be effective in improving pulmonary rehabilitation. On the contrary, the current COVID-19 epidemic has put significant pressure on medical resources around the world. Pulmonary rehabilitation seems to be of particular importance. The goal of pulmonary rehabilitation in COVID-19 patients is to improve the symptoms of shortness of breath, relieve anxiety, reduce complications, minimize disability, maintain function, and improve quality of life.[59] Due to the lack of equipment and the high risk of COVID-19 outbreak, there is a new

need for digital technologies and home health care. Rehabilitation should be done through telemedicine with minimal contact.[59] m-Health apps are a subset of telemedicine technologies. Therefore, mobile apps can be used in epidemic conditions. According to the results of the present study, which show that m-Health apps are an effective tool for pulmonary rehabilitation, seems that it is possible to use this technology effectively for the pulmonary rehabilitation of patients with COVID-19.

One limitation to our study is that most studies did not report detailed app capabilities such as alerts, sensors, and so on. So no conclusions can be drawn about the impact of these factors on app effectiveness.

5 | CONCLUSION

The results of the present study show the effectiveness of using the m-Health apps and their effective application in pulmonary rehabilitation to help patients with respiratory disorders. The multipurpose m-Health apps have the acceptable potential for improving quality of life, self-management, improving symptoms, and helping to increase physical activity in patients with respiratory disorders. However, the long-term consequences of adhering to such interventions are contradictory. With the high prevalence of CRD and its exacerbation due to the COVID-19 epidemic, the need to use technology in the management of these diseases is felt more than ever. Due to the high penetration rate of smartphones, the investment of health organizations in mobile-based rehabilitation can be effective in reducing the economic and social burden of respiratory disorders. According to the results of this study and the positive impact of m-Health apps on pulmonary rehabilitation and its importance, the development and use of m-Health apps for pulmonary rehabilitation of COVID-19 patients are recommended for future studies. Also, because most m-Health apps studies are not integrated with EHRs, more work is needed to determine how to integrate, record data generated by the m-Health apps into the existing electronic medical records, how to combine and organize data.

AUTHOR CONTRIBUTIONS

Shamim Kiani: conceptualization; methodology; visualization; writing—review and editing. **Sanaz Abasi**: conceptualization; formal analysis; methodology; writing—original draft. **Azita Yazdani**: conceptualization; formal analysis; methodology; supervision; validation; visualization; writing—original draft; writing—review and editing. All authors have read and approved the final version of the manuscript. Dr. Azita Yazdani had full access to all of the data in this study and take complete responsibility for the integrity of the data and the accuracy of the data analysis.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

All data analyzed for and presented in this paper are from the twenty-seven studies we reviewed. The data is accessible via referenced articles.

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