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Digital Health Intervention in Pulmonary Rehabilitation for Chronic Obstructive Pulmonary Disease: A Systematic Review

Ananda Liza Putri Sarah
RSUD Waled, Indonesia
Email: anandalizaputri@gmail.com

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Abstract

Chronic obstructive pulmonary disease (COPD) is a major contributor to global morbidity and mortality. Although pulmonary rehabilitation (PR) improves exercise capacity and health-related quality of life (HRQoL), participation in conventional center-based programs remains limited due to accessibility, financial, and geographic barriers. Digital health interventions have emerged as potential solutions to expand the delivery of PR services. This systematic review aimed to evaluate the effectiveness of digital health interventions in pulmonary rehabilitation for individuals with COPD. A systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Literature searches were performed in Google Scholar, PubMed, Emerald, and SpringerLink for studies published from January 2022 to June 2026. Eligible studies included adults with COPD who received digital health-supported PR interventions, including tele-rehabilitation, telemedicine, mobile health (mHealth), smartphone applications, wearable devices, remote monitoring, and web-based rehabilitation. Data were synthesized narratively due to variations in study designs and outcome measures. Fifteen studies were included in the review. Digital health interventions consistently improved exercise capacity, symptom management, HRQoL, rehabilitation adherence, and patient engagement. Smartphone applications and telerehabilitation demonstrated outcomes comparable to conventional PR while improving accessibility and continuity of care. Remote monitoring and mHealth platforms supported self-management and long-term participation. Successful implementation was influenced by health literacy, user-friendly technologies, and institutional support. Digital health interventions are effective and feasible approaches for supporting pulmonary rehabilitation among individuals with COPD. Their integration may improve accessibility, adherence, and clinical outcomes. Further multicenter studies are needed to evaluate long-term effectiveness and optimize implementation in routine clinical practice.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) remains one of the leading causes of morbidity and mortality worldwide, posing a substantial burden on patients and healthcare systems. Pulmonary rehabilitation (PR) is a cornerstone of COPD management, with strong evidence demonstrating its effectiveness in improving exercise capacity, reducing dyspnea, enhancing health-related quality of life (HRQoL), and decreasing healthcare utilization (Long et al., 2023; Religioni et al., 2025; Singh et al., 2025; Zhang et al., 2026). Nevertheless, participation in conventional center-based PR programs remains limited due to barriers such as transportation difficulties, geographical disparities, financial constraints, and limited availability of specialized rehabilitation services (Gao et al., 2025; Park et al., 2025; Yoon &

Song, 2026). These challenges have accelerated the adoption of digital health technologies as alternative approaches to improve the accessibility and continuity of pulmonary rehabilitation services.

Pulmonary rehabilitation (PR) is a cornerstone of COPD management, with strong evidence demonstrating its effectiveness in improving exercise capacity, reducing dyspnea, enhancing HRQoL, and decreasing healthcare utilization (Long et al., 2023; Religioni et al., 2025; Singh et al., 2025; Zhang et al., 2026). PR is defined as a comprehensive intervention based on a thorough patient assessment, followed by patient-tailored therapies that include exercise training, education, self-management interventions, and behavior change strategies designed to improve the physical and psychological conditions of individuals with chronic respiratory diseases (Rochester et al., 2023). Despite its proven benefits, participation in conventional center-based PR programs remains considerably low. Evidence indicates that only 1–2% of eligible patients with COPD participate in PR programs, with dropout rates ranging from 30% to 50% (Gao et al., 2025; Park et al., 2025; Yoon & Song, 2026). Barriers to participation include transportation difficulties, geographical disparities, financial constraints, limited availability of specialized rehabilitation services, and insufficient awareness among both patients and healthcare providers (Gao et al., 2025; Park et al., 2025; Yoon & Song, 2026). These challenges were further exacerbated by the COVID-19 pandemic, which disrupted conventional rehabilitation services and accelerated the adoption of digital health technologies as alternative approaches to improve the accessibility and continuity of pulmonary rehabilitation (Rutkowski, 2021; Wen et al., 2022).

Digital health interventions, including tele-rehabilitation, telemedicine, mobile health (mHealth), wearable devices, web-based rehabilitation platforms, and remote patient monitoring, have emerged as promising strategies to support pulmonary rehabilitation beyond conventional clinical settings (Al-Jabr et al., 2025). Evidence indicates that digital PR can achieve improvements in exercise capacity, dyspnea, and HRQoL comparable to conventional rehabilitation while enhancing patient adherence and self-management through personalized exercise programs, real-time monitoring, and remote feedback (Al-Jabr et al., 2025; Quispe et al., 2024; Rutkowski, 2021; A. J. Shah et al., 2023; N. M. Shah & Kaltsakas, 2021; Wen et al., 2022). Furthermore, wearable technologies and home-based rehabilitation programs have demonstrated encouraging results in increasing physical activity levels and maintaining rehabilitation participation, although their effectiveness varies according to intervention design and implementation strategies (Daniels et al., 2024; Robinson & Moy, 2022).

Despite these promising findings, current evidence remains heterogeneous regarding intervention modalities, implementation strategies, outcome measures, and long-term effectiveness. Previous reviews have generally focused on specific technologies, such as tele-rehabilitation or wearable devices, without comprehensively synthesizing the broader spectrum of digital health interventions used in pulmonary rehabilitation (Takáč, 2025). Moreover, rapid advances in digital technologies and the increasing integration of telehealth, mHealth, wearable monitoring, and remote coaching into routine COPD care highlight the need for an updated synthesis of current evidence (Bhaskar et al., 2020; Liu et al., 2026).

Therefore, this systematic review aimed to comprehensively evaluate the effectiveness of digital health interventions in pulmonary rehabilitation for individuals with COPD. By synthesizing evidence across various digital health modalities, this review sought to compare

their clinical effectiveness, summarize implementation characteristics, identify existing research gaps, and provide evidence to support the integration of digital health technologies into pulmonary rehabilitation programs and future clinical practice.

METHOD

Study Desain

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review aimed to evaluate the effectiveness of digital health interventions implemented in pulmonary rehabilitation programs for individuals with chronic obstructive pulmonary disease (COPD). The review process involved systematic literature identification, study selection, data extraction, quality assessment, and narrative synthesis of the available evidence.

Eligibility Criteria

The eligibility criteria were established using the Population, Intervention, Comparison, Outcomes, and Study Design (PICOS) framework.

Population (P): Studies involving adults aged 18 years or older with a confirmed diagnosis of chronic obstructive pulmonary disease (COPD) according to recognized diagnostic criteria, including the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines or physician diagnosis.

Intervention (I): Studies evaluating digital health interventions integrated into pulmonary rehabilitation programs, including but not limited to tele-rehabilitation, telemedicine, telehealth, mobile health (mHealth) applications, smartphone applications, web-based rehabilitation platforms, wearable devices, remote patient monitoring systems, virtual rehabilitation, digital coaching, and other technology-assisted rehabilitation approaches.

Comparison (C): Conventional pulmonary rehabilitation, usual care, standard clinical management, face-to-face rehabilitation, or no intervention.

Outcomes (O): Primary outcomes included exercise capacity (e.g., six-minute walk distance [6MWD]), health-related quality of life, dyspnea severity, pulmonary function, and physical activity. Secondary outcomes included adherence to rehabilitation, patient satisfaction, hospitalization, COPD exacerbation, healthcare utilization, and adverse events.

Study Design (S): Randomized controlled trials (RCTs), non-randomized controlled studies, controlled clinical trials, quasi-experimental studies, and prospective cohort studies evaluating the effectiveness of digital pulmonary rehabilitation interventions.

Studies were excluded if they (1) involved pediatric populations, (2) included participants without COPD or did not report COPD-specific data separately, (3) were conference abstracts, editorials, letters, study protocols, reviews, commentaries, or case reports, (4) were not published in peer-reviewed journals, or (5) were published in languages other than English.

Information Sources

A literature search was conducted in the following electronic databases: Google Scholar, *PubMed*, *Emeral and Springer Link*. The search included studies published from January 2022 to Juni 2026, without geographical restrictions. Additionally, the reference lists of all included studies and relevant systematic reviews were manually screened to identify potentially eligible articles that were not retrieved through the electronic database search.

Search Strategy

The search strategy combined Medical Subject Headings (MeSH) and free-text keywords related to COPD, pulmonary rehabilitation, and digital health interventions. Boolean operators ("AND" and "OR") were used to optimize the search.

The PubMed search strategy was developed as follows:

("Pulmonary Disease, Chronic Obstructive" OR COPD OR "Chronic Obstructive Pulmonary Disease")

AND ("Pulmonary Rehabilitation"[Mesh] OR "pulmonary rehabilitation")

AND ("Digital Health" OR Telemedicine OR Telehealth OR Telerehabilitation OR "Mobile Health" OR mHealth OR eHealth OR Smartphone OR "Mobile Application" OR Wearable OR "Remote Monitoring" OR "Digital Intervention" OR "Virtual Rehabilitation" OR "Web-based Rehabilitation")

The search strategy was adapted appropriately for each database while maintaining equivalent search concepts and Boolean logic.

Study Selection

All identified records were imported into reference management software, and duplicate articles were removed before screening. Two independent reviewers screened titles and abstracts according to the predefined eligibility criteria. Full-text articles were subsequently retrieved and assessed for eligibility. Disagreements between reviewers were resolved through discussion, and if consensus could not be reached, a third reviewer was consulted. The study selection process was documented using the PRISMA 2020 flow diagram.

Data Synthesis

Due to the anticipated heterogeneity in digital health interventions, rehabilitation protocols, outcome measures, and follow-up durations, findings were synthesized using a narrative approach. The included studies were grouped according to the type of digital health intervention, including tele-rehabilitation, mobile health applications, wearable technologies, remote monitoring, web-based rehabilitation, and hybrid digital pulmonary rehabilitation models.

The effectiveness of interventions was summarized across key outcomes, including exercise capacity, quality of life, dyspnea, physical activity, adherence, hospitalization, exacerbation rate, and patient satisfaction. Where appropriate, similarities and differences across intervention types were compared to identify emerging evidence and research gaps.

RESULTS AND DISCUSSION

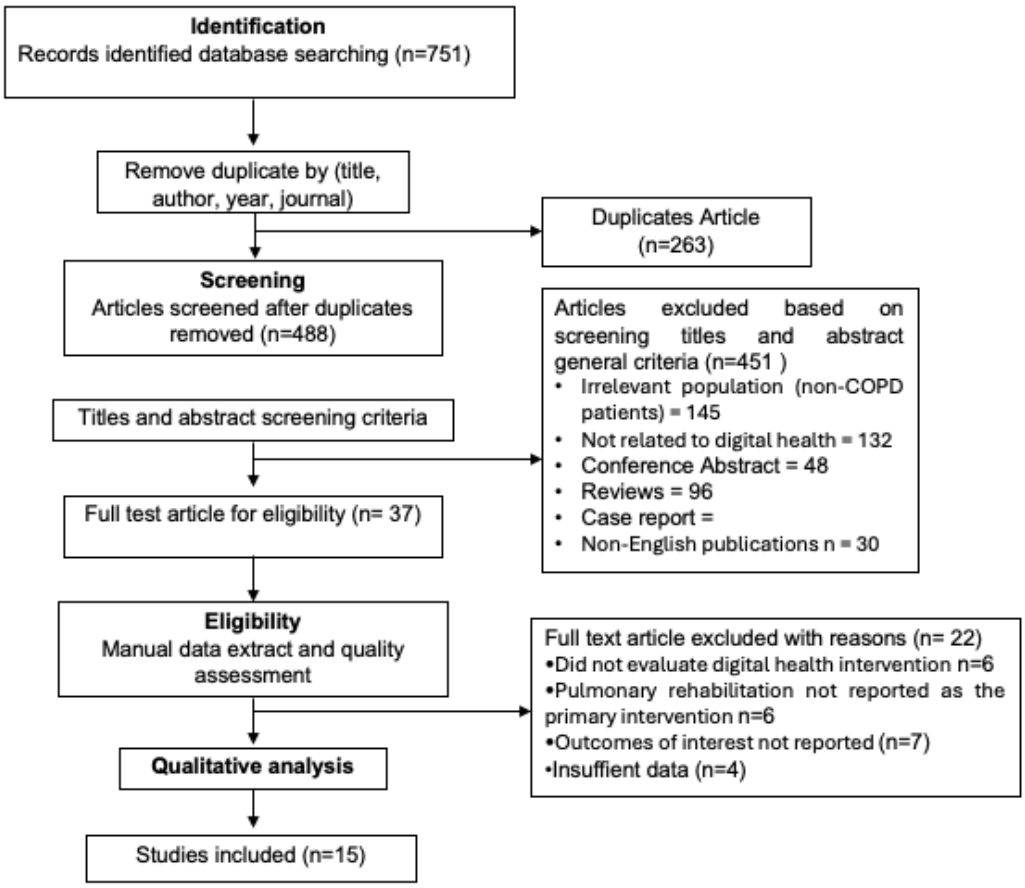


Figure 1. Gold PRISMA/Flow Chart
Source: Adapted from Page et al. (2021)

The literature search identified 751 records from electronic databases. After removing 263 duplicate records, 488 articles remained for title and abstract screening. During this stage, 451 articles were excluded because they involved an irrelevant population (n = 145), were not related to digital health interventions or pulmonary rehabilitation (n = 132), were reviews, systematic reviews, meta-analyses, guidelines, or commentaries (n = 96), were conference abstracts (n = 48), or were published in languages other than English (n = 30).

A total of 37 full-text articles were assessed for eligibility. Of these, 22 studies were excluded because they did not evaluate a digital health intervention (n = 6), pulmonary rehabilitation was not the primary intervention (n = 6), the outcomes of interest were not reported (n = 7), or insufficient data were available for data extraction (n = 4). Consequently, 15 studies met the predefined eligibility criteria and were included in the qualitative synthesis. The study selection process is presented in **Figure 1**.

Table 1. Characteristics of Study

Author (Year)	Country	Study Design	Population	Sample Size	Intervention	Comparison	Outcomes	Main Findings
Li et al. (2022)	China	Randomized Controlled Trial	Stable COPD	140	Remote pulmonary rehabilitation via WeChat	Hospital-based PR and usual care	6MWD, CAT, mMRC, AECOPD	Remote pulmonary rehabilitation maintained clinical improvements and reduced exacerbations over 12 months.
Gloeckl et al. (2025)	Switzerland	Multicenter RCT	Stable COPD	278	Smartphone application-based pulmonary rehabilitation	Enhanced standard care	CAT, 1-min STS, physical function	Smartphone-based pulmonary rehabilitation improved exercise performance and symptom control.
Spielmanns et al. (2022)	Germany	Randomized Controlled Trial	COPD after PR	60	Kaia COPD smartphone application	Standard follow-up	Physical activity, CAT, CRQ	Smartphone-guided rehabilitation maintained physical activity after PR.
Zanaboni et al. (2023)	Norway	Multicenter Randomized Controlled Trial	Stable COPD	120	Long-term telerehabilitation	Home exercise and usual care	Hospitalizations, QoL, exercise capacity	Telerehabilitation reduced hospital admissions and maintained exercise capacity.
Gelbman et al. (2022)	United States	Prospective Pilot Study	Adults with COPD	19	Wellinks multimodal mHealth platform	None	Engagement, usability	Digital platform demonstrated high feasibility and patient engagement.
O'Connor et al. (2025)	United States	Prospective Feasibility Study	Adults with COPD	100	Digital home monitoring and tele-PR	Single-arm	CAT, adherence, QoL	Integrated digital rehabilitation demonstrated high adherence and improved COPD outcomes.
Cooper et al. (2022)	United Kingdom	Real-world Feasibility Study	COPD	113	myCOPD digital self-management platform	Pre–post comparison	Hospital admissions, engagement	High activation and user engagement demonstrated feasibility in routine clinical practice.

Author (Year)	Country	Study Design	Population	Sample Size	Intervention	Comparison	Outcomes	Main Findings
Lundell et al. (2022)	Sweden	Participatory Research	COPD patients and stakeholders	17	Co-creation of eHealth tool	None	User engagement, usability	Digital co-creation successfully developed a patient-centered eHealth tool for COPD.
Lee et al. (2023)	South Korea	Empirical Clinical Study	Patients with chronic diseases including COPD	Multiple clinical cohorts	Internet of Medical Things (IoMT) platform	Conventional monitoring	Remote monitoring, clinical implementation	IoMT-based digital platform enabled real-time monitoring and precision healthcare delivery.
Guecamburu et al. (2023)	France	Nationwide Population Study	Hospitalized COPD	48,638	Pulmonary rehabilitation referral after hospitalization	No PR	PR uptake	Pulmonary rehabilitation utilization remained low despite guideline recommendations.
Li et al. (2023)	China (Macao)	Retrospective Prediction Study	Hospitalized COPD	782 hospitalizations	Electronic health record–based prediction model	Machine-learning model	30-day readmission	Digital prediction model accurately identified patients at high risk of readmission.
Quach et al. (2023)	Canada	Original Research (Cross-sectional App Evaluation)	Publicly available COPD self-management applications	13 mobile applications	Evaluation of publicly available mHealth applications for COPD self-management	None	App quality, privacy, functionality, self-management features	COPD self-management apps commonly included education, symptom tracking, medication reminders, and action plans; however, most lacked clinical validation and evidence to support routine implementation.

Author (Year)	Country	Study Design	Population	Sample Size	Intervention	Comparison	Outcomes	Main Findings
Lundell et al. (2022)	Sweden	Participatory Action Research	COPD patients, caregivers, and healthcare professionals	17	Digital participatory co-design of an eHealth intervention	None	Feasibility, usability, stakeholder engagement	The digital co-design process was feasible and highly acceptable, providing a strong foundation for developing patient-centered eHealth interventions for COPD.
Bickton & Shannon (2022)	Seven low- and middle-income countries (Africa, Asia, and South America)	Qualitative Study (Semi-structured Interviews)	Healthcare professionals with experience in pulmonary rehabilitation implementation in LMICs	7 healthcare professionals	Exploration of barriers and enablers to pulmonary rehabilitation implementation through online semi-structured interviews	None	Barriers and facilitators to pulmonary rehabilitation implementation	Resource limitations and low awareness hindered pulmonary rehabilitation implementation, while local adaptation and institutional support facilitated digital pulmonary rehabilitation delivery.
Jiang et al. (2022)	China	Qualitative Descriptive Study	Older patients with COPD and healthcare providers	52 participants (29 older patients with COPD and 23 healthcare providers)	Exploration of experiences with telehealth and online health information use in chronic disease management through semi-structured interviews	None	Perceptions, user experience, telehealth adoption, online health information use	Successful telehealth implementation for COPD management depended on health literacy, user-friendly digital technologies, and healthcare provider support.

Source: Compiled by the authors based on data extracted from the 15 included studies published between 2022 and 2026

Principal Findings

This systematic review synthesized evidence from 15 studies evaluating digital health interventions in pulmonary rehabilitation for patients with COPD. Overall, smartphone applications, telerehabilitation, mobile health (mHealth), remote monitoring, Internet of Medical Things (IoMT), and web-based rehabilitation demonstrated positive effects on exercise capacity, symptom control, rehabilitation adherence, and patient engagement. These findings support the growing role of digital health as an effective strategy to overcome barriers associated with conventional center based pulmonary rehabilitation. Similar conclusions have

been reported in previous reviews, which suggested that digital pulmonary rehabilitation provides clinical outcomes comparable to conventional rehabilitation while improving accessibility and continuity of care (Long et al., 2023; Park et al., 2025; Wen et al., 2022). The findings of the present review are also supported by randomized controlled trials demonstrating improvements in exercise performance and symptom management following smartphone-based and remote pulmonary rehabilitation programs (Li et al., 2022; Gloeckl et al., 2025; Zanaboni et al.).

Digital Health Improves Exercise Capacity and Quality of Life

One of the most consistent findings across the included studies was the improvement in exercise capacity following digital pulmonary rehabilitation. Several studies reported significant improvements in six-minute walk distance (6MWD), one-minute sit-to-stand performance, and physical activity following smartphone-based rehabilitation or telerehabilitation (Li et al., 2022; Gloeckl et al., 2025; Spielmanns et al., 2022). Improvements in health-related quality of life (HRQoL) and COPD Assessment Test (CAT) scores were also consistently observed, indicating better symptom control and functional status. These findings are consistent with previous systematic reviews showing that home-based digital pulmonary rehabilitation is as effective as conventional pulmonary rehabilitation in improving exercise tolerance and quality of life (Quispe et al., 2024; Wen et al., 2022). Similarly, Robinson and Moy (2022) emphasized that remote exercise training can effectively maintain physical activity in individuals with chronic respiratory diseases, while Shah et al. (2023) demonstrated that wearable technologies further enhance rehabilitation outcomes through continuous monitoring and feedback.

Digital Health Enhances Rehabilitation Adherence and Self-Management

Patient adherence is one of the major determinants of successful pulmonary rehabilitation. Across the included studies, digital interventions consistently improved rehabilitation adherence through remote supervision, individualized exercise programs, automated reminders, and continuous communication with healthcare providers. The Wellinks platform, myCOPD, Kaia COPD, and integrated telehealth systems demonstrated high levels of patient engagement and sustained rehabilitation participation (Gelbman et al., 2022; Cooper et al., 2022; Spielmanns et al., 2022; O'Connor et al., 2025). These findings are in agreement with Religioni et al. (2025), who highlighted that improved adherence is associated with better clinical outcomes and reduced healthcare costs. Moreover, digital self-management tools facilitate patient empowerment and encourage active participation in disease management, which are essential components of long-term COPD care (Long et al., 2023; Shah & Kaltsakas, 2021).

Implementation Challenges and Future Directions

Despite the favorable clinical outcomes, several implementation challenges remain. Qualitative studies included in this review identified limited digital literacy, inadequate infrastructure, insufficient awareness of pulmonary rehabilitation, and organizational barriers as major obstacles to the successful implementation of digital rehabilitation programs (Jiang et al., 2022; Bickton & Shannon, 2022). These challenges are particularly relevant in low- and middle-income countries where internet connectivity and access to digital devices remain inconsistent. Similar implementation barriers have been described by Park et al. (2025), who emphasized that successful digital health integration requires supportive healthcare policies,

adequate technological infrastructure, and continuous healthcare professional training. Furthermore, user-centered development approaches, such as participatory co-design, may improve technology acceptance and long-term sustainability of digital rehabilitation programs, as demonstrated by Lundell et al. (2022).

Clinical Implications

The findings of this review suggest that digital health interventions should complement rather than replace conventional pulmonary rehabilitation. Hybrid rehabilitation models integrating face-to-face assessment with remote exercise supervision, digital monitoring, and teleconsultation may represent the most practical strategy for improving access while maintaining rehabilitation quality. Such approaches are particularly relevant for individuals living in rural areas, patients with mobility limitations, and healthcare systems facing shortages of pulmonary rehabilitation services (Wen et al., 2022; Long et al., 2023; Park et al., 2025). As digital technologies continue to evolve, artificial intelligence, wearable sensors, and personalized remote monitoring may further optimize pulmonary rehabilitation delivery and support precision rehabilitation for patients with COPD (Liu et al., 2026).

Strengths And Limitations

This review has several strengths. First, it synthesized recent evidence published between 2022 and 2026, reflecting current developments in digital pulmonary rehabilitation. Second, multiple digital health modalities including smartphone applications, tele-rehabilitation, mHealth, remote monitoring, IoMT, and web-based rehabilitation were comprehensively evaluated. However, several limitations should be acknowledged. Considerable heterogeneity existed regarding intervention characteristics, outcome measures, follow-up duration, and study designs, precluding quantitative meta-analysis. In addition, several included studies were pilot or feasibility studies with relatively small sample sizes, limiting the generalizability of the findings. Future multicenter randomized controlled trials with standardized outcome measures are needed to determine the long-term clinical effectiveness, cost-effectiveness, and implementation strategies of digital pulmonary rehabilitation for patients with COPD.

CONCLUSION

This systematic review demonstrated that digital health interventions, including smartphone applications, telerehabilitation, mHealth, remote monitoring, wearable devices, and web-based rehabilitation platforms, were effective and feasible strategies for supporting pulmonary rehabilitation among patients with COPD. These interventions consistently improved exercise capacity, health-related quality of life (HRQoL), symptom control, rehabilitation adherence, and patient engagement while increasing access to pulmonary rehabilitation services. Digital health interventions also showed potential as cost-effective alternatives to conventional center-based rehabilitation by reducing travel-related expenses, minimizing healthcare facility utilization, and enabling scalable delivery of rehabilitation services; however, robust cost-effectiveness evidence remained limited. Future high-quality multicenter studies incorporating economic evaluations are needed to assess the long-term effectiveness, cost-effectiveness, and broader implementation of digital pulmonary rehabilitation in clinical practice.

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