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DIGITAL DELIVERY OF PULMONARY REHABILITATION IN COPD: ACCESS, ADHERENCE, AND IMPLEMENTATION IN CLINICAL PRACTICE

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ABSTRACT

Digital models of pulmonary rehabilitation are increasingly used to address long-standing access gaps in chronic obstructive pulmonary disease (COPD), yet their value depends on more than technological novelty. This structured narrative review aimed to synthesize current evidence on digital delivery of pulmonary rehabilitation and physical activity support in COPD, with particular emphasis on access, adherence, safety, patient experience, and implementation. The review was based on a curated full-text PDF library and a PubMed-centered search strategy focused on COPD, pulmonary rehabilitation, exercise, telemedicine, mobile applications, and wearable-supported physical activity coaching. The included literature comprised guideline documents, systematic reviews, randomized and comparative trials, maintenance studies, qualitative work, and implementation-focused evaluations. Across the current evidence base, supervised tele-pulmonary rehabilitation and supported online or home-based models generally produced outcomes comparable to center-based pulmonary rehabilitation for functional capacity, symptoms, and quality of life, while app-only models showed more variable results. The most consistent advantages of digital delivery were improved access, better completion in some programs, and support for maintaining physical activity after formal rehabilitation. However, digital readiness, onboarding burden, adherence decay, and heterogeneity of outcomes remain important barriers. Digital pulmonary rehabilitation is therefore best understood as a delivery strategy that can widen access and sustain engagement when core rehabilitation components are preserved and implementation is carefully designed.

KEYWORDS

COPD; Pulmonary Rehabilitation, Telerehabilitation, Digital Health, Physical Activity, Implementation

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1. Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by dyspnea, exercise intolerance, low habitual physical activity, recurrent exacerbations, and progressive functional decline. Pulmonary rehabilitation (PR) remains one of the most effective non-pharmacological interventions in this population because it improves exercise capacity, symptoms, and health-related quality of life. The most recent official American Thoracic Society (ATS) clinical practice guideline strongly recommends PR for adults with stable COPD and after hospitalization for COPD exacerbation, and it also supports offering patients a choice between center-based PR and telerehabilitation as alternative delivery models (Rochester et al., 2023).

The major clinical problem is therefore no longer whether PR works, but how to deliver it to more people and how to sustain gains once the formal program ends. The ATS workshop report defining modern PR emphasized that underuse, limited uptake, and incomplete participation remain persistent weaknesses of current PR services. It also argued that emerging models should preserve the essential components of rehabilitation, including assessment, exercise prescription and progression, education or self-management support, and quality assurance, rather than reduce PR to unsupervised exercise or generic digital follow-up (Holland et al., 2021).

Digital delivery models in COPD now include supervised tele-pulmonary rehabilitation delivered by videoconferencing, web-based and app-based home programs, wearable-supported physical activity coaching, remote feedback, and digitally supported maintenance strategies after PR. Recent syntheses suggest that these approaches are clinically promising but methodologically heterogeneous. Mobile app-based PR has shown overall favorable directions of effect, but statistically robust benefit has been most consistent for health-status outcomes such as the COPD Assessment Test (CAT) rather than for all functional outcomes (Chung et al., 2024). A broader meta-analysis of digital health interventions reported improvements in symptoms, self-efficacy, and selected quality-of-life outcomes, whereas effects on the 6-minute walk test and hospital use were

less consistent (Zhuang et al., 2025). A separate review of videoconferencing interventions found high patient satisfaction across diverse telehealth models, but also recurrent technological barriers and substantial heterogeneity in intervention content and comparator choice (Bowman et al., 2024).

However, digital delivery should not be conceptualized as a single intervention. Some programs reproduce the core components of pulmonary rehabilitation through live supervised exercise and education, whereas others rely on asynchronous web modules, smartphone videos, step targets, or remote monitoring. These models differ in staffing requirements, onboarding burden, safety procedures, and the kind of patient-generated data they produce. For a technology-oriented review, that distinction matters because the key question is not simply whether telehealth pulmonary rehabilitation works, but which configurations of people, platforms, devices, and support processes remain robust in routine care.

Another reason for a focused review is that clinically important outcomes in this field extend beyond change in 6-minute walk distance alone. Digital models may influence who is able to start rehabilitation, who actually completes it, whether physical activity is maintained after the formal program ends, and whether specialist expertise can be redistributed across community tele-sites or into the home. These service-delivery outcomes are especially relevant when the strategic goal is to expand pulmonary rehabilitation capacity rather than merely duplicate a hospital program on a screen.

This pattern suggests that a focused review centered on digital delivery of PR and physical activity support may be more informative than a broad review of all digital interventions in COPD. The present manuscript therefore concentrates on exercise- and rehabilitation-related digital models, including telehealth exercise, home-based PR supported by apps or web platforms, wearable-guided physical activity coaching, and digitally supported maintenance after PR. Interventions limited to symptom surveillance, inhaler reminders, remote biomarker monitoring, or prediction algorithms without a rehabilitation or physical activity component were not included in the main synthesis.

2. Methodology

This manuscript was designed as a structured narrative review. It is not presented as a formal PRISMA systematic review, because the current drafting stage is centered on a curated full-text library and iterative evidence synthesis rather than on a finalized, fully documented screening workflow. Nevertheless, the review followed a transparent logic for scope definition, study identification, data extraction, and synthesis.

The evidence base was assembled from the uploaded full-text PDF library and a PubMed-centered search strategy focused on the intersection of COPD, pulmonary rehabilitation, exercise training, physical activity, telemedicine, telerehabilitation, mobile applications, wearable devices, and remote coaching. The PubMed strategy was structured around three concept blocks: (1) COPD ("Pulmonary Disease, Chronic Obstructive"[MeSH Terms], COPD, chronic obstructive pulmonary disease); (2) digital delivery terms (Telemedicine, Telerehabilitation, Mobile Applications, Wearable Electronic Devices, telehealth, telerehabilitation, app-based, web-based, wearable, activity tracker, remote coaching); and (3) rehabilitation or activity terms (Exercise Therapy, Exercise, pulmonary rehabilitation, rehabilitation, physical activity, exercise training). Representative searches were built by combining these blocks for broad digital pulmonary rehabilitation retrieval, supervised or home-based tele-pulmonary rehabilitation, and wearable-supported physical activity coaching. Priority was given to official society documents, systematic reviews, meta-analyses, randomized controlled trials, follow-up studies, feasibility studies, mixed-methods studies, and qualitative reports.

Eligible studies included adults with COPD and a digital intervention containing an exercise, PR, or physical activity support component. Modalities of interest included synchronous tele-rehabilitation, app-based or web-based PR, wearable-supported activity promotion, remote coaching, and digitally supported maintenance after PR. Studies were considered especially relevant when they reported functional capacity, daily physical activity, symptom burden, quality of life, adherence, safety, exacerbations, hospitalizations, or implementation-related findings.

To ensure that the review captured both clinical and implementation dimensions, the synthesis intentionally gave weight not only to efficacy data but also to service-delivery information. Qualitative studies, fidelity analyses, and real-world program evaluations were therefore retained when they clarified how digital pulmonary rehabilitation was operationalized, what degree of supervision was preserved, how patients engaged with the intervention, and what barriers or facilitators emerged during delivery.

The evidence was organized into five pragmatic domains: supervised tele-pulmonary rehabilitation; app- or web-supported home pulmonary rehabilitation; wearable-supported physical activity coaching; digitally

supported maintenance after formal pulmonary rehabilitation; and implementation or patient-experience studies. This approach allows clinical outcomes and technology-related delivery issues to be interpreted together rather than in parallel silos.

Studies were excluded from the main synthesis when they focused only on remote symptom monitoring, inhaler adherence, biomarker devices, prediction models, or non-COPD populations without a clear rehabilitation component. For each included primary study, the working evidence map extracted study design, sample size, patient group, intervention format, comparator, follow-up, key outcomes, main findings, and major limitations. The narrative synthesis was then organized around intervention type, outcome pattern, and recurrent implementation issues.

Table 1 summarizes the core search logic used to organize the PubMed-led literature review.

Table 1. Structured PubMed-led search logic and thematic focus for the review.

Concept	Representative terms	Purpose in this review
Condition / population	COPD; "Pulmonary Disease, Chronic Obstructive"; chronic obstructive pulmonary disease	To identify the core clinical population of interest.
Digital delivery	telemedicine; telerehabilitation; mobile applications; wearable devices; telehealth; app-based; web-based; remote coaching	To capture technology-enabled rehabilitation and activity-support models.
Rehabilitation / activity	pulmonary rehabilitation; exercise therapy; exercise training; physical activity	To restrict retrieval to interventions containing a rehabilitation or physical activity component.

3. Results and interpretive synthesis

3.1. Overview of the literature

The current corpus contains official guideline-level documents, review-level syntheses, randomized and comparative studies, long-term follow-up studies, qualitative work, and implementation-focused papers. Across this literature, the same broad question recurs: can digital delivery preserve the core benefits of pulmonary rehabilitation while reducing barriers related to travel, scheduling, service availability, and post-program continuity?

The answer is generally positive but conditional. Digital pulmonary rehabilitation does not appear uniformly superior to center-based PR for classical functional outcomes, yet several studies suggest that it can achieve comparable short-term results, improve completion in some settings, and create new options for maintenance of physical activity after formal rehabilitation. The strongest implementation argument is therefore not technological novelty, but the ability to expand access without abandoning the core structure of PR.

Table 2. Selected comparative studies of digital pulmonary rehabilitation and physical activity support in COPD.

Study	Design / population	Digital model and comparator	Main findings	Key limitation
Bourne et al. (2017)	Single-blind RCT; COPD; n=90	Online PR via myPR versus face-to-face PR; 6 weeks	Online PR was noninferior to face-to-face PR for 6MWD and CAT; described as safe and well tolerated.	Participants needed internet access and home devices; relatively short program.
Tsai et al. (2017)	RCT; COPD; n=37	Home-based real-time videoconferenced telerehabilitation versus usual care; 8 weeks	Improved endurance shuttle walk time and self-efficacy versus control; no clear difference in daily steps.	Comparator was usual care, not active PR; small sample.
Hansen et al. (2020)	Multicentre RCT; severe COPD; n=134	Supervised pulmonary tele-rehabilitation versus conventional outpatient PR; 10 weeks	Tele-rehabilitation was not superior for 6MWD or other key outcomes, but more participants completed tele-rehabilitation.	Superiority design may not reflect realistic expectations for delivery-model comparisons.
Godtfredsen et al. (2020)	12-month follow-up of multicentre RCT; severe COPD; n=134	Pulmonary tele-rehabilitation versus standard PR; 12-month follow-up	No between-group difference in 6MWD at 12 months; no long-term superiority signal.	Follow-up focused on maintenance after program completion rather than ongoing intervention.
Alwakeel et al. (2022)	Prospective real-world study; COPD; tele-sites n=7, tele-PR participants n=177	Standardized community tele-PR versus standard PR; 3-year implementation study	Accessible, feasible, and safe model; >70% completion; no major adverse events; sustained 6MWT improvement.	Nonrandomized design; implementation study rather than efficacy trial.
Zanaboni et al. (2023)	International 3-arm RCT; COPD; n=120	Telerehabilitation or unsupervised home training versus standard care; 2 years	Active home-based strategies reduced hospital/ED events and preserved clinically relevant exercise-capacity gains versus control.	Comparator was standard care, not conventional PR; multicomponent intervention.
Spielmanns et al. (2023)	RCT after inpatient PR; COPD; n=30	Smartphone app after PR versus usual post-PR care; 6 months	App use helped maintain physical activity and improved CAT and selected CRQ domains after PR.	Small sample; post-PR maintenance context limits generalizability to initial PR delivery.
Loeckx et al. (2023)	RCT during/after PR; COPD; n=73	Semi-automated PA telecoaching after 3 months of PR versus usual care; 9 months	Improved steps/day across follow-up, but did not maintain all other PR-acquired benefits.	Focused on physical activity maintenance rather than full PR delivery.
Gloeckl et al. (2025)	Multicentre RCT; COPD; n=278	Fully automated smartphone app-based PR versus enhanced standard care; 12 weeks	No clear ITT superiority on CAT or 1-minute sit-to-stand; better exercise-capacity gains among adherent users; no safety signal.	App-only model; active comparator may have reduced between-group contrast.
Minakata et al. (2025)	Open-label randomized study; COPD; n=73	Individualized target step count versus usual care; 6 months	Did not significantly improve formal target achievement, but increased step count and time at ≥3.0 METs.	Behavioral intervention rather than full PR; open-label design.

3.2. Synchronous and supervised tele-pulmonary rehabilitation

The most direct alternative to conventional PR is synchronous tele-pulmonary rehabilitation, usually delivered through videoconferencing with real-time supervision. Evidence from comparative trials suggests that such models can approximate center-based PR for selected patients rather than clearly outperform it. In the randomized controlled trial by Bourne et al. (2017), a 6-week online program was noninferior to face-to-face PR for 6-minute walk distance (6MWD) and CAT, and the intervention was described as safe and well tolerated. In practical terms, this study showed that a digitally supported home model can preserve clinically important outcomes when the rehabilitation structure remains recognizable.

The TeleR trial by Tsai et al. (2017) further supports the value of supervised home exercise. Compared with usual care without exercise training, 8 weeks of real-time videoconferenced telerehabilitation improved endurance shuttle walk time and self-efficacy, although it did not clearly increase daily step count. This distinction is important: improvement in exercise capacity does not automatically translate into higher free-living physical activity, and many digital interventions in COPD appear to work better on structured training outcomes than on spontaneous activity behavior.

Bourne et al. (2017) add another useful comparison point because their myPR platform was tested directly against face-to-face pulmonary rehabilitation rather than against usual care. Over 6 weeks, online-supported pulmonary rehabilitation was noninferior to conventional pulmonary rehabilitation for both the 6-minute walk test and COPD Assessment Test outcomes, and no specific safety concerns emerged. Nevertheless, engagement data were more mixed: online participation declined across the intervention period, illustrating that convenience alone does not guarantee sustained adherence.

Longer follow-up from the Danish multicenter program also tempers overly optimistic interpretations. Godtfredsen et al. (2020) found no significant between-group difference in 6-minute walk distance one year after completion of pulmonary tele-rehabilitation versus standard outpatient pulmonary rehabilitation, and the follow-up analyses did not identify a clear long-term advantage for tele-rehabilitation in subsequent utilization outcomes. This reinforces the view that digital delivery should primarily be judged as a comparable alternative pathway rather than as a higher-potency treatment.

Real-world service data strengthen the access argument. Alwakeel et al. (2022) described a standardized community tele-pulmonary rehabilitation network deployed across six tele-sites, with an 83% completion rate versus 72% in the standard program and no major adverse events. Clinical gains in 6-minute walk distance and COPD Assessment Test scores supported the credibility of the model, but its larger importance lies in demonstrating that tele-pulmonary rehabilitation can be delivered as a regional service architecture rather than only as a small research pilot.

Head-to-head comparison with conventional PR has yielded nuanced rather than dramatic results. Hansen et al. (2020) found that supervised pulmonary tele-rehabilitation was not superior to conventional outpatient PR for change in 6MWD or other major clinical outcomes in severe COPD. However, more participants completed the tele-rehabilitation program than the conventional program, which is highly relevant from a service-delivery perspective. The 12-month follow-up from the same trial showed no between-group difference in 6MWD one year later, suggesting that tele-rehabilitation can match, but not necessarily exceed, the benefits of center-based PR over time (Godtfredsen et al., 2020).

Observational and real-world data point in a similar direction. Bhatt et al. (2022) reported that video telehealth PR produced clinical gains that were broadly comparable to those observed in center-based PR, supporting the feasibility of supervised remote delivery in routine care. Alwakeel et al. (2022) provided stronger implementation-oriented evidence from a 3-year prospective provincial tele-PR program: seven tele-sites were recruited, six remained active over three years, more than 70% of participants completed each program, no major adverse events were reported, and improvements in 6MWT were sustained for up to 12 months. Together, these studies suggest that supervised digital PR is most convincing when discussed as an access and delivery solution rather than as a technologically superior replacement for conventional rehabilitation.

3.3. App-based and web-supported home pulmonary rehabilitation

App-based and web-supported home PR sits on a spectrum ranging from highly structured digital programs with clinician input to fully automated self-directed platforms. Review-level evidence suggests that this category is promising but uneven. In their systematic review and meta-analysis, Chung et al. (2024) found that most pooled estimates leaned in favor of mobile app-based PR, but the clearest statistically significant signal was improvement in CAT rather than consistent benefit across all exercise outcomes. This indicates that app-based rehabilitation can improve health status, yet its effects on functional capacity may depend strongly on patient engagement, baseline disease burden, and the amount of human support embedded in the program.

The multicenter randomized trial by Gloeckl et al. (2025) is particularly informative because it tested a fully automated 12-week smartphone application against enhanced standard care. In the intention-to-treat analysis, the application did not clearly outperform the comparator on CAT or the 1-minute sit-to-stand test. However, participants with better adherence to application use achieved greater improvement in exercise capacity than nonadherent users, and no relevant safety concerns were observed. This trial therefore reinforces a recurring finding across the field: digital content can deliver exercise instructions, feedback, and educational material, but benefit still depends heavily on continued participation.

Some app-based studies also blur the boundary between self-management and rehabilitation. In the 12-month randomized study by Glynn et al. (2025), a smartphone self-management program showed encouraging signals for exacerbation-related outcomes, step count, and exercise capacity in selected arms, particularly when monthly phone contact was included. However, because the intervention extended beyond formal PR into broader COPD self-management, it is more appropriately interpreted as supportive evidence for digitally enabled continuity of care rather than as a pure PR trial. From the viewpoint of implementation, the key lesson is that app-based rehabilitation appears stronger when it is integrated into a wider support strategy instead of being treated as a stand-alone technological substitute for rehabilitation services.

The contrast between supported online rehabilitation and fully automated application-based rehabilitation is informative. When a digital program preserves structured progression, education, and some degree of contact or accountability, outcomes tend to resemble those of established pulmonary rehabilitation models. When the intervention is highly automated and the comparator is not minimal, the evidence becomes less decisive. This pattern suggests that the active ingredient is the successful digital translation of core rehabilitation processes rather than the mere presence of an app.

3.4. Wearable-supported physical activity coaching and step-target interventions

Wearables, step counters, and remote feedback systems are especially relevant when the goal is not just to improve exercise capacity during a program but to change daily activity behavior. This is an important distinction because patients can improve supervised exercise performance without meaningfully increasing their free-living activity. The STEP randomized trial by Loeckx et al. (2023) addressed this maintenance problem by adding a 9-month physical-activity telecoaching intervention after the first 3 months of PR. The intervention improved steps per day throughout follow-up, but it did not preserve all other benefits acquired during rehabilitation. This suggests that behavior-change support can sustain activity volume even when broader PR gains still fade over time.

A related message emerges from the individualized step-target study by Minakata et al. (2025). Providing disease-informed target step counts did not significantly increase the proportion of patients who formally reached target, but it did increase overall step count and the duration of activity at or above 3.0 metabolic equivalents after six months. In other words, target-based feedback may still have practical value even when the primary binary adherence endpoint is not met. For clinicians and service designers, this matters because it shows that wearable-based interventions may be more useful for incremental behavior shaping than for producing large, uniform effects on classical rehabilitation metrics.

At the review level, Zhuang et al. (2025) found that digital health interventions in COPD tended to improve dyspnea, self-efficacy, and selected quality-of-life measures, whereas effects on 6MWD and hospital use were less stable. This pattern is consistent with the wearable and coaching literature: the digital layer may be especially valuable for monitoring, reinforcement, and maintenance, but less likely to create large independent gains when it is not paired with a structured rehabilitation pathway.

This distinction also helps explain why wearable-supported interventions often perform better on daily activity behavior than on formal exercise capacity tests. Step counters and mobile feedback mainly target self-regulation in everyday life, making them particularly relevant for maintenance and activity behavior, whereas they do not fully substitute for the supervised training dose that usually drives larger gains in structured exercise outcomes.

3.5. Maintenance after pulmonary rehabilitation

Maintenance after PR is one of the clearest use cases for digital support in COPD. The randomized trial by Spielmanns et al. (2023) showed that a smartphone application used after inpatient PR helped maintain physical activity and was accompanied by improvement in CAT and selected domains of the Chronic Respiratory Questionnaire. This is clinically meaningful because a common failure point in COPD care is not the initial response to PR, but the loss of activity and routine once the supervised program ends.

Longer-term maintenance is also highlighted by the international randomized trial from Zanaboni et al. (2023), which compared telerehabilitation, unsupervised treadmill training at home, and standard care over two years. Both active home-based strategies reduced overall hospital and emergency department use compared with control, and clinically relevant exercise-capacity gains were maintained. Notably, telerehabilitation in this trial was not just remote exercise prescription; it combined supervised home treadmill training with self-management support. This again suggests that the most successful digital models are multicomponent and relationship-based rather than purely automated.

From a service-design perspective, maintenance is one of the most persuasive use cases for digital support in COPD. It requires less intensive staffing than initial pulmonary rehabilitation, can be delivered over longer periods, and directly addresses the common clinical problem that gains recede once a supervised program ends. The reviewed studies suggest that low-cost digital follow-up may be easier to scale as an adjunct to pulmonary rehabilitation than as a total replacement for every element of conventional care.

3.6. Safety, adherence, and patient experience

Across the current literature, safety signals are generally reassuring. The systematic review and meta-analysis by Bondarenko et al. (2024) found that clinically meaningful benefits were achieved by similar proportions of participants in center-based and home-based PR, and that most trials reported no adverse events. This is useful for clinical decision-making because it shifts the debate away from a simplistic assumption that home- or tele-based models are inherently less safe. Instead, the safer interpretation is that appropriately designed digital PR can be acceptable and low-risk for selected patients, provided that assessment, monitoring, and progression are built into the model.

Adherence and completion, however, remain decisive. Bowman et al. (2024) found consistently high patient satisfaction with videoconferencing interventions, yet technological difficulties and variability in intervention design remained common. The qualitative study by Rutherford et al. (2025) helps explain why: participants valued flexibility, accountability, structured routines, and app functions such as daily task lists, but multimorbidity, fluctuating illness burden, and the practical demands of living with COPD still disrupted participation. The same study showed that mHealth delivery changed how patients organized rehabilitation within daily life; home-based participants often fitted the program around their schedules, whereas center-based participants organized their schedules around the program.

The fidelity study by Dal Corso et al. (2024) adds an important implementation perspective from primary care. In that home-based model, exercise prescription remained highly consistent with protocol, and early engagement was strongly linked to later completion. This finding supports a broader point across the literature: adherence is rarely a simple property of the technology itself. Completion depends on referral pathways, early contact, encouragement, technical support, symptom burden, and the degree to which a digital program still feels like guided rehabilitation rather than isolated self-management homework.

Another consistent observation is that adherence is not a single construct. Depending on the study, it may refer to session attendance, module completion, log-ins, device wear time, or the proportion of prescribed weeks completed. This makes cross-study comparison difficult and may partly explain why superficially similar interventions appear to perform differently. A program can achieve good satisfaction yet still lose active engagement across weeks, which is exactly why implementation reporting deserves a central place in digital rehabilitation literature.

3.7. Outcome measures and interpretation

A further source of heterogeneity in this field is the choice of outcomes. Digital PR studies commonly report 6MWD, endurance shuttle walk time, the 1-minute sit-to-stand test, CAT, Chronic Respiratory Questionnaire or St George's Respiratory Questionnaire scores, daily step count, and occasionally exacerbation-related outcomes. These measures are not interchangeable. Functional exercise tests primarily reflect supervised exercise capacity, whereas steps per day and time spent at a given metabolic intensity reflect free-living behavior. A digital intervention can therefore appear clinically successful on one level but neutral on another, as seen in studies where endurance or sit-to-stand performance improved without a parallel increase in daily activity.

This distinction matters when interpreting apparently mixed evidence. For example, supervised tele-rehabilitation often reproduces the exercise-training structure of center-based PR and can therefore improve

capacity-related outcomes. Wearable-supported coaching, by contrast, may be more relevant for maintaining activity behavior over time, even if it produces smaller changes in traditional PR endpoints. For this reason, trials that combine several outcome domains are more informative than those relying on a single measure. In COPD care, one digital program may succeed because it improves completion, another because it maintains step count after PR, and another because it reduces travel barriers while preserving symptom gains.

Adherence and implementation outcomes also deserve more prominence than they often receive. In many studies, engagement is reported indirectly through attendance, log-ins, or simple completion status, making cross-study comparison difficult. Yet several papers in the current review indicate that initiation, early contact, and sustained use strongly influence effectiveness. In practice, a digital model may fail not because the exercise prescription is weak, but because patients never start, use the system inconsistently, or lack enough support to continue. Better standardized reporting of adherence, uptake, and technical problems would therefore make the field far easier to interpret.

3.8. Summary of what seems to work and what remains uncertain

Overall, the studies reviewed here suggest that digital PR works best when it addresses a concrete service problem: limited access to center-based PR, difficulty completing a program because of travel or scheduling barriers, or loss of activity after discharge. The evidence is less convincing for low-touch, fully automated models delivered without ongoing reinforcement. What remains uncertain is not whether digital PR has any value, but which patients need which model, how much human support is necessary, and how health systems should integrate digital options without worsening inequalities for people with low digital literacy or complex multimorbidity.

3.9. Implementation themes across the reviewed literature

Across comparative trials, qualitative interviews, and fidelity studies, several implementation themes recur. First, digital delivery increases reach most clearly when it removes travel time, parking, and scheduling burdens. Second, supervision or structured contact remains important; programs with live oversight, coaching, or regular calls generally provide more convincing results than low-touch app-only models. Third, digital readiness cannot be assumed, as several successful interventions relied on introductory home visits, equipment installation, or brief face-to-face onboarding. Fourth, adherence usually declines over time unless maintenance strategies and feedback loops are built into the pathway. Finally, inconsistent outcome reporting still limits direct comparison between models. Table 3 summarizes these themes in a practice-oriented format.

Table 3. Recurring implementation themes in digital pulmonary rehabilitation and physical activity support for COPD.

Implementation theme	How it appears in COPD digital PR	Practical implication
Access and convenience	Home delivery and community tele-sites can reduce travel, parking, and scheduling burdens that commonly limit uptake and completion.	Digital PR is most valuable when used to widen access, not merely to replicate hospital delivery.
Onboarding and technical support	Successful programs often include initial setup, brief face-to-face instruction, equipment delivery, or staff troubleshooting.	Simple workflows and early support should be planned as core service components, not optional extras.
Supervision and coaching	Live supervision, coaching calls, or structured feedback generally produce more convincing outcomes than low-touch app-only models.	Human support remains important even in technology-enabled pathways.
Adherence over time	Participation may decline across weeks, especially in asynchronous programs, despite good initial interest or satisfaction.	Programs should include reminders, progression, and maintenance strategies rather than relying on convenience alone.
Patient selection and safety	Not all patients are suited to identical models; symptom burden, oxygen needs, digital confidence, and home context matter.	Hybrid pathways and triage are more realistic than a one-size-fits-all digital model.
Outcome heterogeneity	Studies variably report 6MWD, endurance tests, CAT, QoL, steps/day, utilization, log-ins, or completion.	A core outcome set for efficacy and implementation would strengthen comparison and scale-up.

4. Discussion

The main conclusion of this review is that digital pulmonary rehabilitation should be understood primarily as a delivery strategy rather than a separate therapeutic category. The most persuasive studies do not show that telehealth, apps, or wearables magically outperform conventional rehabilitation. Instead, they show that the core benefits of PR can often be reproduced, extended, or maintained through digital delivery when the program still contains recognizable rehabilitation elements. This is consistent with the ATS workshop definition of modern PR, which emphasizes essential components and quality assurance over location alone (Holland et al., 2021).

4.1. Implications for digital service design

A central implication of the reviewed literature is that digital pulmonary rehabilitation should not be framed as a software procurement exercise. The stronger models combine technology with workflow: triage, onboarding, remote supervision, symptom review, troubleshooting, and clear plans for progression or escalation when a patient deteriorates. Programs that perform best generally preserve the essential architecture of pulmonary rehabilitation - individually prescribed exercise, education, self-management support, and follow-up - even when the location of delivery changes.

The evidence also argues against a binary choice between center-based and digital pulmonary rehabilitation. A more realistic interpretation is that COPD care needs a spectrum of rehabilitation pathways. Some patients may do well in fully home-based supervised programs, some may need an initial center-based assessment followed by digital maintenance, and others may benefit from community tele-sites or other hub-and-spoke solutions. This flexible pathway logic is better aligned with routine care than the assumption that one delivery model will fit all patients.

This interpretation also matters beyond conventional efficacy questions because the value of technology in COPD care lies as much in service design and access as in the intervention content itself. Digital pulmonary rehabilitation can reduce dependence on travel, improve scheduling flexibility, extend specialist input into satellite or community settings, and support continuity after discharge. The real-world tele-pulmonary rehabilitation study by Alwakeel et al. (2022) is especially relevant here, because it demonstrates that implementation at scale is possible when programs are standardized, when satellite sites are retained over time, and when outcomes are monitored longitudinally. Likewise, the higher completion seen in tele-rehabilitation arms of some comparative studies suggests that the social and logistical architecture of delivery matters as much as efficacy at the endpoint level (Hansen et al., 2020).

Implementation and equity considerations deserve special emphasis. Although digital PR can reduce barriers related to travel and geographical distance, it can also create new barriers for patients who lack devices, stable internet access, technical confidence, or support at home. The online PR trial by Bourne et al. (2017) explicitly excluded people who could not use an internet-enabled device, illustrating how access-enhancing interventions may still reach a digitally selected population. Qualitative work similarly shows that flexibility is highly valued, but that illness burden, multimorbidity, and the practical demands of daily life continue to shape adherence even when travel is removed (Rutherford et al., 2025).

4.2. Equity and digital inclusion

Digital pulmonary rehabilitation can reduce geographical exclusion, but it may simultaneously create a new layer of digital exclusion. Some comparative studies required home internet access and sufficient technical confidence to use a web interface, whereas other successful models depended on introductory training, equipment setup, or staff assistance. These requirements are manageable for many patients, but they may disadvantage people with low digital literacy, sensory limitations, cognitive impairment, unstable housing, or limited caregiver support.

Accordingly, equitable implementation should include simple interfaces, clear instructions, fallback non-digital options, and realistic expectations about the amount of support some patients will need. Older age alone should not be treated as a contraindication to digital delivery, but programs must still account for multimorbidity, frailty, and the day-to-day instability that can make home-based participation more difficult even when access barriers are reduced.

Accordingly, implementation should not focus only on software or platform choice. It should include onboarding, simple instructions, troubleshooting pathways, early staff contact, and mechanisms for identifying patients who need a higher-touch or hybrid approach. The fidelity study from primary care suggests that early program engagement may be pivotal for later completion (Dal Corso et al., 2024), while the real-world tele-

PR study indicates that outcomes can be sustained when delivery is standardized across sites and monitored over time (Alwakeel et al., 2022). These are health-system design issues as much as they are rehabilitation issues, and they are central to whether digital PR becomes scalable and equitable in practice.

At the same time, digital delivery does not solve every barrier. Some patients may still require center-based rehabilitation because of clinical instability, severe oxygen needs, safety concerns during exercise, poor technical confidence, sensory or cognitive impairment, or a preference for direct in-person interaction. Furthermore, app-only models may struggle when they demand persistent self-discipline without meaningful human contact. The trial by Gloeckl et al. (2025) illustrates this tension well: the intervention was safe and promising, but benefits were strongest in adherent users, making adherence itself part of the intervention mechanism rather than a secondary detail.

From a practical standpoint, digital PR may be best implemented as one option within a flexible COPD rehabilitation pathway. Initial triage could identify who is suitable for center-based PR, who may prefer supervised home tele-rehabilitation, and who may benefit from a hybrid or maintenance-focused digital program after completing conventional rehabilitation. Wearables and step-target systems appear particularly useful when the goal is to preserve activity behavior over time, whereas supervised telehealth models are more appropriate when the goal is to reproduce the structure of full PR. In both cases, coaching, feedback, and patient support remain central.

Several limitations of the evidence base should be acknowledged. Interventions differ substantially in intensity, duration, comparator choice, and degree of professional involvement. Study populations also vary in disease severity, baseline activity, and previous PR exposure. Some trials compare digital delivery with usual care, while others compare it with active, high-quality center-based rehabilitation, making direct comparison difficult. Reporting of adherence is inconsistent, and longer-term maintenance data are still relatively scarce. In addition, the present manuscript is a structured narrative review rather than a PRISMA-based systematic review, so the identification strategy was transparent but not reported as a formal record-flow diagram.

Future studies should therefore move beyond the simple question of whether digital PR works. More useful questions concern which components are indispensable, how digital models can be matched to patient characteristics, whether hybrid pathways improve uptake and continuity, and how programs can avoid excluding patients with limited digital access or low technical confidence. Cost-effectiveness, workforce implications, and standardized reporting of adherence and adverse events deserve particular attention if digital PR is to move from promising innovation to routine service delivery.

4.3. Research and reporting priorities

Future work should prioritize pragmatic and noninferiority designs over repeated small superiority trials. The most useful unanswered questions concern which components of digital pulmonary rehabilitation are indispensable, what minimum level of supervision is required for different patient groups, and whether digital pathways improve real-world uptake among patients who would otherwise decline or fail to attend conventional rehabilitation. More consistent reporting of adherence, adverse events, and patient-experience data would also make the field easier to compare and translate into practice.

There is also a need for implementation studies that go beyond feasibility alone. Health systems will require evidence on staffing models, resource requirements, technical standards, and cost-effectiveness before successful pilots can be adopted at scale. In this respect, regional tele-site models and hybrid pathways may prove at least as important as fully home-based applications, because they offer a bridge between specialist supervision and improved local access.

5. Conclusion

Digital pulmonary rehabilitation and physical activity support represent a clinically relevant response to long-standing gaps in COPD rehabilitation delivery. The strongest evidence does not suggest a universal superiority of digital models over conventional center-based pulmonary rehabilitation. Instead, it shows that well-designed digital pathways can achieve comparable outcomes for many patients while widening access, improving completion in some settings, and supporting longer-term maintenance of physical activity.

Across the current evidence base, the most credible digital interventions are those that preserve core rehabilitation components, include meaningful support or feedback, and are implemented within a realistic clinical pathway. For practice and policy, the key issue is therefore not whether technology can replace pulmonary rehabilitation, but how technology can help deliver pulmonary rehabilitation to more people without losing the elements that make it effective.

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