

Effectiveness of digital health interventions for chronic obstructive pulmonary disease: systematic review and meta-analysis

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Abstract

Background: Background Chronic obstructive pulmonary disease (COPD), characterized by dyspnoea, cough, and sputum production, significantly impacts patients' quality of life and functional status. To reduce the burden on both patients and healthcare utilization indicators, it is crucial to explore more effective management strategies. These strategies should include empowering patients to actively manage their condition. Digital health interventions (e.g., mobile apps for symptom monitoring, wearable sensors for vital sign tracking, and web-based pulmonary rehabilitation programs) have the potential to positively influence health behaviors and enhance self-efficacy, encouraging greater patient engagement in their care. By fostering self-management skills and improving self-efficacy, these interventions may also mitigate the strain on healthcare services.

Objective: Objective This systematic review and meta-analysis aims to evaluate the clinical efficacy of smartphone-based applications (e.g., symptom trackers), remote monitoring devices (e.g., wearable oximeters), and web-delivered platforms (e.g., telehealth portals) across four evidence-based COPD management domains: (1) disease-specific quality of life measured by COPD Assessment Test (CAT) and St. George's Respiratory Questionnaire (SGRQ), (2) behavioural self-efficacy assessed through General Self-Efficacy Scale, (3) functional capacity quantified via 6-Meter Walk Test (6MWT) and Modified Medical Research Council Dyspnea Scale, and (4) healthcare resource utilization reflected by hospital admissions and emergency department visits.

Methods: Methods A systematic literature review was performed using predefined key search terms in the PubMed, EMBASE, Cochrane, and Web of Science databases up to 26 January 2025, to identify eligible randomized controlled trials (RCTs) involving digital health interventions for COPD patients. Two independent reviewers screened the literature according to the eligibility criteria and extracted data from the included articles. The outcomes assessed were quality of life, self-efficacy, functional outcomes, healthcare utilization indicators.

Results: Results This review included 17 studies involving 2,027 participants across 11 countries. In 11 of the trials, healthcare professionals were involved in digital health platforms usage, while 12 trials reported measures to ensure adherence to digital health interventions. Digital health tools designed for COPD patients mainly focused on two key areas: telerehabilitation (e.g., video-guided breathing exercises) and electronic self-management systems (e.g., AI-driven exacerbation alerts). The study participants were predominantly older adults. Meta-analysis results indicated that digital health interventions significantly improved quality of life at 3 months on COPD Assessment Test (CAT) (MD -1.65, 95% CI [-3.17, -0.14]; P = 0.03), at 6 months on CAT (MD = -2.43, 95% CI [-3.93, -0.94]; P = 0.001) and St. George's Respiratory Questionnaire (SGRQ) (MD = 3.25, 95% CI [0.69, 5.81]; P = 0.01), at 12 months on the CAT (MD = -2.53, 95% CI [-3.91, -1.16]; P = 0.0003), EuroQol 5 Dimensions (EQ-5D) (MD = 0.04, 95% CI [0.01, 0.07]; P = 0.02), and EuroQol 5 Dimensions Visual Analogue Scale (MD = 5.88, 95% CI [0.38, 11.37]; P = 0.04); General Self-Efficacy Scale at 3 months (MD = 1.65, 95% CI [0.62, 2.69]; P = 0.002) and 6 months

(MD = 1.94, 95% CI [0.83, 3.05]; P = 0.0006); and Modified Medical Research Council Dyspnea Scale over 3 months (MD = -0.23, 95% CI [-0.36, -0.11]; P = 0.0003). However, no significant differences were observed in the 6-meter walk test (6 MWT), emergency department admissions, hospital admissions, emergency department admissions for COPD or hospital admissions for COPD.

Conclusions: Conclusion Our research indicated that digital health interventions might offer potential benefits to COPD; however, their clinical effectiveness needs to be confirmed. Further studies employing robust methodologies are needed to evaluate their utility. Additionally, future research should include a greater number of older adult with COPD.

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Original Manuscript

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Conclusion Our research indicated that digital health interventions might offer potential benefits to COPD; however, their clinical effectiveness needs to be confirmed. Further studies employing robust methodologies are needed to evaluate their utility. Additionally, future research should include a greater number of older adult with COPD.

Keywords mHealth, Telemedicine, Self-management, Remote patient monitoring, Chronic

respiratory disease, Evidence synthesis

Introduction

Chronic obstructive pulmonary disease (COPD), the third leading global cause of mortality, imposes a disproportionate burden on low- and middle-income countries, where over 90% of its 384 million cases reside^[1,2]. In China alone, COPD affects 13.7% of adults ≥ 40 years, driving substantial disability and healthcare expenditures that threaten household economic stability^[3,4]. While current guidelines emphasize multidisciplinary care, systemic barriers such as workforce shortages and fragmented care pathways limit implementation, particularly in resource-constrained settings^[5].

The growing imperative for scalable, patient-centered solutions has catalyzed interest in digital health technologies. Telehealth platforms, wearable sensors, and AI-driven predictive tools now enable remote symptom monitoring, personalized rehabilitation, and real-time clinician-patient communication, potentially overcoming geographical and financial access barriers^[6-7]. Accelerated by the COVID-19 pandemic, these innovations align with WHO priorities for integrating digital tools into chronic disease frameworks^[8].

Despite proliferating trials evaluating COPD-focused digital interventions—ranging from smartphone-based pulmonary rehabilitation to smart inhalers with adherence tracking, critical evidence gaps persist. Earlier reviews either examined narrow subsets (e.g., telemonitoring alone) or aggregated heterogeneous technologies (for example, combining SMS reminders with AI systems), obscuring the efficacy of advanced tools like sensor-guided activity adapters or exacerbation prediction algorithms^[9-12]. No synthesis has specifically assessed whether contemporary digital health tools (1) improve COPD-specific quality of life and self-efficacy, (2) enhance functional capacity, or (3) reduce acute care utilization—knowledge essential for guiding clinical adoption.

The hypothesized pathways through which digital health tools may influence COPD outcomes are illustrated in Figure 1. We propose that these interventions operate via three synergistic mechanisms: 1. Enhanced Self-Management: Mobile apps and wearable sensors provide real-time feedback on symptoms (e.g., dyspnea thresholds) and medication adherence, enabling early detection of exacerbations. This may reduce hospitalization risk by prompting preemptive interventions^[13]. 2. Personalized Rehabilitation: AI-driven telerehabilitation platforms adapt exercise regimens based on continuous spirometry or oxygen saturation data, potentially improving functional capacity and QoL through optimized physical activity^[14]. 3. Clinician-Patient Synergy: Remote monitoring systems facilitate data sharing between patients and care teams, allowing timely adjustment of treatment plans (e.g., corticosteroid titration during exacerbations), which could decrease emergency visits^[15].

This framework posits that effective tools must concurrently engage patients (via behavioral nudges) and clinicians (through actionable analytics) to disrupt the cycle of COPD deterioration. This systematic review and meta-analysis addresses these gaps by evaluating rigorously designed digital health interventions targeting COPD management. By synthesizing evidence on patient-centered outcomes and healthcare utilization metrics, we aim to clarify the clinical value of these technologies and inform equitable implementation strategies.

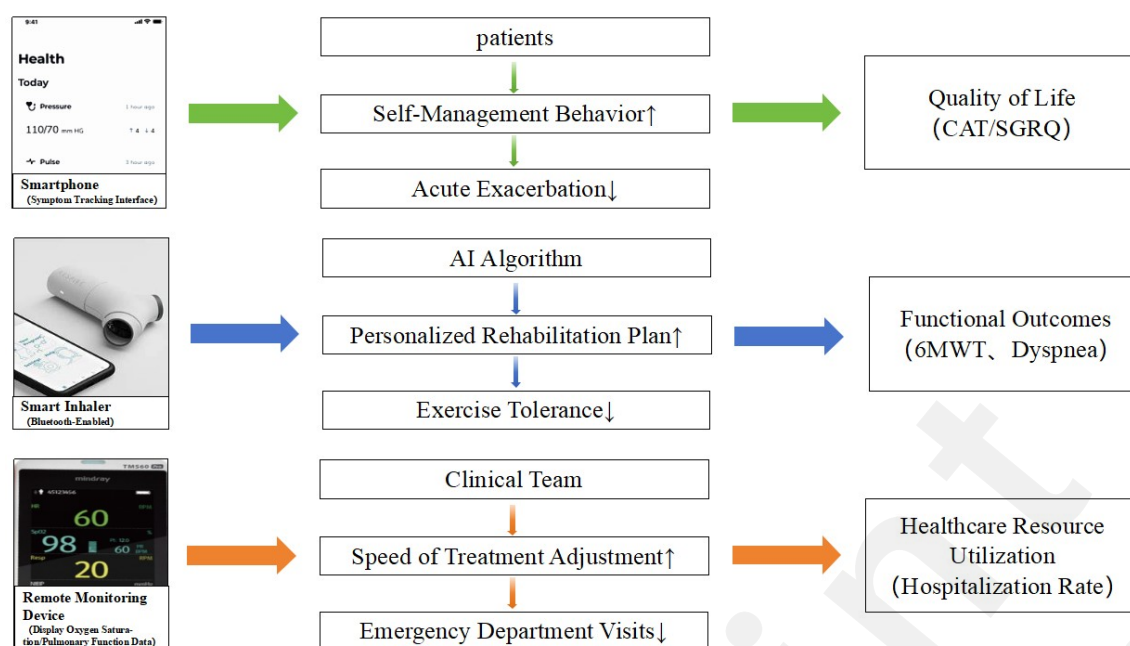


Fig. 1 hypothesized pathways

Methods

This systematic review and meta-analysis was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines^[16], and the 'PRISMA 2020 Checklist' was utilized (Appendix S1). The protocol for this study was registered in PROSPERO, the international prospective register for systematic reviews (CRD420251032053).

Search strategy

A systematic search of the PubMed, Embase, Cochrane, Web of Science and Scopus databases were conducted up to 26 January 2025 to identify relevant publications. The search utilized combinations of keywords and indexing terms, such as MeSH or Emtree, associated with the search domains. An automated electronic search was carried out using the MeSH terms identified in PubMed. The following MeSH terms keywords were included: "Pulmonary Disease, Chronic Obstructive" OR "chronic obstructive pulmonary disease" OR "COPD" OR "chronic obstructive lung disease" OR "chronic airflow obstruction" OR "emphysema" AND "digital health" OR "telehealth" OR "mHealth" OR "eHealth" OR "biosensor" OR "remote monitoring" OR "Smartphone" OR "Mobile Applications" OR "Apps" OR "Internet-based interventions" OR "Web-based platforms" AND "self-management" OR "self-monitoring" OR "self-care" AND "randomized controlled trial" OR "controlled clinical trial" OR "Clinical Trial". A comprehensive search strategy for every database was outlined in the Supplementary material online, Appendix S2. Boolean operators were employed to merge and cross-reference across different domains. Furthermore, a manual search was conducted by examining the reference lists of reviews on related topics as well as selected articles.

Eligibility criteria

The specific eligibility requirements of inclusion criteria in the PICOS format were used as follows: 1) Population: COPD; 2) Intervention: intervention delivered via a web-based remote digital health management system; 3) Comparison: the control group that received only the usual care interventions and the intervention group that used the web-based remote digital health management system in addition to the usual care interventions; 4) Outcomes: impacts of interventions on overall or at least one type of relevant health-related outcomes (e.g., quality of life, self-efficacy, functional outcomes, healthcare utilization indicators and so on); and 5) Study Design: randomized controlled trials (RCTs). Since the inclusion of unpublished studies can potentially introduce bias [20], this systematic review and meta-analysis only considered publications from peer-reviewed journals.

The review excluded case reports, preprint papers, letters to editors, simulation studies, published

conference abstracts, research lacking adequate details on the measurement of the outcomes of interest, qualitative studies, surveys or reviews, studies describing protocols, along with those focusing solely on the interface or internal structure of apps, and studies based on webpages or websites without associated applications.

Study selection and data extraction

Two researchers separately reviewed the identified papers to reduce potential errors and bias throughout the selection process. Initially, the authors screened the title and abstracts of the potential papers against the set inclusion and exclusion criteria. Following this, the final selection of papers was made after thoroughly reading the complete manuscripts of the qualifying papers and their references. Any discrepancies were settled through discussions among the authors until a consensus was reached.

A structured data extraction form was utilized to gather the following details: the first author's name, year of publication, study type, participant demographics (age range, sex ratio, sample size and country), interventions for remote digital health management, intervention duration, involvement of healthcare professionals (HCPs), strategies implemented to ensure participant compliance, and outcomes. The corresponding authors were contacted to clarify or obtain any information that was unclear or missing.

Study quality evaluation

Two researchers performed the quality assessment independently. Any disagreements were resolved through discussion between the two researchers, and a third investigator independently reviewed the final decisions. The quality of the RCTs was evaluated by two researchers using the Cochrane Collaboration's tool for assessing risk of bias^[17]. This tool addresses six domains of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases. The risk of bias was classified as high, low, or unclear, with reasons provided for each classification.

Statistical analysis

All meta-analyses were conducted using RevMan version 5.4 (The Cochrane Collaboration, Copenhagen, Denmark). The statistical indicators used included the standardized mean difference (SMD), odds ratio (OR), and 95% confidence interval (CI). An inverse-variance-weighted linear meta-analysis of SMD (Hedge's g) was carried out to evaluate the effect size of smartphone-based remote digital health management on changes in review outcomes, such as Self-efficacy/mMRC /6 MWT. In general, a Hedge's g value of less than 0.2 suggests a small effect, approximately 0.5 indicates a moderate effect, and greater than 0.8 signifies a strong effect. Heterogeneity among the results was assessed using the I^2 statistical test. The choice between a random-effects model and a fixed-effects model was based on the heterogeneity I^2 test, with I^2 values below 50% indicating the use of a fixed-effects model and values above 50% suggesting the use of a random-effects model^[17]. Effect sizes were compared using z-tests, and a P-value ≤ 0.05 was considered statistically significant.

Results

Study selection

The PRISMA flow diagram (Fig. 2) illustrates the screening process and the criteria used for excluding papers. The initial search yielded 1206 citations, from which 63 duplicates were eliminated. Following the removal of duplicates, 1143 records were evaluated against the inclusion and exclusion criteria. Subsequently, 40 full-text manuscripts were examined for eligibility. Out of these 45 articles, 23 studies were excluded for various reasons. As a result, 17 records were ultimately included in this review.

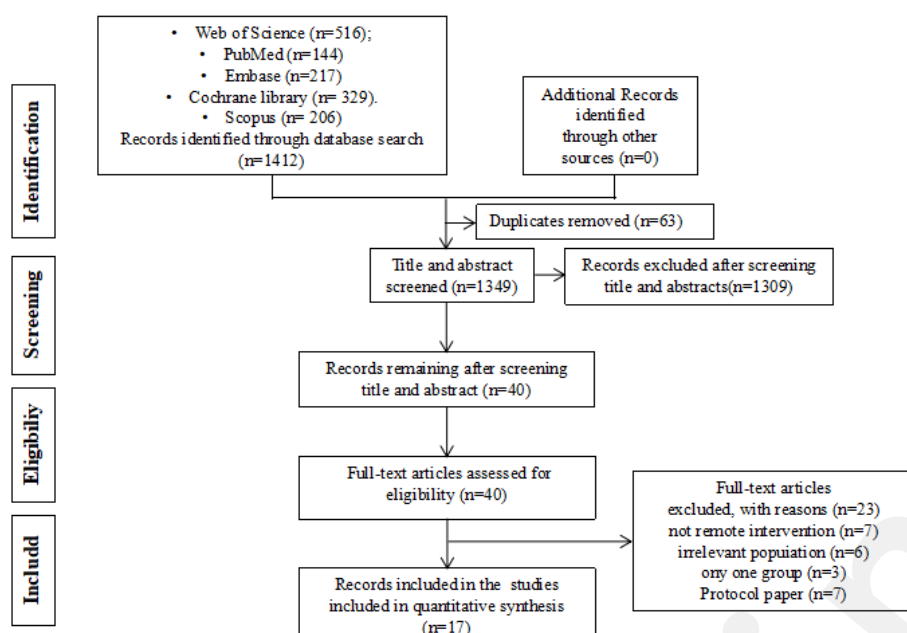


Fig. 2 The PRISMA (Preferred Reporting Item for Systematic Reviews and Meta-Analysis) flow diagram

Quality of study

Figures 3 and 4 show the risk of bias judgment of RCTs. All of studies^[18-34] showed specific random sequence generation methods. Allocation concealment was rated as low risk of bias in 9 trials^[21- 22, 24-26, 29-32] (53.0%) and unclear in 4 trials^[18-20, 23] (23.5%). Given the nature of web-based remote digital health management interventions, blinding of researchers and participants is unreasonable, which inevitably leads to risk deviation. In total, only 9 trials^[18-22, 27-28, 31, 33] had a low risk of in complete outcome data, it's worth noting that there were 14 trials^[18-28, 32-34] had a low risk of selective outcome reporting. The rates of dropout and attrition were within acceptable limits.

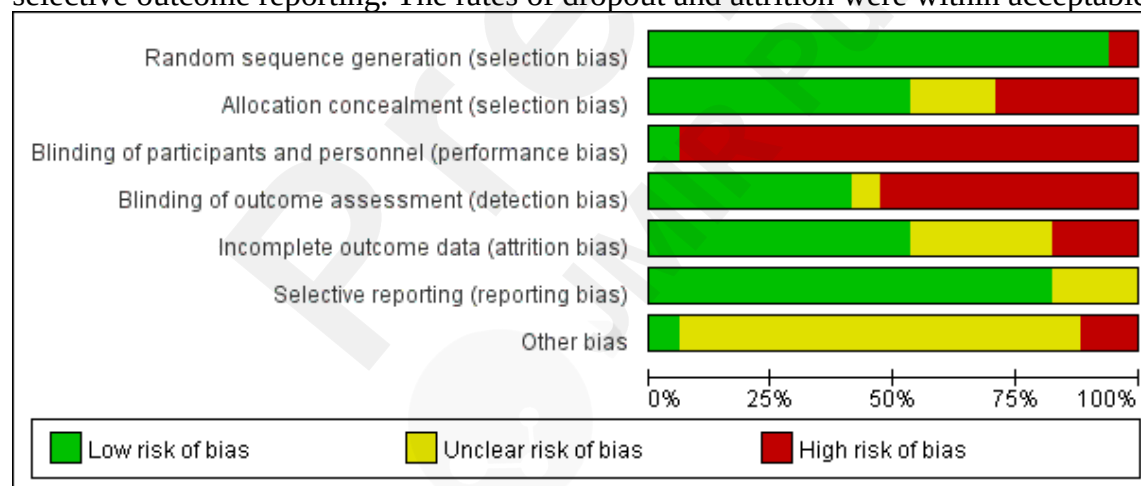


Fig.3 Risk of bias graph of RCTs: review authors' judgments about each risk of bias item presented as percentages The x-axis represents the percentage of studies that were found to be of low (green), unclear (yellow), or high (red) risk of bias for each domain

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Ali 2021	+	+	-	-	-	?	?
Benzo 2022	+	-	-	-	+	+	?
Bischoff 2019	+	?	-	-	?	+	?
De 2013	+	+	-	-	?	+	?
Farmer 2017	+	+	-	-	+	+	+
Jiang 2020	+	?	-	+	+	+	?
Kenealy 2015	+	+	-	?	?	+	?
Moy 2015	+	+	-	+	+	?	?
Nguyen 2009	+	+	-	+	?	+	?
Nyberg 2019	-	-	-	-	+	+	-
Park 2020	+	-	-	-	+	+	?
Robinson 2021	+	-	-	+	-	+	?
Stamenova 2020	+	+	-	-	?	+	?
Tabak 2014	+	+	-	-	-	?	-
Wan 2017	+	-	+	+	+	+	?
Wang 2021	+	+	-	+	+	+	?
Zanaboni 2022	+	?	-	+	+	+	?

Fig.4 Risk of bias summary of RCTs

Characteristics of the included studies

Table 1 provides a summary of the specific information extracted from the included studies. A total of 17 studies were published between 2009 and 2023. All studies compared either the use of a single app/web or an app/web combined with additional participant support against a control group. Collectively, these studies involved 2027 participants, with sample sizes ranging from 17^[32] to 375^[28]. Geographically, five studies^[28, 31-34] were conducted in USA; two in China^[18, 21], Australian^[20, 25], Netherlands^[23, 29], Sweden^[27, 30] and one in Korea^[19], Norway^[20], Denmark^[20], England^[22], Canada^[24] and New Zealand^[26]. In terms of study design, all of the studies were randomized controlled trials (RCTs). Fourteen articles^[18-26, 28, 30-31, 33-34] reported clinical outcomes, whereas three^[27, 29, 32] were pilot studies. Regarding the duration of interventions, four studies lasted three month or less^[11-12, 14, 16], nine studies^[18-19, 24-27, 30, 32, 34] lasted between 3 and 6 months, three studies^[20-21, 27] lasted

between 6 and 12 months, and three studies^[20, 22-23] lasted 12 months or longer. All of participants in these studies were aged 60 years or older.

In 15 trials, the control group received standard care without the use of the app^[18-23, 25-31, 33-34]. In one trial, they received routine in-person follow-up appointments and access to a certified respiratory educator^[24] or as per the physician's judgment based on current guidelines^[30], while in four trials, they were provided with leaflets^[22], paper action plan^[23], COPD book^[25], or an educational packet of 12 self-management themes^[28]. Telephone follow-up was utilized in two trials^[19, 26], and in one trial, the control group used the same app as the intervention group but with different functionality^[32].

Involvement of HCPs and strategies to ensure adherence via a digital health tools management interventions

Eleven trials^[18-22, 24, 26-27, 29, 30, 32] included the participation of HCPs in digital health tools usage, while the remaining six trials^[23, 25, 28, 31, 33, 34] did not provide specific information regarding HCP involvement in digital health tools usage (Table 1). The roles of HCPs varied across the trials; in most cases, HCPs were involved in prescribing rehabilitation or self-management training for patients^[18-19, 22, 27, 29-30, 32], guiding the training process^[20, 29], installing the digital health equipment and instructing patients on how to use them^[21-22, 25-26, 29-30], and reviewing the data^[20, 22, 24, 26]. Three trials described approaches to enhance adherence to the digital health tools management interventions. The strategies involved checking progress^[29], scheduling the follow-up meetings^[30], sending regular SMS reminders and making periodic phone calls^[32].

Digital health tools characteristics

Across the studies, a total of 17 distinct digital health tools were utilized. These tools were deployed across various types of digital platforms: one WeChat Official Account, five apps, seven websites, and four did not specify the platform's details. The functionality of these platforms varied significantly across the trials. Within the context of COPD management, digital platforms were employed in two key areas: self-management^[19, 21-31] and rehabilitation^[18, 20, 32-34]. Concerning self-management, the majority of digital health platforms' s feature functionalities such as self-monitoring, medication reminders, health information provision, assessment, feedback, access to health services, and social support. In the realm of rehabilitation, these digital health platforms are capable of tracking various physical activities and transmitting rehabilitation-related data to a server, allowing therapists to review this information. Notably, most of these tools require additional devices to fully realize their capabilities. Furthermore, certain tools facilitate patients' access to visual and auditory feedback on their exercises by displaying real-time information on connected device screens. An overview of digital health tools characteristics is provided in Table 2.

Table 1 Special information of the studies included

Studies	Country	Study design	Study type	Participants, n	Age	Intervention duration	Intervention and control arm	Involvement HCP	Measures to ensure intervention adherence	Outcome
(Jiang et al, 2020) [18]	China	Clinical outcome	RCT	E:53 C:53	E:70.92±6.39 C:71.83±7.60	6 months	Intervention: Lung rehabilitation intervention plan based on wechat Control: Routine outpatient rehabilitation	Respiratory experts, clinicians, rehabilitation practitioners, nurses	regularly calls	CAT mMRC SGRQ
(Park et al, 2020) [19]	Korea	Clinical outcome	RCT	E:22 C:20	E:70.45±9.40 C:65.06±11.12	6 months	Intervention: Smartphone-based self-management plan Control: telephone	A pulmonary physician and a nurse researcher	send SMS	6MWT Self-efficacy
(Zanaboni et al, 2023) [20]	Norway, Australia, Denmark	Clinical outcome	RCT	E:40 C:40	E:64.9±7.1 C:63.5±8.0	24 months	Intervention: Telerehabilitation Control: usual care	Physiotherapist	send SMS	6MWT, EQ-5D mMRC, CAT Self-efficacy
(Wang et al,	China	Clinical	RCT	E:39	E:63.2±7.5	12 months	Intervention:	A respiratory	not stated	CAT

2021) [21]		outcome		C:39	C:64.4±7.0		Plans based on mobile health apps Control: usual care	nurse		Self-efficacy
(Farmer et al, 2017) [22]	England	Clinical outcome	RCT	E:110 C:56	E:69.8±9.1 C:69.8±10.6	12 months	Intervention: Digital health system Control: usual care	Doctor, nurse or physiotherapist	postal reminders, telephone contact	SGRQ EQ-5D

Table 1 (continued)

Studies	Country	Study design	Study type	Participants, n	Age	Intervention duration	Intervention and control arm	Involvement HCP	Measures to ensure intervention adherence	Outcome
(Bischoff et al, 2019) [23]	Netherlands	Clinical outcome	RCT	E:35 C:41	E:69.3±8.8 C:65.9±8.9	12 months	Intervention: Smart mobile Health Program Control: paper action plan	Not stated	Regularly calls	EQ-5D EQ-5D VAS
(Stamenova et al, 2020) [24]	Canada	Clinical outcome	RCT	E:41 C:20	E:71.98±9.52 C:72.78±9.16	6 months	Intervention: Remote monitoring Control: routine in-person follow-up appointments and access to a certified respiratory educator	A respiratory therapist	Regularly calls	Emergency department admissions or for COPD, Hospital admissions or for COPD
(De et al, 2013) [25]	Australian	Clinical outcome	RCT	E:36 C:35	E:71 C:74	6 months	Intervention: Remote monitoring Control: usual care	Not stated	Regularly calls	Emergency department admissions or for COPD, Hospital

admissions or
for COPD

Table 1 (continued)

Studies	Country	Study design	Study type	Participants, n	Age	Intervention duration	Intervention and control arm	Involvement HCP	Measures to ensure intervention adherence	Outcome
(Kenealy et al, 2015) [26]	New Zealand	Clinical outcome	RCT	E:98 C:73	E:62-83 C:60-77	6 months	Intervention: Telemedicine Control: usual care	Three respiratory physicians, two respiratory nurse specialists and one respiratory nurse practitioner	Not stated	Self-efficacy SGRQ
(Nyberg et al, 2019) [27]	Sweden	pilot study	RCT	E:43 C:40	E:65±7 C:71±8	12 months	Intervention: Remote self-management Control: usual care	Four asthma/COPD-nurses, one district nurse, one dietician and one physiotherapists	Not stated	CAT mMRC EQ-5D
(Benzo et al, 2022) [28]	USA	Clinical outcome	RCT	E:188 C:187	E:69.335±9.53 C:68.676±9.53	3 months	Intervention: Remote monitoring Control: usual care	Not stated	Regularly calls	mMRC
(Tabak et al, 2014)	Netherlands	pilot study	RCT	E:12 C:12	E:64.1±9.0 C:62.8±7.4	3 months	Intervention: Telemedicine program	A chest physician or	Regularly calls	6MWT EQ-5D

[29]							Control: usual care	nurse practitioner	EQ-5D VAS	
(Ali et al, 2021)	Sweden	Clinical outcome	RCT	E:110	E:71.1±9.8	6 months	Intervention:	Not stated	Regularly calls	Self-efficacy
[30]				C:112	C:70.4±9.1		Digital-based intervention			
							Control: usual care			

Table 1 (continued)

Studies	Country	Study design	Study type	Participants, n	Age	Intervention duration	Intervention and control arm	Involvement HCP	Measures to ensure intervention adherence	Outcome
(Moy et al, 2015) [31]	USA	Clinical outcome	RCT	E:144 C:77	E:67.0±8.6 C:66.4±9.2	3 months	Intervention: Internet-mediated pedometer based intervention Control: usual care	Not stated	Not stated	SGRQ
(Nguyen et al, 2009) [32]	USA	pilot study	RCT	E:8 C:9	E:64.0±12 C:72±9	6 months	Intervention: Mobile phone based rehabilitation Control: Routine rehabilitation	Nurses	Send SMS	SGRQ
(Wan et al, 2017) [33]	USA	Clinical outcome	RCT	E:57 C:52	E:68.4±8.7 C:66.8±7.9	3 months	Intervention: Web-based pedometer intervention Control: Individual pedometer intervention	Not stated	Not stated	6MWT SGRQ mMRC
(Robinson et al, 2021)	USA	Clinical outcome	RCT	E:93 C:92	E:69.2±7.2 C:70.4±7.3	6 months	Intervention: Web-based exercise	Not stated	Follow-up, in-person	6MWT SGRQ

[34]	routine	
	intervention	assessments mMRC
	Control: usual care	

Table 2 Special information on digital health tools characteristics

Studies	Digital health tools name	Generally objective	Specific objective	Devices	Main feature of the digital health tools
(Jiang et al, 2020) [18]	PeR	Rehabilitation	Improve quality of life, symptoms, and exercise self-efficacy	WeChat official account	PeR management on the basis of evaluation, including respiratory training, sports training, diet guidance, medication knowledge.
(Park et al, 2020) [19]	SASMP	Self-management	Self-care behavior	An Android platform (version 2.3 Gingerbread)	Education, exercises, self-monitoring of symptoms and exercise, and social support.
(Zanaboni et al, 2023) [20]	Not stated	Rehabilitation	Reducing hospital readmissions	A treadmill, a pulse oximeter, a tablet computer, and a holder for the tablet computer	1) An integrated intervention consisting of exercise training at home, telemonitoring, and self-management. 2) Access the individual training program, fill in a daily diary and a training diary, review historical data, exchange electronic messages, schedule videoconferencing sessions, and facilitate individual goal setting and goal attainment.
(Wang et al, 2021) [21]	Not stated	Self-management	Quality of life, self-management behaviour and exercise and smoking cessation behaviour	No device	1) Provided knowledge and information support to participants. 2) Provided visual aids to teach participants skills to manage the disease. 3) Provided motivational support to participants, which included a peer support chat room and an expert support portal.
(Farmer et al, 2017)	EDGE	Self-management	Improve quality of life and clinical outcomes	Android tablet computer (Samsung Galaxy Tab)	1) Provide monitoring and self-management support. 2) Complete the symptom diary and recorded their oxygen

[22]	running the app software and a Bluetooth-enabled oximeter probe	saturation and heart rate. 3) Set alerts when the vital sign value go above (or below)
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Table 2 (continued)

Studies	Digital health tools name	Generally objective	Specific objective	Devices	Main feature of the digital health tools
(Bischoff et al, 2019) [23]	Not stated	Self-management	The number of exacerbation-free weeks	A mobile phone, a pulse oximeter (CMS50D, Contec Medical Systems), a spirometer (PiKo-1 monitor, nSpire), and a forehead thermometer (FTN, Medisana AG)	Provide predictions of early exacerbation onset and timely treatment advice without the interference of health care professionals.
(Stamenova et al, 2020) [24]	Not stated	Self-management	Self-management	A custom tablet computer, a Pulsewave wrist cuff monitor (which measures blood pressure), an oximeter, a weighing scale, and a thermometer	1□Record their vitals by the Cloud DX platform. 2□Provide a written version of a personalized COPD action plan.
(De et al, 2013)[25]	Health HUB	Self-management	Reduce the incidence of hospitalizations and emergency department (ED) presentations	No device	1□Measure and record their vital signs (blood pressure, weight, temperature, pulse, and oxygen saturation levels) on a daily basis. 2□Transmitted signs automatically via telephone to a secure Web site where they were monitored each day by the telehealth nurse.
(Kenealy et al, 2015) [26]	Health HUB	Self-management	Quality of life, self-care, hospital use, costs and the experiences of	A LCD	Entering the data into a commercially-available electronic device that uploaded data once a day to a nurse-led monitoring station peer support chat room and an expert support portal.

patients, informal carers and health care professionals.					
(Nyberg et al, 2019) [27]	COPD Web	Self-management	Increasing PA	No device	The COPD Web includes, texts, pictures, and videos as well as interactive components such as a tool for registration of PA, including automated feedback.

Table 2 (continued)

Studies	Digital health tools name	Generally objective	Specific objective	Devices	Main feature of the digital health tools
(Benzo et al, 2022) [28]	Not stated	Self-management	Improves the physical and emotional disease-specific QoL	A computer tablet, a Garmin Vivofit activity monitor and an oximeter (Nonin 3150)	1) Capture daily steps and self-report of symptoms. 2) Send and receive messages to/from the coach. 3) The data gathered on the tablet via Bluetooth (steps, compliance with daily exercises, messages, and symptoms) was transmitted to a server and, ultimately, to an online patient portal.
(Tabak et al, 2014) [29]	Condition Coach	Self-management	The number of hospitalizations, length of stay, and emergency department visits	An accelerometer-based activity sensor (Inertia Technology, Enschede, the Netherlands) and a smartphone (Desire S; HTC, New Taipei, Taiwan)	1) Activity coach for ambulant activity monitoring and real-time coaching of daily activity behavior. 2) Web-based exercise program for home exercising. 3) Self-management of COPD exacerbations via a triage diary on the web portal, including self-treatment of exacerbations. 4) Teleconsultation.
(Ali et al, 2021)[30]	Not stated	Self-management	General self-efficacy and hospitalization or death	No device	Comprising PCC using a combined digital platform and structured telephone support system
(Moy et al, 2015) [31]	Not stated	Self-management	Increasing PA	A computer with an internet connection, a USB port, and Windows XP, Vista, 7, or 8	A novel Internet-mediated, pedometer-based exercise intervention.
(Nguyen et	Not stated	Rehabilitation	Maximal workload, 6MW	An Omron HJ-112 digital	1) Develop an individualized exercise plan, were issued a

al, 2009) [32]	distance, HRQL or total steps	pedometer	pedometer and exercise booklet. 2) Instructed to continue to log their daily exercise and symptoms. 3) MOBILE-Coached also received weekly reinforcement text messages on their cell phones; reports of worsening symptoms were automatically flagged for follow-up.
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Table 2 (continued)

Studies	Digital health tools name	Generally objective	Specific objective	Devices	Main feature of the digital health tools
(Wan et al, 2017)[33]	ESC	Rehabilitation	Increasing PA	An Omron HJ-720 ITC pedometer	1) a pedometer and website which provided goal-setting, feedback, disease-specific education, and an online community forum or 2) Pedometer alone for 3 months.
(Robinson et al, 2021)[34]	Not stated	Rehabilitation	Increasing PA	Pedometer	Personalised, progressive step-count goals, feedback, online COPD-related education and social support via an online community

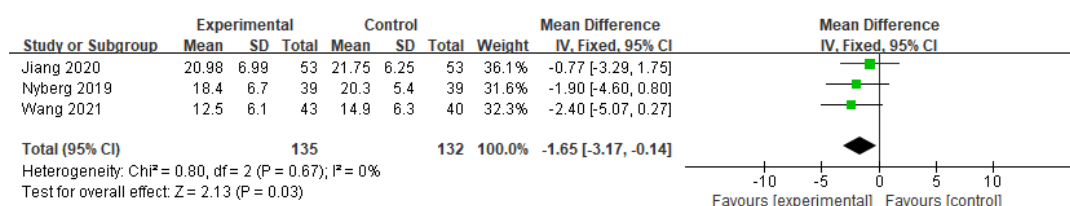


Fig.5 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by CAT at 3 months

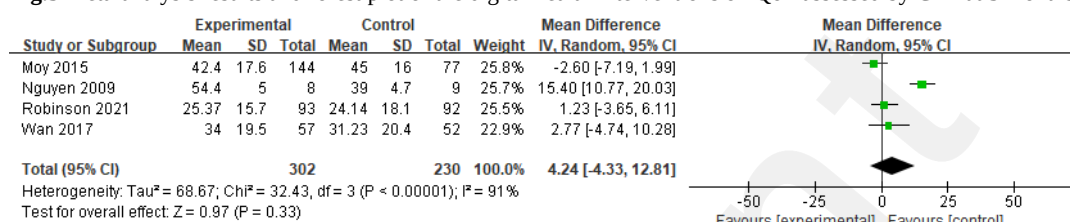


Fig.6 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by SGRQ at 3 months

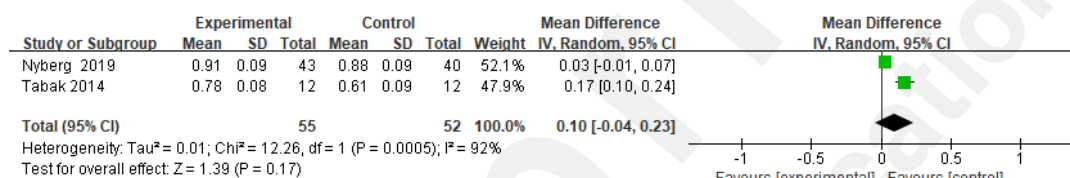


Fig.7 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by EQ-5D at 3 months

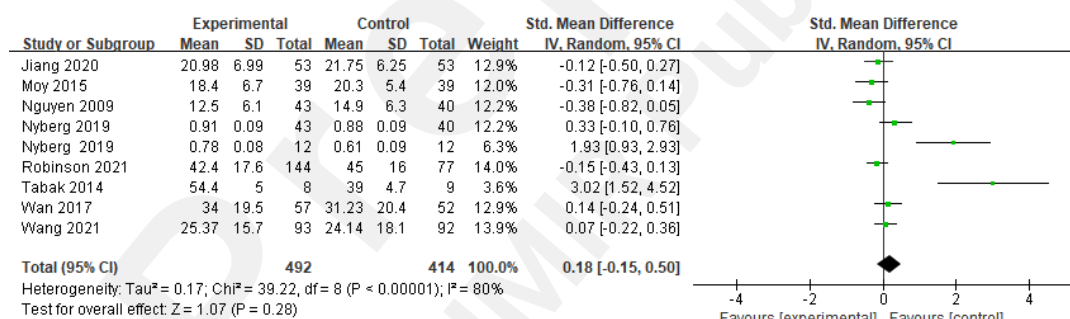


Fig.8 Meta-analysis results and forest plot of the digital health interventions on QoL at 3 months

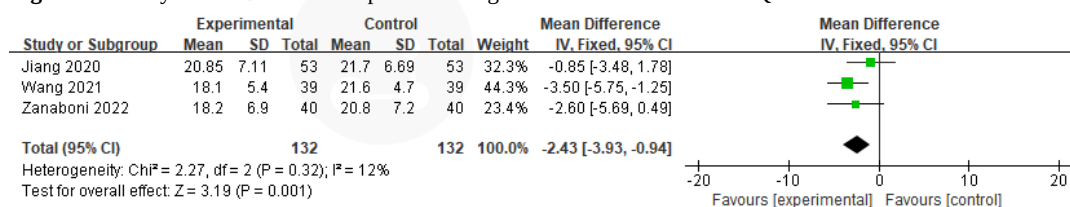


Fig.9 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by CAT at 6 months

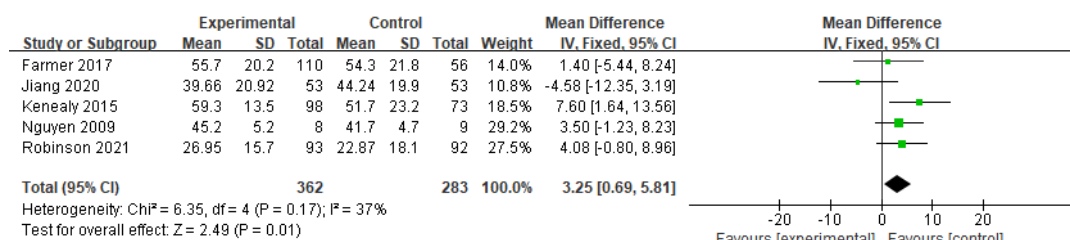


Fig.10 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by SGRQ at 6 months

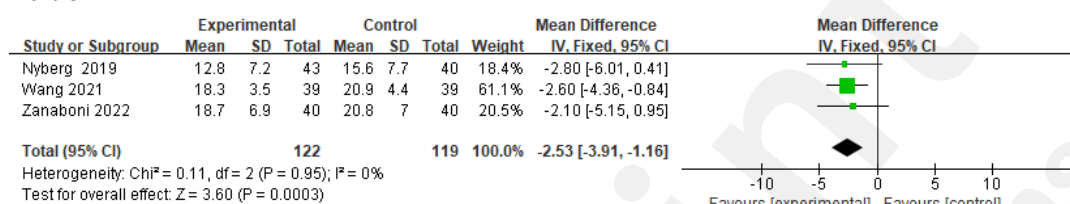


Fig.11 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by CAT at 12 months

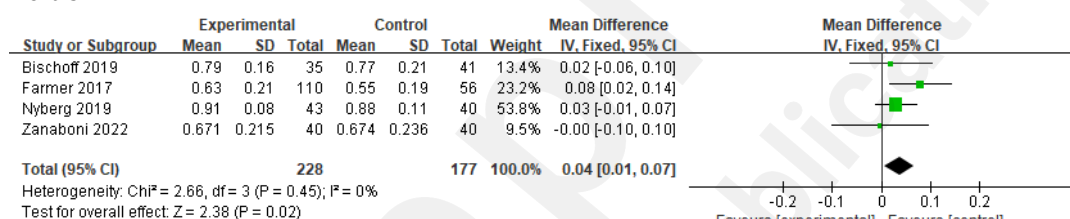


Fig.12 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by EQ-5D at 12 months

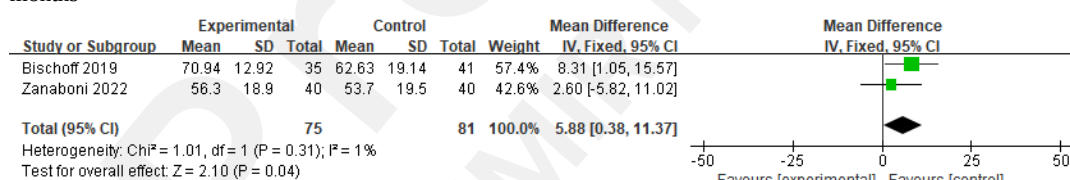


Fig.13 Meta-analysis results and forest plot of the digital health interventions on QoL assessed by EQ-5D VAS at 12 months

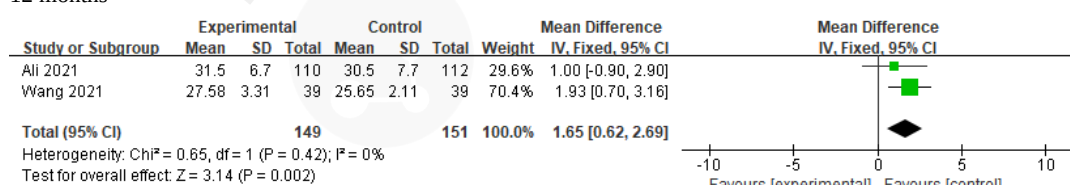


Fig.14 Meta-analysis results and forest plot of the digital health interventions on self-efficacy at 3 months

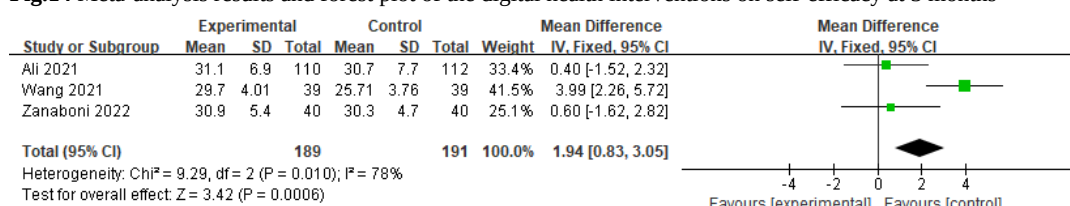
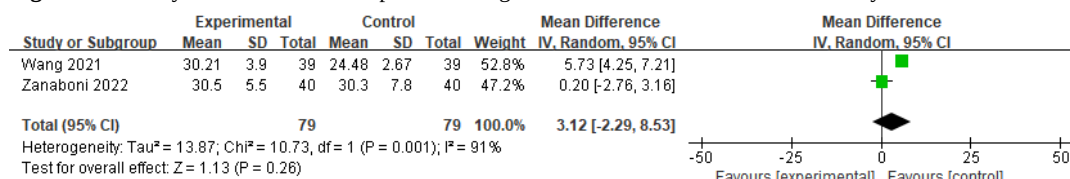
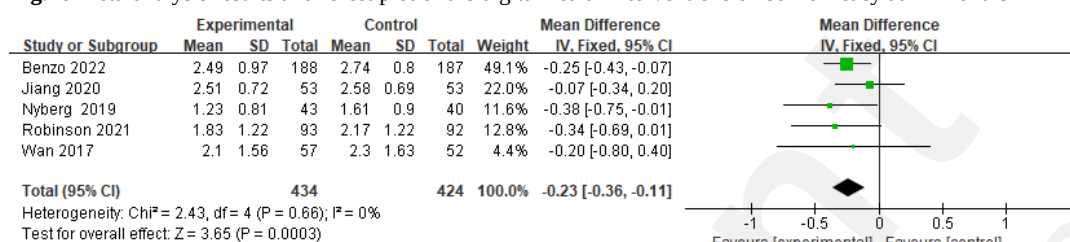
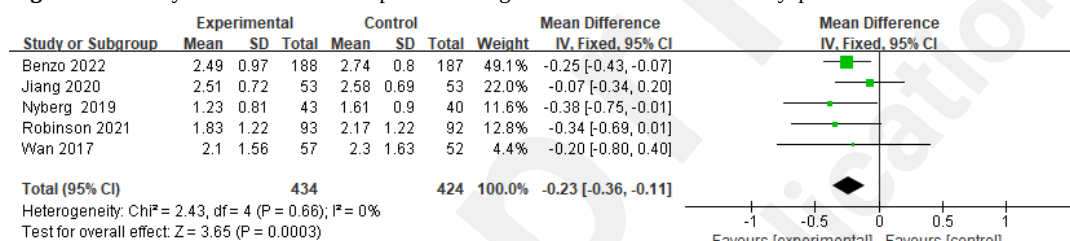
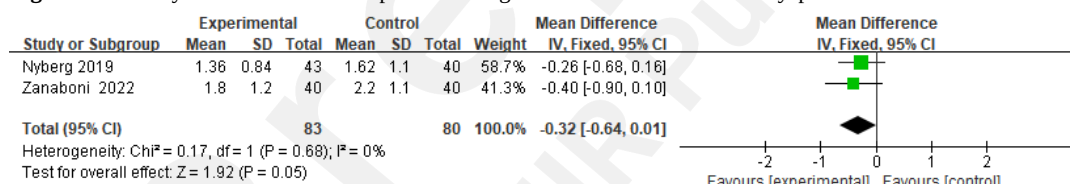
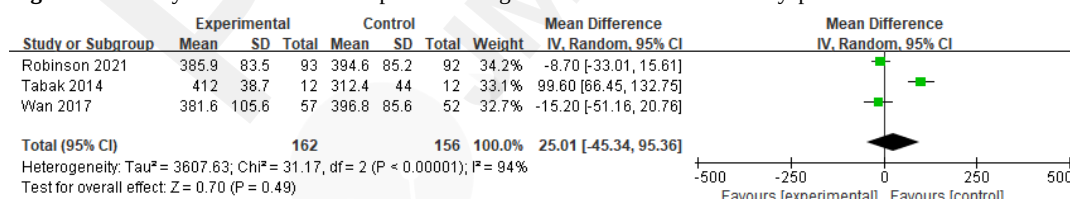
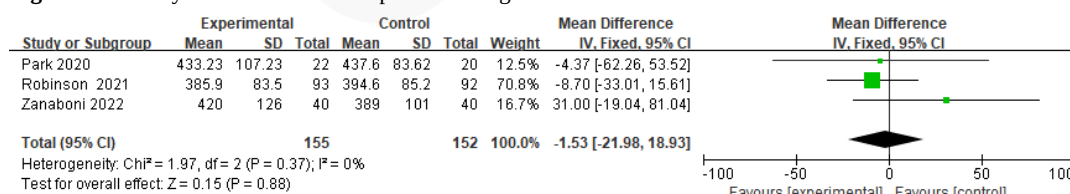


Fig.15 Meta-analysis results and forest plot of the digital health interventions on self-efficacy at 6 months**Fig.16** Meta-analysis results and forest plot of the digital health interventions on self-efficacy at 12 months**Fig.17** Meta-analysis results and forest plot of the digital health interventions on dyspnea at 3 months**Fig.18** Meta-analysis results and forest plot of the digital health interventions on dyspnea at 6 months**Fig.19** Meta-analysis results and forest plot of the digital health interventions on dyspnea at 12 months**Fig.20** Meta-analysis results and forest plot of the digital health interventions on 6MWT at 3 months**Fig.21** Meta-analysis results and forest plot of the digital health interventions on 6MWT at 6 months

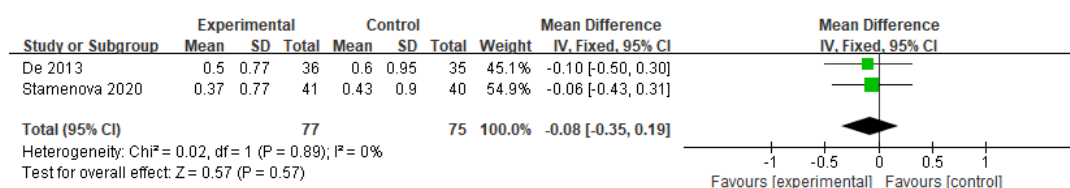


Fig.22 Meta-analysis results and forest plot of the digital health interventions on emergency department admissions

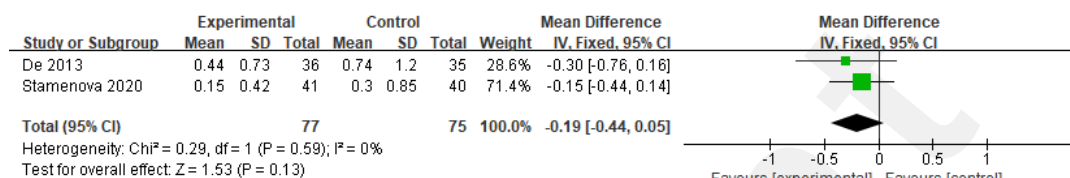


Fig.23 Meta-analysis results and forest plot of the digital health interventions on hospital admissions

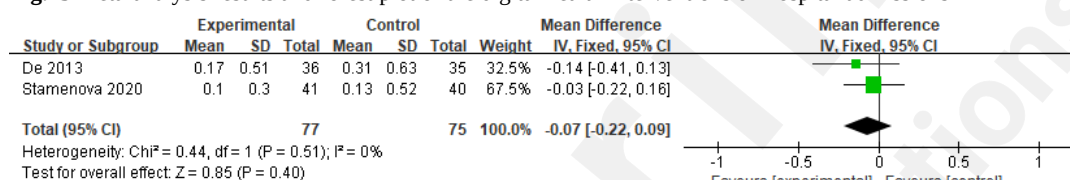


Fig.24 Meta-analysis results and forest plot of the digital health interventions on emergency department admissions for COPD

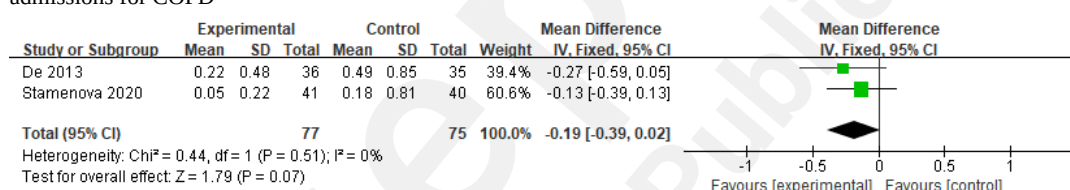


Fig.25 Meta-analysis results and forest plot of the digital health interventions on hospital admissions for COPD

Intervention effectiveness

Quality of life QoL

An array of QoL outcomes were measured across the trials, which included a COPD Assessment Test (CAT), St. George's Respiratory Questionnaire (SGRQ), EuroQol 5 Dimensions (EQ-5D) and EuroQol 5 Dimensions Visual Analogue Scale (EQ-5D VAS). And assessments are conducted at three different time points, which are 3 months, 6 months, and 12 months, respectively.

At 3 months, the effects of digital health management were limited but showed some promising trends. Three studies ($n=267$) assessed its impact on CAT scores, revealing a mild but significant effect size (Hedge's $g = -1.65$; $MD = -1.65$, 95% CI [-3.17, -0.14]; $P = 0.03$; Fig.5) with no heterogeneity ($I^2 = 0\%$). However, four studies ($n=532$) evaluating SGRQ scores found no significant effect ($MD = 4.24$, 95% CI [-4.33, 12.81]; $P = 0.33$; Fig.6) and high heterogeneity ($I^2 = 91\%$). Similarly, two studies ($n=107$) on EQ-5D also showed no significant improvement ($MD = 0.10$, 95% CI [-0.04, 0.23]; $P = 0.17$; Fig.7) with high heterogeneity ($I^2 = 92\%$). The overall meta-analysis ($n=639$) indicated that digital health management did not significantly improve quality of life ($MD = 0.18$, 95% CI [-0.15, 0.50]; $P = 0.28$, $I^2 = 80\%$; Fig.8).

At 6 months, the benefits of digital health management became more pronounced. Three RCTs ($n=264$) examining CAT scores revealed a statistically significant benefit for the intervention group compared to controls (MD = -2.43, 95% CI [-3.93, -0.94]; $P = 0.001$; Fig.9), with low heterogeneity ($I^2=12\%$). Additionally, one study on SGRQ scores also showed a significant effect (MD = 3.25, 95% CI [0.69, 5.81]; $P = 0.01$; $I^2=37\%$; Fig.10), indicating improved symptom control and health status over time.

At 12 months, the positive effects observed at 6 months were sustained, with findings showing statistically significant improvements across multiple outcomes. Five studies ($n=802$) assessing CAT, EQ-5D, and EQ-5D VAS scores demonstrated highly significant effects in favor of digital health management ($P \leq 0.05$), with no or low heterogeneity (Fig.11-13). These results suggest that long-term intervention has a sustained impact on symptom relief and overall health status improvement.

Self-efficacy

Self-efficacy was also evaluated at 3, 6 and 12 months, using the General Self-Efficacy Scale (GSE). Analysis showed significant differences at 3 months (MD = 1.65, 95% CI [0.62, 2.69]; $P = 0.002$; Fig.14) and 6 months (MD = 1.94, 95% CI [0.83, 3.05]; $P = 0.0006$; Fig.15). Amongst the outcomes that were reported by two studies, no significant difference at 12 months (MD = 3.12, 95% CI [-2.29, 8.53]; $P = 0.26$) was observed between the two groups, with high statistical heterogeneity ($I^2 = 91\%$). (Fig.16).

Functional outcomes

Dyspnea

Six studies (total sample size=1,392 patients) assessed the effect of digital health management on Modified Medical Research Council Dyspnea Scale (mMRC). Meta-analysis showed a significant difference favoring digital health management at 3 months (MD = -0.23, 95% CI [-0.36, -0.11]; $P = 0.0003$; $I^2= 0\%$; Fig.17) and at 12 months (MD = -0.32, 95% CI [-0.64, 0.01]; $P = 0.05$; $I^2= 0\%$; Fig.19). However, no significant difference was observed at 6 months, with moderate heterogeneity among studies (MD = -0.17, 95% CI [-0.46, 0.12]; $P = 0.26$; $I^2= 50\%$; Fig.18).

Six-Minute Walk Test (6 MWT)

Meta-analysis indicated a positive trend for digital health management in 6 MWT. However, no significant differences were observed between the intervention and control groups at 3 months (MD = 25.01, 95% CI [-45.34, 95.36]; $P = 0.49$; $I^2= 94\%$; Fig.20) or at 6 months (MD = -1.53, 95% CI [-21.98, 18.93]; $P = 0.88$; $I^2= 0\%$; Fig.21).

Healthcare utilization indicators

Healthcare utilization indicators included emergency department admissions, hospital admissions, emergency department admissions for COPD and hospital admissions for COPD. The overall effect revealed that the digital health management intervention couldn't effectively reduce healthcare utilization indicators. Analysis showed no significant differences in emergency department admissions (MD = -0.08, 95% CI [-0.35, 0.19]; $P = 0.57$; Fig.22), hospital admissions (MD = -0.19, 95% CI [-0.44, 0.05]; $P = 0.13$; Fig.23), emergency department admissions for COPD (MD = -0.07, 95% CI [-0.22, 0.09]; $P = 0.40$; Fig.24) and hospital admissions for COPD (MD

= -0.19, 95% CI [-0.39, 0.02]; $P = 0.07$; Fig.25), all of them with no statistical heterogeneity ($I^2 = 0\%$).

Discussion

Principal findings

This systematic review and meta-analysis aggregated data from 17 RCTs, encompassing a total of 2027 participants, to assess the efficacy of digital health interventions aimed at COPD. The digital health tools were mainly utilized for rehabilitation and self-management purposes. Although many trials included healthcare professionals in the intervention process, few elaborated on strategies to maintain participant adherence throughout the intervention period. Most participants were older adults. Our study results showed that the remote digital health intervention demonstrated significant effects in improving QoL. Specifically, the CAT score showed statistically significant improvements at 3 months, 6 months (CAT and SGRQ, respectively), and 12 months (CAT, EQ-5D, and its visual analog scale VAS, respectively). Additionally, the degree of dyspnea (mMRC) significantly decreased at 3 months and approached significance at 12 months. Self-efficacy (GSE) also improved significantly in the short term, particularly at 3 months and 6 months, but no significant changes were observed at 12 months. Despite these encouraging results, no significant improvements were observed in physical performance (e.g., the 6-minute walk test, 6MWT) or hospitalization rates. For instance, the 6MWT did not show significant effects at either 3 months or 6 months. Similarly, although there were trends toward reduced all-cause hospitalization rates and COPD-related hospitalization rates, these did not reach statistical significance. While these results are promising, they should be interpreted with caution due to differences in digital health tools characteristics, content variability, and the diverse methodologies and clinical settings across studies, alongside generally small sample sizes.

Effects of intervention on COPD patients' health outcomes

Quality of life—QoL

The overall effect indicated that the QoL of the group using digital health interventions was superior to that of the control group, with effects at 12 months being more pronounced than at 3 and 6 months. This sustained improvement can be attributed to the benefits of prolonged treatment without requiring therapist's online presence, ensuring offline monitoring of rehabilitative activities^[35]. This finding aligns with the Technology Acceptance Model (TAM)^[36], where prolonged exposure enhances perceived usefulness (e.g., recognizing tools' role in exacerbation prevention). However, early dropout may reflect low perceived ease of use among elderly users struggling with multi-device complexity. Therefore, while sustained engagement leads to better health outcomes, addressing usability challenges is crucial, especially for older adults^[37].

The improvements in CAT, SGRQ, EQ-5D, and EQ-5D VAS scores hold clinical significance, particularly when considering their impact on patient outcomes. Taking CAT as an example, the improvement (an average reduction of 1.65 points), although slightly below the minimal clinically important difference (2 points), may indicate mild symptom relief, such as reductions in dyspnea and coughing. This can have

practical importance for daily functioning, especially for patients with a higher symptom burden. While these improvements do not directly translate into significant enhancements in overall quality of life, they may help reduce the risk of acute exacerbations or slow disease progression, serving as a valuable supplementary tool for personalized management, particularly in resource-limited or remote healthcare settings.

Notably, while the 12-month quality of life data suggest potential long-term benefits, the effect sizes are derived from only five studies with varying designs and high heterogeneity (I^2 up to 92%). Due to the limitations of the available data, these long-term findings should be interpreted with caution. Additionally, we emphasize the need for further high-quality, long-term studies to confirm the robustness and generalizability of these results.

Functional outcomes

In the second subgroup analysis, digital health interventions showed the greatest impact on dyspnea in COPD patients at 3 months, likely due to high adaptability and initial learning effects. However, no significant differences were observed at 6 months, suggesting a decline in novelty and short-term adjustable factors reaching their limit. A marginally significant improvement was noted at 12 months, indicating that long-term adherence may gradually alleviate chronic issues. Individual differences, environmental changes, and study design characteristics also contribute to these observations. These findings highlight the dynamic and complex nature of digital health interventions. Future longitudinal studies should include larger, more diverse patient populations and conduct detailed analyses of intervention effects over time to validate these results and explore underlying mechanisms.

Despite significant improvements in dyspnea (mMRC) and quality of life (CAT/SGRQ) for COPD patients through digital health interventions, no such benefits were seen in the 6-minute walk test (6 MWT). This may be due to a mismatch between interventions and functional improvement needs. Most digital tools focused on symptom monitoring (e.g., dyspnea diaries) and self-management education (e.g., medication reminders), lacking structured exercise prescriptions. Evidence shows that improving 6 MWT requires high-intensity aerobic training, which remote monitoring alone cannot provide^[38]. Only one trial included sensor-guided walking training; others did not prioritize exercise adherence^[29]. Additionally, the sensitivity of 6 MWT is limited by comorbidities and testing conditions, diluting intervention effects. Future research should use accelerometers for more precise functional assessment. Furthermore, declining patient engagement over time, possibly due to "digital health fatigue," where interest in repetitive tasks wanes, may reduce effectiveness^[39]. No improvements in 6 MWT or mMRC at 6 months suggest short-term effects diminish with reduced participation.

Self-efficacy

Subgroup analysis results indicate that at 6 months, digital health interventions significantly enhanced self-efficacy in COPD patients, but no significant effect was observed at 12 months. This pattern aligns with Bandura's Social Cognitive Theory^[40]: early improvements (at 3 and 6 months) stem from mastery experiences (e.g.,

symptom control via real-time feedback) and clinician-mediated social persuasion. Self-efficacy (GSE) improved significantly in the short term but showed no significant changes at 12 months. The lack of sustained adaptive reinforcement likely contributed to 'digital health fatigue,' leading to attrition at 12 months^[39]. Patients may have felt they maximized benefits within a 6-month period, experiencing the greatest benefit during this phase. This contrasts with longer-duration trials where improvements plateaued. These findings also align with Pierz et al.^[41], who noted digital health technologies enhance self-efficacy through remote management, improved communication, and personalized support. The improvement in self-efficacy indicates an increased confidence among patients in managing their disease, which may promote behavioral changes such as better medication adherence and greater participation in physical activity.

Healthcare utilization indicators

The reason for the lack of improvement in healthcare resource utilization is, first, that the monitoring systems in the two included studies lacked closed-loop response mechanisms — Stamenova's personalized plans did not integrate automated clinical pathways^[24], while De's nurse-led monitoring experienced response delays, preventing data from being promptly translated into preventive interventions^[25]. Secondly, there was insufficient patient-side execution efficacy: the complexity of multi-device operation in the former affected adherence among elderly patients, while the latter relied on self-recording, which was prone to errors. Additionally, the interventions were not deeply integrated with regional healthcare resources (e.g., emergency medication delivery, rapid referrals), meaning that even when deterioration was detected, timely treatment could not be ensured. Moreover, the technical design did not align with COPD management needs —the interfaces were complex and lacked threshold alerts for deterioration, resulting in inefficient data utilization. Fundamentally, the application of technology remained at the data collection level, failing to address systemic bottlenecks such as the "monitoring-to-action" transition and resource accessibility, which explains why hospitalization rates were not reduced^[24-25].

Analysis of High Heterogeneity

SGRQ Scores of QoL($I^2=91\%$)

The high heterogeneity in SGRQ scores is primarily due to the multidimensional nature of the scale (symptoms, activity, disease impact) conflicting with the varied focus of interventions. For instance, Farmer et al.^[22] improved symptoms through blood oxygen monitoring but had limited effects on activity, while Zanaboni et al.^[20] demonstrated greater improvements in activity via exercise training. Additionally, differences in control group settings (e.g., basic outpatient rehabilitation in China vs. passive follow-ups in the UK) further contributed to result dispersion.

EQ-5D Scores of QoL($I^2=92\%$)

The high heterogeneity in EQ-5D scores likely stems from a mismatch between general health assessments (mobility, self-care) and COPD-specific interventions (lung function, symptom control). Stamenova et al.^[24] showed that remote monitoring reduced hospitalizations but had minimal impact on daily activities, while Nyberg et

al.^[27] found increased physical activity improved overall health, though comorbidities diluted these effects. Small sample sizes and varying intervention durations (12 vs. 24 months) further exacerbated variability.

Overall QoL Assessments ($I^2=80\%$)

The high heterogeneity in overall QoL assessments arises from combining different scales (SGRQ, EQ-5D, CAT), which vary in structure and sensitivity. For example, CAT may show improvements in symptoms, while EQ-5D indicates no change or even deterioration. Additionally, intervention goals often focus on symptom control or reducing exacerbations (e.g., Bischoff et al.'s "exacerbation-free weeks")^[23] rather than directly enhancing overall QoL.

Self-Efficacy at 12 Months ($I^2=91\%$)

The high heterogeneity in self-efficacy at 12 months observed in Wang 2021^[21] and Zanaboni 2023^[23] studies primarily stems from key differences in their intervention approaches. Wang's study used a mobile app focusing on education and social support but lacked structured behavioral training, whereas Zanaboni's study implemented home-based tele-rehabilitation, incorporating exercise training and real-time monitoring. Differences in assessment timing, adherence strategies, and cultural contexts also contributed to outcome variability, leading to significant heterogeneity in pooled analysis.

6MWT at 3 Months ($I^2=94\%$)

The high heterogeneity in the 6MWT at 3 months is primarily due to fundamental differences in interventions and population adaptability across studies. Robinson (2021)^[34] relied on fully self-guided online exercise with community feedback; Tabak (2014)^[29] integrated real-time monitoring with remote counseling; and Wan (2017)^[33] focused on a pedometer combined with an educational website. Furthermore, significant variations in participant age, baseline disease severity, and intervention support intensity collectively led to highly dispersed improvements in walking capacity.

Relationship with Previous Published Literature

Previous systematic reviews have evaluated the effectiveness of digital health interventions in various areas such as blood pressure control in non-dialysis chronic kidney disease^[42], prevention of cardiovascular disease^[43], hypertension management^[44], and weight management in children and adolescents^[45]. Many of these reviews concluded that digital health interventions are effective tools that lead to positive outcomes. To our knowledge, five other systematic reviews have been published on this topic specifically for COPD patients^[46-50]. One of these reviews was limited to the effects of digital health interventions for pulmonary rehabilitation in people with COPD^[46]; the other focused on the role of digital health interventions for the self-management of COPD^[47]; and the other review focused on the cost-effectiveness of digital health interventions for asthma or COPD^[48]. Additionally, although two recent systematic reviews and meta-analyses aimed to assess the effects of home remote monitoring with mobile applications in patients with COPD^[49-50], they included interventions module focusing solely remote monitoring rather than other module (e.g., health education □ behavioral incentive □ social support) and the

technologies do not involve electronic health records, wearable technology and data analysis platforms. Therefore, this systematic review is unique because it extends beyond previous reviews by including evidence from newly published studies that provide more comprehensive health management services.

Limitations

This study has several limitations that warrant consideration. Firstly, there may be language biases since the searches were conducted in English, which could restrict the cross-cultural applicability of our findings. Secondly, our exclusive focus on randomized controlled trials (RCTs)—while methodologically rigorous—excluded potentially relevant non-randomized studies (e.g., pragmatic trials) that could provide complementary insights into real-world implementation of digital health tools. Thirdly, the Scopus database was not retrieved, and it should be included in the future. So we searched PubMed, EMBASE, Cochrane, and Web of Science databases. Keyword searches in PubMed provide optimal update frequency and include early online articles; other databases rank articles by the number of citations as an indicator of importance. Additionally, due to the small number of studies, subgroup analyses were not conducted, and publication bias was not explored. Finally, variations in the number of participants, intervention duration, frequency, research tool, and follow-up times led to heterogeneity.

Practical implications for healthcare and further studies

Digital health interventions show potential as a valuable addition to standard clinical care for COPD. Nevertheless, the adoption of digital health tools in this population is still in its early stages. Further research is essential to evaluate the impact of such interventions. Moreover, it is crucial to determine whether the currently limited effectiveness remains consistent and to explore the conditions under which their benefits could be maximized. These are areas that warrant systematic investigation. Additionally, with the growing aging population, future studies should focus on older adults with COPD, who represent the largest group of potential users. Older adults need access to digital health tools to support them to live independently and the self-care of chronic diseases. Computer or smartphone ownership among individuals aged 65 and above has risen significantly^[51]. However, according to the European Union Commission's 2012-2020 eHealth Action Plan, the current mHealth environment lacks intuitive tools and services tailored for elderly patients^[51]. Therefore, gaining insights into the needs of older adults with COPD is critical for designing, developing, and assessing digital health tools interventions for this demographic.

Conclusions

Our analysis revealed that digital health interventions may have the potential to improve QoL at 3 months, 6 months and 12 months. Additionally, the degree of dyspnea significantly decreased at 3 months and approached significance at 12 months. Self-efficacy also improved significantly in the short term, particularly at 3 months and 6 months. However, no significant differences were observed in the 6 MWT, emergency department admissions, hospital admissions, emergency department admissions for COPD or hospital admissions for COPD. Furthermore,

there is insufficient generalizable evidence to confidently advocate for replacing conventional management strategies with digital health interventions for COPD. This limitation arises due to clinical and methodological variability across studies, small sample sizes, and inconsistencies in platforms functionalities, content, duration and follow-up protocols. Considering the global surge in digital health tools usage and the increasing adoption of eHealth solutions, additional research employing robust study designs, long-term follow-ups, and samples representative of older adults is essential to evaluate the long-term sustainability of digital health-based interventions.

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Supplementary Files