Digital technologies to deliver pulmonary rehabilitation programmes for adults with COPD [GID-HTE10019]

ON External Assessment Group report

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Early Value Assessment Programme

Produced by

Peninsula Technology Assessment Group (PenTAG)
University of Exeter Medical School
South Cloisters
St Luke's Campus
Heavitree Road
Exeter
EX1 2LU

Authors

Maxwell S. Barnish[1]
Madhusubramian Muthukumar[1]
Alan Lovell[1]
Ahmed Abdelsabour[1]
Philip McBride[2]
Jemma Perks[2]

Caroline Farmer[1]

Edward C. F. Wilson[1]

Helen Dawes[2]

G.J. Melendez-Torres[1]

[1] Peninsula Technology Assessment Group (PenTAG), University of Exeter Medical School, Exeter

[2] University of Exeter Medical School, Exeter

Correspondence to Alan Lovell

3.09 South Cloisters, St Luke's Campus, Heavitree Road, Exeter, EX1 2LU; [redacted]

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Purpose of the assessment report

The purpose of this External Assessment Group (EAG) report is to review the evidence currently available for included technologies and advise what further evidence should be collected to help inform decisions on whether the technologies should be widely adopted in the NHS. The report may also include additional analysis of the submitted evidence or new clinical and/or economic evidence. NICE has commissioned this work and the report forms part of the papers considered by the Medical Technologies Advisory Committee when it is making decisions about the early value assessment.

Declared interests of the authors

Description of any declared interests with related companies, and the matter under consideration. See NICE's Policy on managing interests for board members and employees.

None.

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Responsibility for report

The views expressed in this report are those of the authors and not those of NICE. Any errors are the responsibility of the authors.

Contents

Abbreviations

Term	Definition
6MWT	Six-Minute Walk Test
AHP	Allied health professional
AIC	Academic-in-confidence
BCKQ	Bristol COPD Knowledge Questionnaire
CAT	COPD Assessment Test
CCA	Cost-consequences analysis
CE mark	*Conformité européenne* (European conformity) marking
CEA	Cost-effectiveness analysis
CIC	Commercial-in-confidence
COPD	Chronic Obstructive Pulmonary Disease
CRD	Chronic refractory dyspnoea
CRQ	Chronic Respiratory Questionnaire
DPA	Data Protection Agreement
DPIA	Data Protection Impact Assessment
DTAC	Digital Technology Assessment Criteria
EAG	External assessment group
ED	Emergency department
ESF	Evidence Standards Framework
ESWT	Endurance Shuttle Walk Test
EVA	Early value assessment
F2F	Face to face
FEV	Forced expiratory volume
GB	Great Britain
GBP	British Pound
GOLD	Global Initiative for Chronic Obstructive Lung Disease
GP	General Practitioner
HADS	Hospital Anxiety and Depression Scale
HCP	Healthcare professional
HRQoL	Health-related quality of life
ICTRP	International Registry Platform
INAHTA	International Network of Agencies for Health Technology Assessment

ISWT	Incremental Shuttle Walk Test
MAUDE	Manufacturer and User Facility Device Experience
MCID	Minimal clinically important difference
MDD	Medical devices directive
MeSH	Medical subject headings
MHRA	Medicines & Healthcare products Regulatory Agency
MRC	Medical Research Council
mMRC	Modified Medical Research Council
N/A	Not applicable
NPS	Net Promoter Score
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NIHR	National Institute for Health and Care Research
NLM	National Library of Medicine
NR	Not reported
PAM	Patient activation measure
PenTAG	Peninsula Technology Assessment Group
PR	Pulmonary rehabilitation
PRAISE	PR Adapted Index of Self-Efficacy
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSS	Personal Social Services
PSSRU	Personal Social Services Research Unit
RCT	Randomised controlled trial
RWE	Real world evidence
ScHARR	School of Health and Related Research
SEAMS	Self-efficacy for appropriate medication use scale
SCM	Specialist Committee Member
SGRQ	St. George's Respiratory Questionnaire
SIGN	Scottish Intercollegiate Guidelines Network
TIDieR	Template for Intervention Description and Replication
UK	United Kingdom
UKCA	United Kingdom Conformity Assessed marking
USA	United States of America
VAT	Value added tax

VSAQ	Veteran specific activity questionnaire
WD	Walking distance
∆WD	Change in walking distance
WHO	World Health Organization
WPAI	Work productivity activity impairment

1. EXECUTIVE SUMMARY

Quality and relevance of clinical evidence

Digitally supported pulmonary rehabilitation are digital technologies that replace part of conventional face-to-face pulmonary rehabilitation. The NICE scope defines eligible technologies as ones that include at least one digital component of pulmonary rehabilitation: physical training; disease education; nutritional, psychological or behavioural intervention. Technologies that replace the before and after in person assessment or are solely tele-rehab, such as live pulmonary rehabilitation delivered virtually, were not considered eligible.

The findings of this rapid appraisal suggested that there is some evidence that digitally supported pulmonary rehabilitation may be a potentially promising treatment option for people with COPD. However, there are limitations in the evidence base that mean this finding is uncertain and more evidence generation is required. Notably, the evidence is not distributed evenly across technologies or outcomes. Most evidence was available for exercise capacity and respiratory function. There was relatively limited evidence for health-related quality of life, intervention-related adverse events and outcomes related to exacerbations and hospitalisation.

There were two technologies, myCOPD and SPACE for COPD, for which there was more than one eligible RCT and a range of other supporting evidence, reflecting a more advanced evidence base. Evidence for other technologies was fairly limited, although prioritised evidence was able to be identified for all technologies except Active+me REMOTE.

The evidence – in particular for myCOPD and SPACE for COPD – from a research perspective generally supports the concept of non-inferiority between digitally supported and face-to-face pulmonary rehabilitation, in terms of exercise capacity and respiratory function. The clinical evidence for the other technologies is weaker and often too limited to assess the promise these technologies offer.

However, when applying to clinical practice, it is important to interpret this conclusion with considerable caution and critique whether it truly holds, due to several generalisability concerns, which the EAG explore in more detail in the main report:

- UK studies are not UK wide and have a bias towards urban areas. Digital access and literacy may vary in different areas. No studies presented subgroup data for included rural areas.
- Clinical advice and comparisons to UK COPD audit reference standards suggested that control arms representing traditional face to face pulmonary rehabilitation underperformed in at least some of the included studies.
- Reporting clarity of the details of interventions and comparators was limited and does not conform to TIDieR reporting guidelines for interventions and comparators.[1]
- Clinical expert advice to the EAG was that people who choose to participate in trials for digitally supported therapies are likely to not favour face-to-face pulmonary rehabilitation to the same extent as the typical person with COPD and to also have much greater digital literacy, digital access and interest and familiarity with digital technologies. These factors are likely to lead to considerable outperformance in the digitally supported arm. If digitally supported pulmonary rehabilitation is rolled out in routine practice, a proportion of people with COPD with lower digital literacy may access this treatment option, although some may still opt out depending on what other treatment options are available.

Quality and relevance of economic evidence

The findings of the *de novo* economic analysis conducted by the EAG suggested that the digital technologies supporting the delivery of PR (as defined above), may possibly be cost saving when compared to face-to-face pulmonary rehabilitation (using data derived from the UK COPD PR audit). This finding was mainly driven by the reduction in costs associated with healthcare staff time.

Based on the EAG's reference case cost-consequence analysis (CCA), digital technologies were likely to be either on par or less effective compared to face-to-face pulmonary rehabilitation. However, as noted in the clinical evidence summary, caution needs to be exercised where the results were found to be at par based on trial data. The digital technologies appear to be cost saving when considering annual costs per participant based on license fee, staff time costs and training costs. However, there is high heterogeneity in costing model across digital technologies.

The EAG also performed a complementary and exploratory cost-effectiveness analysis (CEA) for the technologies for which the data were available: Clinitouch, myCOPD, Rehab Guru, and SPACE for COPD. It showed that the digital technologies included are likely to be less costly and less effective compared to face-to-face pulmonary rehabilitation, especially when using data from the UK COPD pulmonary rehabilitation audit. The deterministic threshold analysis identified threshold values for change in walking distance (6MWD/ISWD), below or above which the digital technologies could offer good value for money compared to face-to-face pulmonary rehabilitation.

Results of both the analyses (especially that of the exploratory CEA), need to be interpreted with caution as they are only indicative given the evolving evidence base.

Finally, it was noted by the EAG that a direct comparison with either no pulmonary rehabilitation or waitlist was not possible owing to sparsity of such data in the intervention trials. However, based on information sourced from wider literature, EAG incorporated the costs for no pulmonary rehabilitation or waitlist in addition to face-to face pulmonary rehabilitation to aid decision making. Subgroup analyses were also not viable owing to unavailability of effectiveness data for any subgroups.

Evidence Gap Analysis

Evidence gaps highlighted ought to be addressed to enable any definitive conclusions about the cost-effectiveness of digital interventions supporting delivery of pulmonary rehabilitation in COPD. The EAG identified several key evidence gaps, which could be addressed by future research, including:

- A need for more studies to assess wider outcomes including quality of life– beyond exercise capacity and respiratory function – and provide EQ-5D-3L-based utility values.
- A need for studies compared to no pulmonary rehabilitation to demonstrate the benefit of digitally supported pulmonary rehabilitation for use during wait lists for face-to-face pulmonary rehabilitation, in light of long waiting lists for this treatment.
- A need for consistently capturing the impact of digitally supported pulmonary rehabilitation technologies on health care resource use associated with emergency department (ED) visits or hospital admissions for exacerbations, in trials or follow up studies.

- A need for long-term follow up studies assessing the sustained impact of digitally supported pulmonary rehabilitation technologies.
- A need for studies or subgroup analyses with rural populations.
- Trials should include consideration of selection biases in favour of more digitally literate participants found in research studies of digitally supported pulmonary rehabilitation.

2. DECISION PROBLEM

Table 1 details the final scope issued by NICE for this early value assessment (EVA). Given the large volume of evidence for some technologies, the EAG identified priority studies for each technology, where available, based on relevance of population, study location and study design, with a preference for RCTs where possible.

Table 1: Summary scope of the assessment

Population	Adults with a confirmed diagnosis of COPD who: • Have had a recent hospitalisation because of an acute exacerbation, or whose functional baseline has greatly changed and is not following the expected recovery path or • Have a MRC dyspnoea score of 2 or above or • Have decreased exercise capacity as measured by a validated outcome measure such as the 6-minute walk test
Subgroups	If the evidence allows the following subgroups will be considered: • Level of breathlessness (MRC dyspnoea score) • Having or not having comorbidities (including frailty) • Living in a rural or urban setting • Having had an exacerbation which required hospitalisation in the previous 12 months
Interventions (proposed technologies)	Digitally supported pulmonary rehabilitation technologies for adults with COPD. This includes: • Active+me REMOTE • Clinitouch • Kaia Health COPD • myCOPD • Rehab Guru • SPACE for COPD • Wellinks

Comparators	• Standard care face-to-face pulmonary rehabilitation, either in a clinical or home-based setting • No treatment, or waiting list If data are available: • Hybrid of face-to-face and remote live pulmonary rehabilitation • Non-digital non-face-to-face options for components of pulmonary rehabilitation, for example printed exercise sheets
Healthcare setting	Secondary or community care
Outcomes	Outcomes for consideration may include: <u>High priority</u> • Exercise capacity measured by a validated outcome measure* • Health-related quality of life* • Other measures of respiratory function (including but not limited to the COPD assessment test [CAT] score, the MRC and the modified MRC dyspnoea score) • Intervention completion (receiving a final assessment), adherence, rates of attrition (dropouts) • Intervention-related adverse events • Acute exacerbations, hospital admissions, readmissions or emergency admissions <u>Other (if data available)</u> • Intervention uptake from those offered the technologies • Daily activity • Patient experience, technology usability and acceptability • Healthcare professional experience
	Costs will be considered from an NHS and Person Social Services perspective. Costs for consideration may include: <u>High priority</u> • Costs of healthcare professional time (various grades) to deliver digitally supported pulmonary rehabilitation

	• Costs of healthcare professional time (various grades) to deliver standard care
	• Cost of the digital technologies including license fees and staff training
	<u>Other (if data are available)</u>
	• Cost to healthcare system of device acquisition, if relevant
	• Cost of other resource use (e.g. associated with managing COPD, adverse events, or complications):
	  o Healthcare appointments in primary, secondary and community care
	  o Cost of emergency department attendance, and length of stay if admitted to hospital
	  o Medication use and adverse events

Time horizon	The time horizon for estimating the clinical and cost effectiveness should be at least a year. This is to reflect any differences in costs or outcomes between the technologies such as the impact on hospital admissions. One year is also the typical length of time before someone is eligible to repeat a course of pulmonary rehabilitation.

Abbreviations: CAT = COPD Assessment Test; COPD = Chronic Obstructive Pulmonary Disease; MRC = Medical Research Council; NHS = National Health Service.

Note: * these outcomes were classified as 'highly prioritised' in the EAG protocol.

3. OVERVIEW OF THE TECHNOLOGY

3.1. Purpose of the medical technology

In the UK, 1.2 million people are estimated to have COPD. COPD exacerbations are considered to be the second most common cause of UK emergency hospital admissions, accounting for 1 in 8 of all UK hospital admissions. Exacerbations requiring hospitalisation are associated with poorer prognosis and increased risk of death.[2]

Pulmonary rehabilitation is an exercise and education programme for people with lung disease, including COPD, who experience breathlessness. Evidence suggests that 90% of patients who complete a face-to-face pulmonary rehabilitation programme experience increased exercise capacity and improved quality of life. However, it is currently only offered to 13% of eligible COPD patients, with a focus on those with more severe COPD.[3] Clinical experts consulted by NICE during scoping for this EVA stated that limitations in workforce and service funding restrict the ability of the NHS to provide pulmonary rehabilitation to everyone who may benefit.[3] Table 2 sets out an overview of product properties, and Table 3 offers a top-level features profile of them. There are some limitations regarding the level of detail available on the intervention content.

Commitments to addressing respiratory disease, including increasing access to pulmonary rehabilitation, are included in the NHS Long-Term Plan.[4] The Plan also highlights the need to introduce new models of delivering pulmonary rehabilitation care, including digitally supported treatments, to increase access to appropriate rehabilitation treatments.

Digitally supported pulmonary rehabilitation has been identified as a potential treatment option for people with COPD, and a way to increase access, engagement, and adherence to pulmonary rehabilitation programmes. The final scope for this EVA[3] stated that these technologies could reduce unplanned hospital admissions, reduce exacerbations, prevent deterioration and reduce health inequalities in access to and outcomes of care. Although the scope also noted that some people with COPD may need support in accessing and using digital technologies.

3.2. Product properties

This EVA includes seven technologies that:

- are intended for use by adults with COPD;
- include at least one digital component of pulmonary rehabilitation: physical training; disease education; nutritional, psychological or behavioural intervention;
- have a minimum course duration of at least 6 weeks;
- meet the standards within the digital technology assessment criteria (DTAC) and have a CE or UKCA mark where required (products may also be considered if they are actively working towards required CE or UKCA mark and meet all other standards within the DTAC); and
- are available for use in the NHS.

For this EVA, NICE will not consider digitally supported pulmonary rehabilitation technologies that:

- replace the before and after in-person assessment; or
- are solely tele-rehab i.e. live pulmonary rehabilitation delivered remotely

The following technologies were included in the assessment:

- Active + me REMOTE
- Clinitouch
- Kaia Health COPD
- myCOPD
- Rehab Guru
- SPACE for COPD
- Wellinks

Technologies are summarised in Table 2 and their main features in Table 3, with information obtained from company submissions and company website(s). Further information can be found in the final scope.[3]

Table 2: Description of the technologies

Full technology name and manufacturer	Description	Access	Health professional involvement	CE mark and DTAC status
Active+me REMOTE (Aseptika)	Cloud-based platform that supports the hybrid delivery of pulmonary rehabilitation and remote monitoring of adults with COPD at home.	Smartphone, tablet or computer	Not stated	CE marked under MDD as a Class I Medical Device. Undergoing reclassification as class IIa. DTAC certification has been issued.
Clinitouch (Spirit Health)	Online platform that supports the delivery of a 6-week digitally supported pulmonary rehabilitation programme and facilitates remote monitoring of adults with COPD and other conditions	Smartphone, tablet or computer	Users are also contacted weekly by local healthcare professionals to monitor their progress and increase the complexity of exercises	Self-registered as a class I medical device in GB. DTAC certification has been issued.
Kaia Health COPD (Kaia Health)	Online platform that supports the delivery of a 6-week digitally supported pulmonary rehabilitation programme and facilitates remote monitoring of adults with COPD and other conditions	Smartphone or tablet	Facilitates communication with health coaches	CE Marked in Europe as a class IIa medical device. No DTAC submission.
myCOPD (my mhealth Ltd)	Online education, self-management, symptom reporting and pulmonary rehabilitation system.	Smartphone, tablet, or computer (as advised by company)	Health professional involvement is delivered through an optional clinical dashboard, where the patient data can be reviewed, prioritised, and managed by the health professional.	The platform is UKCA marked as a class 1 medical device. DTAC certification has been issued.

Full technology name and manufacturer	Description	Access	Health professional involvement	CE mark and DTAC status
Rehab Guru (Rehab Guru)	Digital exercise programme management software.	Smartphone, tablet or computer	Clinicians can use the technology to prescribe a personalised digitally supported pulmonary rehabilitation programme	No CE marking – company claims not to be a medical device. No DTAC submission.
SPACE for COPD (University Hospitals of Leicester NHS Trust)	Digitally supported self-management programme designed to help people with COPD manage their condition more effectively	Smartphone, tablet or computer	Throughout the duration of the web-based programme the patient's progress was reviewed online and there was weekly contact between the patient and the rehabilitation specialist via email or telephone using a standardised proforma"; HCP's are able to monitor patient progress via the admin site and can contact the patient via email; patients are able to message the HCP with concerns/questions from the site;	No CE marking – company claims to be exempt. No DTAC submission. The company states it has "a DPA in place that trusts sign as part of their contract, as well as a DPIA"
Wellinks (Wellinks)	Online platform that supports the delivery of a digital pulmonary rehabilitation programme and facilitates remote monitoring of adults with COPD.	Smartphone or tablet	Not stated	No information available about CE marking. No DTAC submission.

Abbreviations: CE mark = Conformité européenne (European conformity) marking, COPD = Chronic Obstructive Pulmonary Disease, DPA = Data Protection Agreement, DPIA = Data Protection Impact Assessment, DTAC = Digital Technology Assessment Criteria, GB = Great Britain, HCP = healthcare professional, MDD = Medical Devices Directive, UKCA = United Kingdom Conformity Assessed

Table 3. Feature profile of the technologies

Technology	Exercise	Education	Psychological intervention	In-app communication with AHP	Communication external to app with AHP	Patient reported symptom tracker	Objective symptom tracker	Remote monitoring
Active+me REMOTE	✓	✓		✓	✓	✓	✓	✓
Clinitouch	✓	✓		✓	✓		✓	✓
Kaia Health COPD	✓	✓						
myCOPD	✓	✓	✓	✓	✓	✓	✓	✓
Rehab Guru	✓			✓		✓	✓	
SPACE for COPD	✓	✓	✓	✓	✓	✓		
Wellinks	✓	✓	✓	✓	✓	✓	✓	✓

Abbreviation: AHP = Allied Health Professional

4. CLINICAL CONTEXT

The target population for this assessment is people recommended for pulmonary rehabilitation for COPD.

4.1. Care pathway

The NICE guideline for the diagnosis and management of COPD in over 16s[5] states that COPD care should be delivered by a multidisciplinary team that includes respiratory nurse specialists. Pulmonary rehabilitation is defined as a multidisciplinary programme of care for people with chronic respiratory impairment. It should be individually tailored and designed to optimise each person's physical and social performance and autonomy. The NHS service guidance for pulmonary rehabilitation[6] says that services should be offered to all people with a confirmed diagnosis of COPD or other chronic respiratory diseases. According to these guidelines, pulmonary rehabilitation programmes should last at least six weeks and include a minimum of two sessions per week. Programmes should include individually tailored and prescribed progressive exercise training, including both aerobic and resistance training, as well as a structured education programme.

Clinical advice to the EAG was that usual care or the standard of care – as described in the literature – would be face-to-face pulmonary rehabilitation, although long waiting lists and resource limitations means that in practice only a minority of people receive the recommended treatment. This leads to uncertainty – when assessing the literature – as to what is actually being delivered both in current practice and in comparator interventions described as usual care. Where face-to-face pulmonary rehabilitation is delivered, this would typically be in secondary or community care settings. This necessitates patients travelling to clinics to participate in sessions; the convenience of this is likely to differ between urban and rural settings.

4.1.1. Current use of digitally supported pulmonary rehabilitation.

Digitally supported pulmonary rehabilitation is currently used in the NHS. Submissions were received from four out of the seven included technologies: Active+me REMOTE, Clinitouch, myCOPD and SPACE for COPD.

- Active+me REMOTE is being used within a clinical trial in Harefield Hospital, London.

- Clinitouch is being used in Staffordshire and its use evaluated alongside clinical practice.

- myCOPD has been used in the NHS since 2017, and been implemented in both primary care and rehabilitation services across 30 Integrated Care Boards. This includes, but is not limited to, [redacted] pulmonary rehabilitation services.

- SPACE for COPD was first used in the NHS in 2018 and was used by 73 trusts during the COVID-19 pandemic. There are currently two active contracts with NHS trusts.

Clinical advisers to the EAG were aware of the use of myCOPD and SPACE for COPD, along with videoconference-delivered conventional pulmonary rehabilitation. Some advisers indicated that interest in and use of digitally supported pulmonary rehabilitation had declined since the resumption of normal services following the COVID-19 pandemic.

4.2. User issues and preferences

Digitally supported pulmonary rehabilitation may improve access to pulmonary rehabilitation services in the context of long waiting lists and only a minority of people receiving the recommended treatment of face-to-face pulmonary rehabilitation.

The EAG noted that digitally supported pulmonary rehabilitation may in some cases be an add-on treatment rather than a direct comparator to face-to-face pulmonary rehabilitation. Therefore, no pulmonary rehabilitation or digitally supported pulmonary rehabilitation *followed by* face-to-face pulmonary rehabilitation (as a treatment bundle) could be valid comparators.

Digitally supported therapy may not be suitable for all people with COPD and some people will choose not to use digitally supported therapy, preferring face-to-face approaches. Some considerations about the suitability of digitally supported pulmonary rehabilitation noted in the final scope[3] include:

- individual ability to use the technology (e.g. familiarity with digital technology and access to the internet),

- fear of breathlessness from exercise (not knowing that some types of breathlessness are acceptable during the exercise),

- unpredictable nature of their co-morbidities,

- possible costs incurred from using digital technologies, for example mobile data charges,
- level of human support provided during digitally supported pulmonary rehabilitation,
- data security and quality control.

Clinical advice provided to the EAG suggested that digitally supported pulmonary rehabilitation is likely to offer some benefit over no treatment or waitlist. However, it would not be expected to be as effective as face-to-face pulmonary rehabilitation, as face-to-face treatment offers better tailoring to individual needs and address motivational challenges faced by people with COPD.

5. SPECIAL CONSIDERATIONS, INCLUDING ISSUES RELATED TO EQUALITY

The following issues were highlighted during the scoping process. No new issues were identified during the EAG assessment.

- COPD prevalence is associated with older age, male sex and lower socioeconomic status – the latter likely due to higher smoking rates and poorer living conditions.[7]
- People will need regular access to an internet-enabled device – such as a smartphone, computer or tablet – in order to access digitally supported therapies. Additional support may be needed for individuals unfamiliar with or with limited access to such devices.
- Certain conditions, of combinations of conditions, such as visual, hearing or cognitive impairment, as well as difficulties with manual dexterity, learning disability, neurodivergence, reading difficulties or low levels of English literacy may necessitate additional support to access digitally supported therapies.
- People with mental health conditions or who are living in houses of multiple occupancy, living in residential care or who have no fixed abode, may face challenges in accessing digitally supported pulmonary rehabilitation.
- Cultural, religious, and ethnic backgrounds may influence people's views on the suitability of pulmonary rehabilitation treatment options.

6. POTENTIAL IMPLEMENTATION ISSUES

Several potential implementation issues were noted during the scoping process:

- Equity of access (see Section 5)
- Capacity limitations – increasing training requirements and staff workload due to introduction of new treatment pathways.
- Cost – each technology may be associated with different costs. The introduction of digitally supported technologies may introduce additional costs related to training, hardware, and internet access in the establishment of new treatment pathways. Smaller service areas may have higher per patient costs due to requiring fewer licences.

Clinical advice to the EAG indicated that there could be significant implementation challenges for digitally supported pulmonary rehabilitation within NHS settings. Issues with digital literacy, digital hesitancy (by NHS staff as well as people with COPD) and access to digital technologies may be among the greatest challenges. COPD prevalence and social deprivation are significantly correlated, which in turn is associated with digital awareness and access, possibly suggesting that digitally supported pulmonary rehabilitation could worsen already existing inequities in outcomes and service access.

Furthermore, provision of digitally supported pulmonary rehabilitation to people on the waitlist for face-to-face pulmonary rehabilitation could have unanticipated implications for the waitlist itself. If digitally supported pulmonary rehabilitation were effective, it could reduce waiting times as only people who did not respond satisfactorily to digitally supported therapy would go on to receive face-to-face treatment. However, if most people still need to receive face-to-face pulmonary rehabilitation, the introduction of digitally supported therapy could make waitlists for face-to-face pulmonary rehabilitation longer due to diversion of staff resource to delivering digitally supported pulmonary rehabilitation.

7. CLINICAL EVIDENCE SELECTION

7.1. Search strategy

Search strategies were based on those devised during the initial scoping searches by NICE Information Services with minor adjustments. The search strategies used relevant search terms, comprising a combination of indexed keywords (e.g., Medical Subject Headings, MeSH) and free-text terms appearing in the titles and/or abstracts of database records and were adapted according to the configuration of each database. The NICE health apps filter was used, with the addition of “Digital Technology/” and also adding “enable*” to capture digitally enabled. No date, language, or publication status (published, unpublished, in-press, and in-progress) limits were applied. Searches for clinical and cost-effectiveness were combined and carried out in one search strategy.

Databases searched were Medline (including Medline in Process), Embase, Cochrane, INAHTA, CEA Registry and ScharrHUD. The trial registries searched were Clinicaltrials.gov (NLM) and ICTRP (WHO). The websites of the individual companies were searched, as well as the NICE and SIGN websites for related guidelines, and MAUDE and MHRA for adverse events data. Following deduplication (in Endnote), a total of 712 records of potentially relevant evidence on clinical and/or cost effectiveness were retrieved. The company submission references were also scanned for additional references—from which two new articles were identified.

The search strategies are presented in Appendix A.

7.2. Study selection

The abstracts and titles of references retrieved by the searches were screened for relevance (facilitated by the Rayyan platform). Full paper copies of potentially relevant studies were obtained. The retrieved articles were assessed for inclusion against pre-specified inclusion/exclusion criteria. All duplicate papers were excluded. Screening was performed initially by one reviewer (MSB). This defined the list of eligible studies, from which priority studies were selected by one reviewer (GJMT) and discussed with another reviewer (MSB).

This assessment looked across a range of evidence types, including RCTs and real-world evidence, to inform clinical effectiveness.

The following study types were excluded:

- Animal models
- Pre-clinical and biological studies
- Narrative reviews, editorials, opinion pieces
- Meeting abstracts for studies where full-text papers were available. If studies were only available as meeting abstracts, inclusion depended on sufficient information being available to offer meaningful critique.
- Studies not available in the English language.
- Studies relating to non-respiratory rehabilitation populations, for example cardiac rehabilitation.

Eligible studies assessed digitally supported pulmonary rehabilitation for people with COPD. The full decision problem is outlined in Section 2.

Studies could still be included if the comparator or the outcomes did not match the scope provided the outcomes appeared reasonable and could offer useful information in the context of the appraisal. No studies were identified where this applied. An initial large evidence base was identified for this appraisal, and within the timeframe available, between one and three studies were included for each technology. The EAG's general approach was one of 'best evidence synthesis', focusing on the most useful and rigorous evidence available over all possible included studies.

Randomised controlled trials were prioritised for inclusion where they were available. This was supplemented with additional data from other studies where it was considered appropriate. Where no prospective studies were available for a given technology, the most relevant retrospective studies were sought. If no retrospective studies were available, then conference abstracts were reviewed. If retrospective studies were available for a technology with one or more prospective studies, a brief commentary on these were provided. Studies were prioritised based on a) study design (RCT or observational), b) recency and c) population. Blinding was also noted, where applicable (depending on the study design and outcomes assessed). Qualitative studies were not prioritised when quantitative studies were available, in order to give the clearest insight into effectiveness.

A PRISMA flow diagram is provided as Appendix B.

Data were extracted from included studies by one reviewer (MSB) into a bespoke database and a sample of at least 10% was checked by another reviewer (GJMT). Due to time and resource constraints associated with conducting an EVA, the EAG did not conduct formal risk of bias assessment of the included studies.

8. CLINICAL EVIDENCE REVIEW

The EAG identified a total of 44 reports that were potentially relevant to the present decision problem, of which 9 were prioritised for inclusion in the review. Relevant information provided by companies was also considered for inclusion. Prioritised evidence was available for all studies except Active+me REMOTE, for which there was no evidence relevant to the appraisal scope. It should be noted that some studies for SPACE for COPD used a different mode of delivery, which included the use of the manual as well as or instead of the website. However, these studies were considered eligible for inclusion given how the inclusion criteria were phrased.

The majority of the evidence comprised small-scale observational studies, pilot feasibility trials and conference abstracts. Table 4 presents an overview of the evidence landscape, in which the priority studies are underlined and in bold.

The nine prioritised studies included:

- One unpublished report on Clinitouch
- One full-text RCT on Kaia Health[8]
- One conference abstract on Rehab Guru[9]
- Two full-text RCTs on SPACE for COPD[10-12]
- Three full-text RCTs on myCOPD[13-15]
- One full-text observational study on Wellinks[16]

Table 5 presents a detailed overview of the study design, characteristics, and limitations of each prioritised study.

Table 4: Evidence landscape

Technology	Randomised controlled trials (full-text)	Non-randomised trials and observational studies (full-text)	Qualitative studies	Conference abstracts	Unpublished reports
Active+me REMOTE		Frith et al., 2021[17]			[redacted]
Clinitouch					[redacted]
Kaia Health	**Spielmanns et al., 2023**[8]	Rassouli et al., 2018[22]		Gloeckl et al., 2022[23]	
myCOPD	**Bourne et al., 2017**[15]**; Crooks et al., 2020**[13]**; North et al., 2020**[14]	Chmiel et al., 2022[24]; Cooper et al., 2022[25]; Platt & Jackson, 2022[26]		Cooper et al., 2021[27]; North et al., 2014[28]; North et al., 2015[29]; O'Sullivan et al., 2021[30]; Roberts et al., 2022[31]; Stokes & Savage, 2021[32]; Wilkinson et al., 2017[33]	
Rehab Guru				**Pilsworth et al., 2021**[9]	
SPACE for COPD	**Chaplin et al., 2017**[12]; **Bourne et al.,**	Blackmore et al., 2017[34]; Bourne et al.,	Apps et al., 2017[38]; Apps	Apps et al., 2013[40]; Apps et al., 2009[41];	

Technology	Randomised controlled trials (full-text)	Non-randomised trials and observational studies (full-text)	Qualitative studies	Conference abstracts	Unpublished reports
	2022[10]; **Chaplin et al., 2022**[11]; Johnson-Warrington et al., 2016; Mitchell et al., 2014	2020[35]; Hewitt et al., 2015[36]; Houchen-Wolloff et al., 2021[37]	et al., 2013[39];	Barradell et al., 2018[42]; Chaplin et al., 2021[43]; Chaplin et al., 2016[44]; Horton et al., 2013[45], Horton et al., 2014[46]; Houchen-Wolloff et al., 2021[47]; Johnson-Warrington et al., 2015[48]; Mitchell et al., 2013[49]; Mitchell-Wagg et al., 2012[50]; Wagg et al., 2012[51]; Wagg et al., 2009[52]	
Wellinks		**Gelbman & Reed, 2022**[16]			

Bold and underlined text = extracted priority study (see Table 5)

Frith et al. (2021) study was not extracted because it was conducted in a cardiac rather than COPD population. The Gloeckl et al. (2022) study is a subgroup analysis of the Spielmanns et al. (2023) study and is included in the EAG's broader commentary on the evidence. Bourne et al. (2022) also includes qualitative evidence.

Table 5: Study design and characteristics of prioritised clinical effectiveness studies

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
Active+me REMOTE (number of prioritised studies = 0) – there were no studies in a COPD population with clinical effectiveness data						
Clinitouch (number of prioritised studies = 1)						
Staffordshire Report[21] [AIC]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Kaia Health (number of prioritised studies = 1)						
Spielmanns et al. 2023[8]	Parallel group RCT; Germany and Switzerland.	67 participants with Global Initiative for Obstructive Lung Disease (GOLD) stage II-IV COPD were randomised 1:1.	6-months of daily physical exercise training sessions conducted via the Kaia COPD app. App consisted of an exercise training programme, breathing	Exercise and lifestyle intervention (no pulmonary rehabilitation mentioned). Control group wore an activity tracker but did	Primary: change in steps per day after 6 months as measured by the POLAR A370; Polar Electro Europe AG, Steinhausen, Switzerland	Small sample size (though sufficient for statistical considerations based on primary endpoint) At least three other sites were asked to participate in the

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
		Aged (mean±sd) 64±8 years, severe airflow obstruction (severe COPD) with a mean FEV_1% predicted of 44%±16%. 33 (49.3%) female. Follow-up data available for 60 participants.	exercises, and an educational programme. Regular contacts via telephone with trained healthcare professionals to assess adherence (minimum adherence criteria: exercising with the app at least 4 out of 7 days per week). Exercise training programme consisted of 15-20 minutes whole-body exercises, with focus on compound movements. Each session began with a whole-body warm-up and ended with 2-3 stretching exercises. All exercises were performed without the need for specialised exercise equipment. Intensity increased dynamically based on feedback provided by	not have access to the Kaia COPD app. Both the intervention and the comparator groups received a leaflet to encourage an active lifestyle, as well as individual exercise recommendations, as part of their discharge instructions to reflect standard care.	Secondary: change in functional exercise capacity (60-second sit-to-stand test); Health Related Quality of Life and patient-reported health status (Chronic Respiratory Questionnaire (CRQ) and COPD Assessment Test (CAT)); number of exacerbations (defined as an increase in symptoms and an increase in dosage of or a new prescription of systemic corticosteroids and/or antibiotics); and depression and anxiety (Hospital Anxiety and Depression Scale (HADS)) Additional: compliance,	study but were not eligible due to insufficient inpatient PR case load in COPD and/or no adequate research infrastructure. Only two sites were eligible. Due to preselection of patients with sufficient literacy in mobile technology, results may not be generalisable to a broader population of people with COPD. This could also increase potential for selection bias and a subsequent effect on adherence and engagement. Due to the nature of the intervention, blinding of study participants and

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
			the participant at the end of each session. Participants also wore activity trackers and reported steps per day within the app.		adherence, facilitators, and safety.	study staff was not possible. No observations were made past 6 months.
myCOPD (number of prioritised studies = 3)						
Bourne et al. 2017[15]	Two-arm, parallel, single-blind RCT; United Kingdom.	90 participants with COPD (mMRC score of ≥2) referred for PR were randomised 2:1 (n=64 online PR; n=26 face-to-face PR). Aged (mean±sd) 70±8.2 years, moderate airflow obstruction with a mean FEV_1% predicted of 59%±22%. 31 (34.4%) female.	6 weeks of physical exercise training conducted via myPR (myCOPD). App consisted of a progressive exercise training programme and educational sessions (three educational sessions per week). Participants were given a 5–10-minute introductory session (face-to-face) to convey basic instructions on how to use the app. Participants were asked to use the app a minimum of 2 and a	Face-to-face PR (explicitly stated) Participants attended two supervised physical exercise sessions per week for 6 weeks and were asked to carry out three additional sessions at home. The programme consisted of 10 exercises (identical to those given to the online PR group). These sessions also included a warm-up and cool-down.	Primary: between group difference in best performance 6MWT and CAT score. Secondary: between group difference in respiratory quality of life (St Georges Respiratory Questionnaire (SGRQ)); anxiety and depression (HADS). Additional: adverse events (captured during weekly phones calls with the study team in	Short study duration. Single centre trial. Double blinding not possible.

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
			maximum of 5 times per week. Exercise training consisted of 10 exercises. Exercises were 1 minute each in Week 1, increasing by 30 seconds each week (up to 3 minutes 30 seconds in Week 6). Between exercises, participants were given a 1-minute rest period. All sessions included a warm-up and cool-down.	The same educational sessions as on myPR were delivered but were presented and discussed orally.	the online PR group and twice weekly at in-person meetings in the face-to-face PR group).	
Crooks et al. 2020[13]	Open-label, parallel-group, RCT; United Kingdom.	60 participants with either mild-moderate COPD (FEV_1 >50% predicted and FEV_1/forced vital capacity ratio <70%) or COPD of any severity diagnosed within the past 12 months were randomised 1:1 (n=29 myCOPD;	12 weeks of physical exercise training conducted via myCOPD. Participants were given a link to self-activate the app. This was followed by a "how to use" video which provided information of app usage and content.	Usual care. Usual care participants were asked to continue with usual COPD management for the study duration. No details as to what this comprised. After completion, they were offered life-long app access.	Primary: between group difference in mean CAT score change and proportion of participants with ≥1 critical inhaler error at 90 days. Secondary: between group difference in change in patient activation measure (PAM) score; self-	Marked phenotypic difference between groups. More participants from the usual care group volunteered for activity tracking. The usual care group were also more active than the myCOPD group.

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
		n=31 usual care). Aged (mean±sd) 66.1±7.1 years, mild COPD (n=14 (23.3%)) and moderate COPD (n=46 (76.7%)). 29 (48.3%) female.			efficacy for appropriate medication use scale (SEAMS); EQ-5D-5L. Additional: activity tracking was done in a subgroup for 7 days at baseline and prior to the end study visit.	
North et al. 2020[14]	Single blind acceptability and feasibility RCT; United Kingdom	41 participants with COPD (34% moderate and 41% severe) were randomised 1:1 (n=20 myCOPD; n=21 usual care). Aged (mean±sd) 66.6±7.0 years. 17 female (41%).	12 weeks of physical exercise training conducted via myCOPD. Participants were given a link to self-activate the app. This was followed by a "how to use" video which provided information of app usage and content.	Usual care Treatment as usual participants received usual care and were given a written self-management plan. It is not stated if any or how many participants received face-to-face pulmonary rehabilitation as usual care.	Primary: CAT score Secondary: Exacerbations, inhaler technique, readmission, respiratory quality of life (SGRQ), patient activation (PAM), depression and anxiety (HAD), veteran specific activity questionnaire (VSAQ), work	Limited in power to demonstrate effects on all measured outcomes. Study unable to capture all indices of app usage. Single centre UK trial.

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
		Complete data for treatment as usual (n=18) and myCOPD (n=17).			productivity activity impairment (WPAI).	
Rehab Guru (number of prioritised studies = 1).						
Pilsworth et al. 2021[9]	Single-arm pilot study; United Kingdom	Pilot study UK – Liverpool Thirty three people with a diagnosis of COPD	Rehab Guru over a seven month time period. A home exercise prescribing platform with larger numbers of built-in exercises and templates and facilities for treatment notes, patient forms, outcome measures, telehealth, patient monitoring and diary management	No comparator	6MWT, MRC dyspnoea and CRD dyspnoea	Conference abstract only Pilot study No comparator
SPACE for COPD (number of prioritised studies = 2)						
Bourne et al., 2022[10]	Prospective single blind RCT; United Kingdom	193 participants with established diagnosis of COPD (GOLD criteria) and had median MRC grade of 2. Recruited from 7 GP practices in Leicester,	Participants in the intervention group received a SPACE for COPD manual and attended the SPACE for COPD group-based self-management programme (SMP) usually within 1month of	Usual care Usual care participants continued with any usual check-ups/reviews—no additional care was provided or removed from their current	Change in CAT score at 6 months (primary). Bristol COPD knowledge questionnaire, EQ-5D-3L, Chronic Respiratory Questionnaire, HADS, Patient Activation Measure,	Adherence was not measured. Distance from group venues was a challenge for some participants leading to withdrawal. Some participants dislike group formats. CAT

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
		Leicestershire and Rutland.	their baseline appointment.	access. It is not stated if any or how many received face-to-face pulmonary rehabilitation as usual care.	ISWT and ESWT exercise capacity, qualitative focus group analysis	may not have been to most suitable primary outcome for participants with milder COPD.
Chaplin et al. 2017[12], 2022[11]	Feasibility RCT; United Kingdom	103 participants with COPD (FEV_1%, post-bronchodilation of <80%, predicted ratio of FEV_1 to forced vital capacity of 0.70 and MRC dyspnoea score of between 2 and 5) were randomised 1:1 (n=51 web-based PR; n=52 usual care). Aged (mean±sd) 66.1±8.1 years (web-based PR); 66.4±10.1 (usual care).	Web-based exercise and education programme (around 11-12 weeks to complete). Participants were given a standardised introductory session. Platform encouraged participants to exercise daily at home and to record progress in an online diary. The exercise programme consisted of aerobic and strength training. The intensity of the walking was based on their performance on the baseline maximal shuttle walking exercise tests and prescribed at	Usual care. (advised by the company to be face-to-face pulmonary rehabilitation) Usual care based on the site the participant was being treated at. Hospital programme (7 weeks; 4 supervised and 3 unsupervised) or 12 total session within the community. Typically twice weekly 2-hour exercise and education sessions. It is not stated if any or how many participants received face-to-face pulmonary rehabilitation as usual care.	Physical activity pattern of accumulation, number of steps per day, incremental shuttle walk test (ISWT) and endurance shuttle walk test (ESWT); CRQ-SR; HADS; CAT; PR Adapted Index of Self-Efficacy (PRAISE); Bristol COPD Knowledge Questionnaire (BCKQ); EQ-5D-5L; patient cost questionnaire.	A limitation to the study was a lack of engagement despite patient involvement in the site development. Limitations were identified when recruiting people to a technology-based intervention, in that participants needed to be competent users with an in-depth, specific web-based knowledge.

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
		36.5% female (web-based PR); 25.5% female (usual care).	85% of baseline performance. Motivational interviewing techniques were used by healthcare professionals to help participants to progress their exercise programme in the aerobic and strength training appropriately and to answer any queries that arose. Motivational interviewing is an additional behaviour change intervention and it should be considered whether this will be included in the basic technology offering. Educational content of the web-based programme was based on the 'SPACE for COPD' manual. Participants worked through the website			

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
			content at their own pace.			
Wellinks (number of prioritised studies = 1)						
Gelbman & Reed 2022[16]	A single-site, observational, prospective pilot study USA	(N=19) was conducted using the Wellinks platform in adults with COPD. All patients were aged over 30 years at screening, owned an iPhone, and were currently undergoing a treatment regimen that included nebulized therapy. 10 female, 9 male	8 weeks Enrolled patients received a study kit consisting of the Flyp nebulizer, Smart One spirometer, the Nonin pulse oximeter, plus the Wellinks mHealth app, and training for all devices. Data were sent to the attending physician in a monthly report.	No comparator	For 8 weeks, participants were to enter daily symptoms and medication use manually; spirometry, nebulizer, and pulse oximeter data were automatically recorded. Patient satisfaction was measured via a 5-point scale and the Net Promoter Score (NPS) captured in interviews at the end of the observation period.	Decline in use of spirometry and oximetry over study period This study was a small pilot with all patients selected by 1 physician at 1 pulmonology practice. Patient engagement may be artificially higher than expected in a real-world situation due to the Hawthorne effect There were no interventions taken, and the study was not powered to show improvement in clinical outcomes or

Reference	Study design & country	Population	Intervention	Comparator(s)	Outcomes	Study limitations
						pharmacoeconomic impact.

Abbreviations: 6MWT = 6-minute walk test; BCKQ = Bristol COPD Knowledge Questionnaire; CAT = COPD Assessment Test; CRD = chronic refractory dyspnoea; CRQ = Chronic Respiratory Questionnaire; CRQ-SR = Chronic Respiratory Questionnaire - Self Reported; ESWT = endurance shuttle walk test; FEV = forced expiratory volume; GOLD = Global Initiative for Chronic Obstructive Lung Disease; GP = general practitioner; HADS = Hospital Anxiety and Depression Scale; ISWT = incremental shuttle walk test; mMRC = modified Medical Research Council; MRC = Medical Research Council; PAM = patient activation measure; PR = pulmonary rehabilitation; PRAISE = PR Adapted Index of Self-Efficacy; RCT = randomised controlled trial; SEAMS = self-efficacy for appropriate medication use scale; SGRQ = St Georges Respiratory Questionnaire; SMP = self-management programme; UK = United Kingdom; USA = United States of America

8.1. Overview of methodologies of all included studies

All studies described in Table 5 had some methodological limitations or misalignment with the NICE decision problem for this appraisal.

8.2. Study design, intervention and comparator

The search identified evidence for all scoped interventions, but no studies were prioritised for Active+me REMOTE as the evidence available was not relevant to the appraisal scope. This was because Frith et al.[17] was conducted in a population of people with cardiac problems who did not have COPD. The EAG did not consider evidence in this population to be generalisable to a COPD population.

With regard to the other technologies, full-text published randomised controlled trial evidence was available for Kaia Health[13-15] (mixed Germany and Switzerland), myCOPD[10-12] (UK) and SPACE for COPD[10-12] (UK). For Wellinks, the available evidence was a full-text single-site observational pilot study from the USA without a comparator arm.[16] Finally, no full-text published relevant evidence was available for Clinitouch or Rehab Guru; therefore the EAG prioritised a company report for Clinitouch and a conference abstract for Rehab Guru.

Face-to-face pulmonary rehabilitation was explicitly the comparator in three studies: the Staffordshire report for Clinitouch , the Bourne et al.[15] study for myCOPD, and Chaplin et al[12] (as advised by the company). For most other studies, where there was a comparator, this was usual care and was not defined clearly in the study reports. According to UK practice guidelines, usual care in the UK would be face-to-face pulmonary rehabilitation. However, studies using usual care in a UK context did not provide details as to how many, if any, participants actually received face-to-face pulmonary rehabilitation. Therefore, it is unknown to what extent this usual care comparator reflected reality. It is possible that studies using usual care as the comparator were comparing digitally supported pulmonary rehabilitation with less intensive management strategies, such as self-care and the provision of patient information. The issue is that some of the usual care arms may be less effective than face-to-face pulmonary rehabilitation. For example, in the Spielmanns et al. study[8] for Kaia Health, conducted in a mixed German and Swiss population, usual care is described as a leaflet to encourage an active lifestyle, as well as individual exercise

recommendations. Participants in the control group in this study also wore an activity tracker.

Clinical expert advice to the EAG expressed concern that control arms representing face-to-face pulmonary rehabilitation in the included trials were not 'gold standard' and represented sub-par intervention delivery. Typically, for example, participants in the control arm for myCOPD did not meet the minimally clinically important difference for a change in exercise capacity, Reasons for this underperformance may vary. Usual care, while ideally face-to-face pulmonary rehabilitation, may in practice be waitlist control, GP management or other non-gold standard treatment for a proportion of patients due to resource challenges. Furthermore, in the Bourne et al. study[15] (for myCOPD) the control arm was designed to provide a non-digital close equivalent of digitally supported pulmonary rehabilitation rather than gold standard face-to-face pulmonary rehabilitation.

Selection bias is also a concern. Clinical expert advice indicates that those who want face-to-face pulmonary rehabilitation or are not confident with digital technologies do not consent to trials of digitally supported pulmonary rehabilitation. Therefore, digitally supported arms are likely to overperform. If digitally supported pulmonary rehabilitation is rolled out in routine practice, some people with COPD who have lower digital literacy or lower interest in digital technologies may choose to access this option if appropriate support is offered. However, others may not. Therefore, it is likely there will still be a selection bias in trials compared to routine practice.

Clinical experts also expressed concern about the absence of the social component in digitally supported pulmonary rehabilitation (although the EAG notes that the Bourne study for SPACE for COPD[10] did include group sessions run at community venues).

Intervention reporting across trials was generally limited and did not offer insight into the fine details of the intervention components, the order in which they would occur, how flexible the delivery would be, and what time each component would be expected to take. Intervention reporting did not meet TIDieR guidelines.[1]

> ***Evidence gap:*** *Randomised controlled trials were not available for all scoped interventions in a relevant population. Multiple RCTs were available for SPACE*

for COPD and myCOPD, but the evidence for other interventions was more limited.

Evidence gap: *Details of usual care were not generally adequately reported.*

Evidence gap: *There are also no head-to-head or indirect comparison of the different digital technologies supporting pulmonary rehabilitation delivery.*

8.3. Population

Sample sizes were generally small – two of the studies were classed as feasibility trials and much of the rest of the evidence was early stage or exploratory in nature. Understandably, therefore, studies may not be intended to be optimally powered. However, the available study for Wellinks[16] was particularly small (n=19). Furthermore, the inclusion criteria for this study required participants to have access to an iPhone running iOS version 13.4 or later. This requirement for a specific brand adds further to the potential selection bias resulting from requiring access to smart devices.

There were two prioritised studies not conducted in the UK – the study for Wellinks[16] was conducted in a USA population, while the study for Kaia Health[8] was conducted in a mixed Swiss and German population. The remaining prioritised evidence came from the UK, which may benefit generalisability. However, UK studies generally focused on urban areas, meaning that the studied population may not generalise to the broader UK population. The Clinitouch study was conducted in Staffordshire – a mixed urban and rural county. Two of the three trials for myCOPD[14,15] were based in Portsmouth, while the other trial for this intervention[13] did not specify its geographical base in the published evidence, although the company said it was conducted in Basingstoke, Hull and Hemel Hempstead, which are all urban areas. The study for Rehab Guru[9] was conducted in Liverpool. For SPACE for COPD, one study[11,12] was conducted in Leicester, while the other[10] was conducted across Leicester (a large urban area) as well as the largely rural counties of Leicestershire and Rutland. This bias towards urban settings could be important given the socioeconomic determinants of COPD and how social and geographical factors may influence ease of access to face-to-face pulmonary rehabilitation.

Evidence gap: *The available study for Wellinks was single-arm and only included 19 participants.*

Evidence gap: *Samples were often not adequately powered for appropriate clinical outcome measures.*

Generalisability gap: *While most priority studies were UK-based, there was not UK-based evidence available for Kaia Health and Wellinks.*

Generalisability gap: *UK-based studies were geographically specific rather than UK-wide, leading to potential generalisability challenges due to the socioeconomic pattern of COPD prevalence and differences in accessibility of care and digital access between urban and rural areas.*

8.4. Reported outcomes

Outcomes were classified into six categories, based on the final scope: 1) exercise capacity measured by a validated outcome measure, 2) health-related quality of life, 3) other measures of respiratory function, 4) intervention completion, 5) intervention-related adverse events, and 6) acute exacerbations, hospital admissions, readmissions or emergency admissions.

The outcome domains for which most evidence was available were exercise capacity, respiratory function and intervention completion. There were some differences in the measures used for these concepts, but the EAG considered these to be generally comparable. Intervention completion was considered a fairly limited outcome due to the lack of detail available and differences in how studies assessed completion. Measures based purely on having used the app during the study period are particularly limited and do not tell us what content participants accessed.

Exercise capacity was the clinical outcome that was of greatest relevance for the economic model (see section 11.2.1). Two principal measures were used for exercise capacity: the six-minute walk test (6MWT) and the endurance shuttle walk test (ESWT).

There are multiple estimates of what constitutes an MCID for some outcomes. Within the timeframe of this EVA, it was not feasible for the EAG to conduct a systematic literature review of MCIDs for scoped outcomes. In order to provide some

interpretation of the reported outcomes, the EAG selected MCIDs from published literature (Table 6). Where possible, MCIDs in a UK COPD population were used.

Table 6: MCIDs used for key outcomes

Outcome	MCID	Source
6MWT	54m	Redelmeier et al.[54]
ISWT	48m	Singh et al.[55]
1-MSTST	3 repetitions	Vaidya et al.[56]
CAT	2 points	Schultz et al.[57]
ESWT	174 to 279 seconds	Zatloukal et al.[58]
Used in the Staffordshire report (for Clinitouch)[21]		
6MWT	>30m	Unreferenced
5XSST	>1.7 seconds	Unreferenced
1-MSTST	>3 repetitions	Unreferenced

Abbreviations: 1-MSTST = 1-Minute Sit-to-Stand Test; 5XSST = five times sit to stand test; 6MWT = six-minute walk test; CAT = COPD Assessment Test, ISWT = incremental shuttle walk test

Data were not available for all technologies for quality of life, intervention-related adverse events, and acute exacerbations, hospital admissions, readmissions or emergency admissions.

Quality of life, when assessed, was done so using different tools. For example, by EQ-5D-5L for Clinitouch and myCOPD (Crooks et al.[13]), or with disease-specific tools – such as CRQ and SGRQ – for myCOPD (Bourne et al.[15] and North et al.[14]).

> ***Evidence gap:*** *Evidence was not available for each technology for each priority scoped outcome domain. In particular, data were limited for quality of life, intervention-related adverse events, and exacerbation and hospitalisation outcomes.*

> ***Evidence gap:*** *Utility data were only available for two technologies.*

Evidence gap: *Intervention completion was defined in heterogenous ways. Measures that are based on whether participants used the app during the study period do not offer insight into what content participants accessed.*

8.5. Results from the evidence base

Short narrative summaries of the evidence base for each technology are provided, including a brief mention of studies not prioritised for inclusion. Table 5 gives study characteristics for the prioritised studies. In the appendices, Table 29 offers a detailed breakdown of the results and Table 30 presents a summary table of some of the main outcomes across trials, including where they met MCID. At the end of this section, Table 7 summarises the statistical differences between trial arms for the main outcome categories in the comparative prioritised studies.

Following this results section is the EAG's interpretation of the clinical evidence (section 9). Overall, the EAG drew the following conclusions about the evidence base available for digitally supported pulmonary rehabilitation:

- There were two technologies – myCOPD and SPACE for COPD – for which there was more than one eligible RCT and a range of other supporting evidence, reflecting a more advanced evidence base.
- The evidence, in particular for the two technologies with a more developed evidence base, generally supports the concept of non-inferiority between digitally supported and face-to-face pulmonary rehabilitation across available measures.
- However, based on clinical expert advice, caution should be taken about accepting clinical equivalence due to the potential of selection bias. People who choose to take part in trials of digital technologies are likely to have greater digital access, digital literacy and enthusiasm for digital technologies than the general clinical population. Also, there was evidence and clinical expert opinion, to suggest that face to face pulmonary rehabilitation as evaluated in control arms may have underperformed in comparison with reference standards and other published trials.

8.5.1. Active+me REMOTE

Priority evidence

Digital technologies to deliver pulmonary rehabilitation programmes for adults with COPD [GID-HTE10019]

No priority evidence could be identified for Active+me REMOTE.

Additional evidence

One published study was available for Active+me REMOTE. Frith et al.[17] was an observational cohort study conducted in the context of cardiac rehabilitation among people who did not have COPD. Due to the mismatch in population between this paper and the scope for the present appraisal, the EAG did not consider it appropriate to extract this paper as a priority study. The Frith et al.[17] study found that adding Active+me REMOTE to standard cardiac rehabilitation was associated with increased patient skill, knowledge, and confidence to manage their condition.

The available evidence for Active+me REMOTE in a pulmonary rehabilitation context in COPD came from two unpublished reports on the Liverpool[19] and Tallaght[20] studies. While of interest, these studies did not report clinical effectiveness outcomes in a usable format, so could not be designated as priority studies. It was agreed that the key clinical effectiveness evidence on Active+me REMOTE in this population will come from the Harefield study, data from which are expected to be available in December 2023.

8.5.2. Clinitouch

Priority evidence

The priority evidence for Clinitouch was an unpublished clinical evaluation report submitted by the company.

[redacted]

Additional evidence

No further evidence was identified for Clinitouch.

8.5.3. Kaia Health

Priority evidence

The priority evidence for Kaia Health was an RCT[8] in a mixed Swiss and German population as compared against no pulmonary rehab (although the comparator included a leaflet to encourage an active lifestyle and individual exercise recommendations). Evidence was presented within this trial for all six outcome domains.

The arms were stated not to be statistically different in terms of adverse events (data were not provided to the EAG for validation) or exacerbations, while no evidence was available for hospitalisations. Adherence to digitally supported pulmonary rehabilitation was moderate, with 67% using the app on at least 90 days. This showed that most people were using the app fairly frequently, but over 30% were not frequently actively engaged. It was not stated clearly what would count as app usage.

There was no statistically significant difference in disease-specific quality of life between groups at baseline or follow-up. Superior performance on 60 second sit-to-stand test was shown for Kaia Health versus usual care control at 3 months post intervention (mean±sd 22.87±8.00 vs 16.83±7.64 repetitions, p=0.004), but this difference was not sustained at 6 months (22.66±7.23 vs 19.45±9.09 repetitions, p=0.143), but neither was inferiority observed. Changes in the intervention group just exceeded the MCID of 3 repetitions at both 3 and 6 months. CAT scores did not differ statistically between groups at 3 months (15.53±8.26 vs 18.70±6.71 points; p=0.109), with a statistically significant difference in favour of the intervention group emerging by 6 months (15.13±8.58 vs 19.72±6.42, p=0.024, lower scores indicating less impact of COPD). CAT scores change did not meet the MCID threshold in either arm.

Additional evidence

A subgroup analysis within this same trial population was conducted by Gloeckl et al.[23] and was presented as a symposium abstract. From the limited information available, this subgroup analysis showed that observed benefits only occurred in participants with good adherence to app usage.

An observational study by Rassouli et al.[22] provides additional evidence that use of the Kaia Health app may offer a short-term benefit in quality of life, but that this depends on the feasibility and acceptability of the use of digitally supported pulmonary rehabilitation using a smartphone app for the individual participant.

8.5.4. MyCOPD

Priority evidence

Prioritised evidence for myCOPD came from three RCTs: Bourne et al., 2017[15], Crooks et al., 2020[13], and North et al., 2020[14]. Detailed results at the study level can be found in Table 29.

One of the myCOPD trials explicitly used a comparator of face-to-face pulmonary rehabilitation,[15] while the other two trials used a usual care comparator. While clinical guidelines say this should be face-to-face pulmonary rehabilitation, there were no details provided in the reports as to whether participants in the studies actually received this.

Across the three trials, results from the intervention and control arms were comparable for the exercise capacity, health-related quality of life, and respiratory function. Both arms improved and were not statistically significantly different. Changes in CAT scores met the MCID (of 2 points) in the intervention arm in all three trials.

It should be noted that there was a large difference in baseline step count between the groups in the Crooks et al. study[13] (myCOPD group (n=5) (mean±sd), 4948.7±1667.6 steps; usual care group (n=9), 9060±5135.1)), so a much lower step count at follow-up in the myCOPD group should not be interpreted as poorer performance of the myCOPD group.

Intervention completion, engagement and adherence were mixed for myCOPD across all three studies[13-15]: North et al. found that 40% of participants used the app every week (which the EAG considered low) and 85% activated the app during the study; Crooks et al. found that 72% of participants registered and activated the app, of whom 86% were still using the app during the last month of the trial, although there was still over 30% non-engagement; Bourne et al.[15] found that mean online session

attendance dropped slightly from 3.9 sessions per participant in week one to 2.5 sessions per participant in week six. No details were provided on what counted as app usage.

Adverse events across studies were largely comparable between arms and generally not of particular concern. However, in the Crooks et al. study[13], there were more exacerbations during the study in the myCOPD group than the control group (18 (62%) vs 11 (35%)), though it should be noted that, despite randomisation, there were also more exacerbations in the myCOPD group than the control group in the three months prior to the study (12 (41%) vs 3 (10%)). This baseline imbalance should be considered as a potential limitation to the study.

Additional evidence

Additional evidence from three non-randomised studies[24-26] was consistent with evidence from the pivotal trials. Due to the large number of full-text papers for this technology, the EAG does not offer a commentary on identified conference abstracts.

8.5.5. Rehab Guru

Priority evidence

The only evidence identified for Rehab Guru comes from a conference abstract by Pilsworth et al.[9] This reported a single-arm observational pilot study. Six-minute walk test scores improved by an average of 45 metres – below the MCID – between pre- and post-test assessments. Average CRD dyspnoea scores improved by 0.68 points (from 2.69 to 3.37), while average MRC dyspnoea scores improved from 4 (“I am too breathless to leave the house” or “I am breathless when dressing/undressing”) to 3 (“I stop for breath after walking about 100 yards or after a few minutes on level ground”). 81% of participants completed the 6-8 week intervention. The interpretation of these findings is limited by the lack of a control arm. No evidence was available for other key scoped outcomes.

Additional evidence

None.

8.5.6. SPACE for COPD

Priority evidence

Prioritised evidence for SPACE for COPD comes from two RCTs. Across both studies, performance on exercise capacity, quality of life, and respiratory function was comparable across the web-based and face-to-face pulmonary rehabilitation arms, with both arms showing improvements. Change exceeded the MCID for Chaplin et al.[11,12] for ESWT, but not for Bourne et al. (2022)[10] Neither did changes in the CAT score exceed the MCID threshold in Bourne et al.

Available information on intervention completion was limited. In Bourne et al.[10] completion was not reported but it is stated that six out of 97 dropped out due to inability to attend group sessions and two dropped out as the intervention was too similar to face-to-face pulmonary rehabilitation. It is not clear how drop out was defined – for example, whether was there a threshold of sessions after which a participant was considered to have completed. In Chaplin et al.,[11] 29 (56%) participants from the web-based arm dropped out. The average number of weeks to complete the website was 11±4 with an average number of four logins per week. No specific weekly target was stated. Adverse events were only reported by Bourne et al (2022)[10] – none were deemed to be attributable to the intervention. Details of the adverse event profile were not reported. Neither study reported data on hospitalisations or exacerbations.

Additional evidence

Additional evidence from a range of non-randomised studies[34,36-39] did not provide any evidence that contradicted the findings of the pivotal trials. Apps et al.[38] provide additional qualitative insight into usability and participant experiences with the technology. Due to the large number of full-text papers for this technology, the EAG does not offer a commentary on identified conference abstracts.

8.5.7. Wellinks

Priority evidence

The priority evidence for Wellinks comes from a single-arm, single-site, observational prospective pilot study in the USA.[16] All participants were reported to have completed

the intervention. Clinical advice to the EAG was that this sounds unrealistic, raising questions about how completion was defined and whether there was substantial selection bias in the sample.

Participants had an average forced expiratory volume in one second of 56.2% of predicted (range 23%-113%) and most participants (11/19) had severe or very severe COPD according to GOLD classification criteria. The interpretation of this information is limited by the single-arm nature of the study. No evidence was available for the other key scoped outcome domains. The data were a cross-sectional snapshot as the study was looking at the ability of people with COPD to use the Wellinks platform, rather than specifically looking at the clinical effectiveness of Wellinks on COPD over time. Therefore, no measure of change in score is provided. These findings therefore cannot show whether or not people with COPD improved while using Wellinks. The EAG was advised that the key clinical effectiveness results for Wellinks are forthcoming.

Additional evidence

No further evidence was identified for Wellinks.

8.5.8. Multiple technology comparison

There were no included studies that compared multiple scoped interventions.

8.5.9. Comparative outcomes summary

Table 7 shows a top-level summary of statistical measurements of differences in outcome categories between the intervention and control arms in the prioritised studies.

Cells shaded in grey represent one of two things. First, they show where there are no comparative studies available (this is the case for Active+me REMOTE, Rehab Guru and Wellinks); in this case they are marked up as not available (N/A). Second, in the case where comparative studies do exist, they show where no statistical analyses between groups were reported for that category; in this case they are marked up as not reported (NR). The light green cells with the horizonal arrow represent where there was no statistically significant difference in outcome between intervention and control. Finally, the darker green cells with a slanting arrow represent instances

where a statistically significant difference was seen for the intervention over control for at least one, but not necessarily all, follow up timepoints.

The table provides an overall representation of the findings. The only trial for which some outcomes showed a statistically significant improvement against control was in Spielmanns et al., 2023[8], in which case the control arm included no pulmonary rehabilitation. When compared to face-to-face or usual care in this trial, no significance difference was observed between arms.

Table 7: comparison between digitally supported PR vs control for prioritised studies

Technology	Study	Control	Exercise capacity	HRQoL	Respiratory function	Adverse effects	Exacerbations etc
Active+me REMOTE	N/A	None	N/A	N/A	N/A	N/A	N/A
Clinitouch	Staffordshire Report[21] [AIC]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Kaia Health	Spielmanns et al., 2023[8]	No PR	↗[a]	↔	↗[b]	↔	↔
myCOPD	Bourne et al., 2017[15]	F2F	↔	↔	↔	↔	NR
	Crooks et al., 2020[13]	UC	↔	↔	↔	↔	NR
	North et al., 2020[14]	UC	↔	↔	↔	↔	NR
Rehab Guru	Pilsworth et al. 2021[9]	None	N/A	N/A	N/A	N/A	N/A
SPACE for COPD	Bourne et al., 2022[10]	UC	↔	↔	↔	NR	NR
	Chaplin et al., 2017[12]; Chaplin et al., 2022[11]	F2F	↔	↔	↔	NR	NR
Wellinks	Gelbman & Reed, 2022[16]	None	N/A	N/A	N/A	N/A	N/A

Abbreviations and key: ↔ = no significant difference between intervention and control, ↗ = significant improvement was seen for the invention vs control in at least one (but not all) follow up timepoint, F2F = face-to-face, N/A = not applicable, NR = not reported, PR = pulmonary rehabilitation, UC = usual care. Two trials were non-inferiority studies against face-to-face pulmonary rehabilitation explicitly.[15,21]

[a] The exercise capacity outcome (60-second Sit-to-Stand Test) for the Kaia intervention arm reached a statistically significant difference at three months, but this was not maintained at six months.

[b] The respiratory function outcome (CAT score) for the Kaia intervention arm did not reach statistically significant difference at three months, but did at six months.

9. INTERPRETATION OF THE CLINICAL EVIDENCE

There were two technologies – myCOPD and SPACE for COPD – for which there was more than one eligible RCT and a range of other supporting evidence, reflecting a more developed evidence base. The evidence for these two technologies generally supports the concept of non-inferiority between digitally supported and face-to-face pulmonary rehabilitation, in terms of exercise capacity and respiratory function. However, there are concerns about the generalisability of this evidence, and clinical expert advice suggested that we should be cautious about accepting clinical equivalence between traditional face-to-face pulmonary rehabilitation for COPD and digitally supported pulmonary rehabilitation. As previously discussed, there are particular concerns about: underperforming control arms, socioeconomic and geographic bias, and selection bias.

The clinical evidence for the remaining technologies – Active+me REMOTE, Clinitouch, Kaia Health, Rehab Guru and Wellinks – was more limited. There is some evidence from usual care trials that digitally supported pulmonary rehabilitation may be superior to no treatment, but the generalisability of the control arms to NHS care is unclear. It was noted by clinical experts that in the UK usual care may be much more likely to be GP management or waitlist control than the recommended face-to-face pulmonary rehabilitation.

10. ADVERSE EVENTS AND TECHNOLOGY CONSIDERATIONS

Adverse events are described above under clinical effectiveness outcomes, as they represented one of the key scoped clinical outcome domains.

In summary, data for adverse events were available for Kaia Health, myCOPD and SPACE for COPD. These data did not show any particular concerns about the adverse event profile of these technologies.

There are no specific technology considerations besides those already described regarding digital literacy, digital confidence and access to relevant devices and network infrastructure, such as data signal and Wi-Fi access.

> ***Evidence gap****: Adverse event data were only available for three of the scoped technologies.*

11. ECONOMIC EVIDENCE

11.1. Published economic evidence

The EAG did not identify any published cost effectiveness evidence – such as cost utility analyses, cost effectiveness analyses, cost minimisation analyses or cost consequences analyses – that compared any of the included digital supported pulmonary rehabilitation technologies against each other. As a consequence, specific inputs were selected from existing evaluations that compared individual digital technologies against either face-to-face pulmonary rehabilitation or no pulmonary rehabilitation. These sources were identified from supplementary searches and are listed in Table 8. The specific inputs used are detailed later in Sections 11.2.2 and 11.2.3.

Table 8. Economic evaluations consulted from the literature.

	Economic evaluations consulted	Details of key inputs derived for the EAG model	Study details
1	Davies et al. 2023[59] and EAG report received from NICE for MTG68[60]	Cost assumptions for myCOPD and PR waitlist	Davies et al. 2023 is based on MTG68 (published 2022), which evaluated myCOPD. Data on PR waitlist and the associated waiting times were adopted from these sources to inform the current analyses.
2	Dritsaki et al. 2016[61]	Resource use and cost items derived for 'no PR'	Dritsaki et al 2016 is a UK based economic evaluation of a self-management programme in COPD using digital technology ("SPACE") vs TAU. TAU specifically excluded PR but healthcare resource utilisation was measured which made it a suitable proxy for the costs of no PR.
3	Griffiths et al. 2001[62]	Resource use components and assumptions derived for 'face-to-face PR'	Griffiths et al. 2001 is a UK based economic evaluation of outpatient PR vs TAU in people with COPD. The study provided a detailed breakdown of resources used to deliver F2F PR. After checking with SCM to make sure that the structure of the intervention in the study still matches the usual care in the NHS at present, the adjusted costs were used to represent the F2F PR.

Abbreviations: F2F = face-to-face; PR = pulmonary rehabilitation; SCM = specialist committee member; TAU = treatment as usual

***Evidence gap**: There is currently a lack of published cost effectiveness evidence comparing the included digital technologies to either face-to-face or no pulmonary rehabilitation/waitlist in adults with COPD. There are also no head-to-head or indirect comparison of the different digital technologies.*

11.2. Economic evaluation

The primary purpose of this analysis was to collate and summarise the existing economic evidence for the technologies supporting the digital delivery of PR. The secondary purpose was to assess whether there is a plausible *prima facie* case for any of the digitally supported pulmonary rehabilitation technologies to be cost-effective and identify any relevant evidence gaps to guide future data collection.

Due to the high-level exploratory nature of the modelling, the current analyses should be considered broadly indicative and not definitive.

11.2.1. Overall modelling approach

There are many challenges in modelling digital health interventions, compared to drugs and medical devices. Digital health interventions evolve over time, dynamically interact with both the user and the environment, and often have associated non-health impacts.[63] Given these challenges, the EAG opted for a disaggregated cost-consequences analysis (CCA) as the primary analysis, complemented with exploratory cost-effectiveness analyses (CEA).

There are many reasons for proceeding with a CCA approach. It not only allows for a transparent and holistic assessment of all the relevant costs and consequences of the technologies under consideration, but also provides the evidence currently available in a manner similar to an 'impact inventory'.[64] This approach enables decision makers to derive their own value judgements where needed so as to decide whether the cost-benefit ratios offered by the digital interventions are favourable, rather than collating them all into an overall measure of quantity of life years accrued (i.e. QALYs). The CCA approach is also supported by the NICE evidence standards framework (ESF) for digital health technologies[65] when a cost-utility analysis is not possible. Likewise, the NIHR recommends[66] CCA as a useful way to present results from feasibility trials with small sample sizes – which happens to be the case for some of the digitally supported pulmonary rehabilitation interventions under consideration in this EVA.

For example, the RCT examining the feasibility of SPACE for COPD[12] featured 52 participants in the intervention group. In another instance, the non-inferiority RCT assessing myCOPD[15] enrolled 64 participants. The feasibility RCT for the same technology, conducted by North et al. in 2020[14], included 21 people with COPD assigned to the digital technology group and 20 to the face-to-face group. Additionally, the RCT conducted by Kaia Health[8] included 33 participants in the intervention arm and the study that explored the efficacy of Clinitouch[21] involved 27 patients accessing PR through guided digital technology.

In addition to the CCA, the EAG performed a complementary exploratory cost-effectiveness analysis, expressed as cost per unit change in functional exercise capacity (measured in terms of 6MWD or ISWD) of the digital technologies compared to standard care or face-to-face pulmonary rehabilitation from a health service perspective. The EAG notes that results of this analysis should be interpreted with caution owing to their indicative nature and associated high levels of uncertainty.

Despite the evidence base being suggestive of non-inferiority between digitally supported and face-to-face pulmonary rehabilitation (see Table 7), the EAG did not consider a cost-minimisation approach (CMA) to be appropriate. This is because small sample sizes and short follow-up poses substantial challenges for CMA. Even if a non-inferiority claim is established for one specific endpoint, the potential for discovering differences in treatment effects between the interventions may arise during longer follow-up periods. In addition, clinical expert advice to the EAG indicated that often the face-to-face or centre-based pulmonary rehabilitation arm in non-inferiority studies underperforms (as described in more detail in the clinical section). Therefore, the trials could only demonstrate equivalence to a “sub-par” or “sub-optimal” intervention.

11.2.2. Reference case analysis: Cost-consequences analysis

Digital technologies were compared (where feasible) with face-to-face pulmonary rehabilitation from the NHS and PSS perspective, over a time horizon of one year. Costs were presented in 2022 GBP, but not discounted owing to the short time horizon. Unit costs were sourced from NHS reference costs 2021/22[67] and PSSRU 2022[68].

The EAG noted that none of the studies compared a digital technology to ‘no treatment’ or ‘no pulmonary rehabilitation’. However, as the scope mentioned ‘no treatment’ as a

comparator (see Table 1), the EAG extracted the costs reported for the usual care arm from Dritsaki et al.[61] The study's comparison involved self-management using SPACE for COPD, which encompasses educational materials, exercise recommendations, follow-up calls, and related components, against standard care that was managed by their GP practice. The control group (where no participants received pulmonary rehabilitation), was used as a proxy for 'no treatment'. Dritsaki et al. was chosen because its definition of the control arm was as close as possible to no treatment or no pulmonary rehabilitation. Also, the costs of face-to-face pulmonary rehabilitation were derived primarily based on the COPD PRIME tool.

All the costs and consequences reported in included studies were extracted along with their respective control arms, typically standard-of-care or usual care. However, as noted in the clinical section, there was considerable heterogeneity in the definition of control arms, and it did not always clearly refer to face-to-face pulmonary rehabilitation. For instance, the control arms in Bourne et study for myCOPD[15] referred to a combination of home-based pulmonary rehabilitation with a few supervised sessions while Chaplin et al. study for SPACE for COPD[12] referred to hospital or community-based pulmonary rehabilitation at a referral site.

As previously described, clinical outcomes considered in the studies included metrics for exercise capacity, respiratory function, health-related quality of life, along with other outcomes such as, number of adverse events and events related to hospitalisation or ED visit. These outcomes have been presented in a disaggregated form in Table 9. The incremental consequences for digital technologies versus their respective control arms have also been calculated where feasible. Results are reported as mean difference in the change over time between intervention and control, unless otherwise stated. Note that for Active+me REMOTE the results from the study are expected only in December 2023, and hence the technology has not been included in the table.

The costs considered for digital technologies primarily involved 1) licensing costs for technologies, 2) health care professional (HCP) costs, and 3) training or any other additional costs. There was heterogeneity in the cost components considered across the digital technologies. This was primarily due to different pricing models used by the included technologies. For example, myCOPD provided an annual license determined by number of COPD patients registered to that service (with fixed year 1 costs and

subsequent year costs based on number of user registrations and engagements achieved in previous year(s)), Clinitouch charged a cost per clinician, SPACE for COPD had an annual cost per trust along with an additional cost to add patients to be managed by the clinician through their platform, and Rehab Guru provided a cost per trust and a cost per clinician.

To compare the costs of these technologies in terms of cost per patient, the EAG considered data on caseload per clinician (based on clinical opinion to EAG), uptake levels for the technologies, and the number of patients who have registered and completed pulmonary rehabilitation. This allowed for a more comprehensive analysis of the cost the NHS is expected to pay per patient.

All costs have been presented in a disaggregated form in Table 10.

Table 9. Disaggregated consequences or effects

	Clinitouch vs F2F PR			MyCOPD vs F2F PR			SPACE for COPD vs TAU[a]			Kaia Health vs TAU[b]			Rehab Guru[c]		
Consequences (disaggregated)	**N (I,C)**	**Diff**	**P**	**N (I,C)**	**Diff**	**P**	**N (I,C)**	**Diff**	**P**	**N (I,C)**	**Diff**	**P**	**N (I,C)**	**Diff**	**P**
Exercise capacity															
6MWT, m	[redacted]	[redacted]	[redacted]	(64, 26)	23.8[d]	0.098							45		
ISWT, m							?<(52, 70)[e]	24.8[f]	NS						
EWST, s							?<(52, 70)[g]	40.6[h]	NS						
STST										<(33, 34)[i]	0.390	0.143			
HRQoL															
EQ-5D-5L, mean difference (%)	[redacted]	[redacted]	[redacted]						NS[j]						
EQ-5D VAS, mean difference in change	[redacted]	[redacted]	[redacted]						NS[j]						
SGRQ				(64, 26)	-3.72[k]	0.291									
CRQ (dyspnoea)							?<(52, 70)[l]	0.0[m]	NS	<(33, 34)[n]	0.570	0.033			
CRQ (total)										<(33, 34)[o]	0.508	0.056			
Respiratory function															
CAT[p]	[redacted]	[redacted]	[redacted]	(64, 26)	-1.0[q]	0.373	?(52, 70)[r]	0.511[s]	0.575	<(33, 34)[t]	-0.605	0.024			
MRC dyspnoea	[redacted]	[redacted]	[redacted]	(64, 26)	0.03[u]	0.909							-1		
AE (number of events)				(64, 26)	3	2	11 (however, none due to treatment)	7							
ED or resulting in Hospitalisation				1.88[v]	1.06[v]	0.82[v]				1.08[w]	1.23[w]	-0.15[w]			
Source(s)	Staffordshire report by Clinitouch [21]			Bourne et al. 2017[15] and hospitalisation data from North et al. 2020[14]			Bourne et al., 2022[10] except Chaplin et al. 2017[12] where stated.			Spielmanns et al. 2023[8]			Rehab Guru poster by Pilsworth et al.[9] & CS		

Abbreviations: 6MWT = 6-minute walk test; AE = adverse events; C = comparator; CAT = COPD Assessment Test; CRQ = Chronic Respiratory Disease Questionnaire; CS = company submission; Diff = difference; ED = emergency department; ESWT = endurance shuttle walk test; I = intervention; ISWT = incremental shuttle walk test; m = metres; MRC, Medical Research Council; s = seconds; SGRQ, Saint George's Respiratory Questionnaire; STST = sit-to-stand test

[a] TAU could include PR.

[b] Unknown whether TAU included PR.

[c] No comparative data available for Rehab Guru

[d] Adjusted, ITT population.

[e] Sample sizes for individual outcomes not reported explicitly reported, but primary outcome (CAT) data availability was (52,70), with between 2.6% and 52.3% of data missing for others.

[f] Baseline ISWT and ESWT in control group not reported. Details of statistical tests not reported. Figures shown are difference in metres between intervention and control at 9m

[g] Sample sizes for individual outcomes not reported explicitly reported, but primary outcome (CAT) data availability was (52,70), with between 2.6% and 52.3% of data missing for others.

[h] Baseline ISWT and ESWT in control group not reported. Details of statistical tests not reported. Figures shown are difference in metres between intervention and control at 9m

[i] 60 of 67 patients completed the study but data missingness not reported.

[j] Source: Chaplain 2017. Data not reported, but declared NS

[k] Adjusted, ITT population.

[l] Sample sizes for individual outcomes not reported explicitly reported, but primary outcome (CAT) data availability was (52,70), with between 2.6% and 52.3% of data missing for others.

[m] Difference in change from BL to 9m. 6m figures: 0.0, NS

[n] 60 of 67 patients completed the study but data missingness not reported.

[o] 60 of 67 patients completed the study but data missingness not reported.

[p] As CAT represents the impact of the disease on patient life a negative value in the table represents a decrease in that impact and an improvement in patient health

[q] Adjusted, ITT population

[r] Sample sizes for individual outcomes not reported explicitly reported, but primary outcome (CAT) data availability was (52,70), with between 2.6% and 52.3% of data missing for others.

[s] At 9m FU. 6m mean difference 1.70, p=0.135

[t] 60 of 67 patients completed the study but data missingness not reported.

[u] adjusted, ITT population.

[v] Mean in-patient treated

[w] Mean exacerbations treated

Table 10. Disaggregated costs (per patient)

	Active +me	Clinitouch	SPACE for COPD	myCOPD	Rehab Guru	Waitlist (without exacerbations)	Waitlist (with exacerbations)	F2F PR
License cost	£89	[redacted] £26.67[k]	£57[b]	yr1: [redacted][c] yr2: [redacted][c] [redacted][o]	£33[d]	-	-	-
Staff training	£42[e]	-	£12.5[f]	-	-	-	-	-
Participant training	£60 (ex VAT) [g]	-	-	-	-	-	-	-
Staff time	£144	£144[h]	£144	£144	£144			£432
Expected annual cost per patient	£335	[redacted] £171	£ 272	[redacted]	£177	£164[i]	£402[j]	£432
Uptake rate, %	-	10%[p] 30%[l]	10%[p] 5%	10%[p] (first year) 20% (Second year)	10%[p] 5%[m]	-	-	85%
Completion rate, %	-	76.6%	47%	62%	68%[n]	-	-	71%
Source(s)	Active+me company submission (request for information: Active+me ATT7-A~1)	[CIC] Email from Jim Swift from Spirit Health Att 7 -Spirit Dig_PR PR_Staffs_COPD_ PR_NICE_July_23 (includes company's HE analysis)	Att 7 - Company - request for information v2	Email from NICE : Updated pricing information from myCOPD [CIC] myCOPD pricing model	Email from NICE : FW_ URGENT AND TIME SENSITIVE - information required for NICE evaluation	Melina Dritsaki 2016, costs updated as per 2021/2022 NHS reference costs and PSSRU 2022	previous report on myCOPD DHT001 YHEC Assessment Report 18.08.2021 V5.0 post fact check CLEAN cost updated to 2022 PSSRU	COPD PRIME 2017 with costs adjusted using PSSRU 2022 Uptake and completion rates from UK COPD PR audit

[a] £1200 license cost per clinician, assuming a health care professional manages an average of 30 cases of PR annually based on SCM advice = 1200/30 = £40

[b] £500 license cost per trust and £50 for each patient added to a maximum of 30 patients per clinician. There are a total of 217 NHS trusts in the UK. According to the NACAP PR benchmark report, there are 15,713 people registered to the audit and attending PR programs. Assuming that each clinician sees 30 patients based on clinical opinion to EAG, the cost per patient can be calculated as follows: = ((500 * 217/15,713)+50*30)/30 = £57

[c] License costs corresponding to 10% uptake rate in first year and 20% uptake rate in second year sourced from myCOPD pricing model.

[d] A license for £2,000 per NHS trust, along with an additional charge of £150 per clinician to use the technology. There are a total of 217 NHS trusts in the UK. According to the NACAP PR benchmark report, there are 15,713 people registered to the audit and attending PR programs. Assuming that each clinician sees 30 patients based on clinical opinion to EAG, the cost per patient can be calculated as follows:(£2,000 * 217 / 15,713) + (£150 / 30) = £32.62 per patient.

[e] £1250 to train a clinician to use the technology, SCM advised the EAG that all clinicians would likely need training before managing their patients through the technology. And assuming a Clinician manages 30 patients = 1250/30 = £41.6

[f] The company submission- reports a cost of £375 to train a HCP and support the delivery of tech = 375/30 = £12.5

[g] The company a training cost of £150 per patient to instruct them on the usage of the technology. According to a study conducted on digitally supported pulmonary rehabilitation during the COVID-19 pandemic, it was found that 40% of the patients require assistance or lack confidence in their internet usage skills. Therefore, it can be estimated that these patients would necessitate training, resulting in a cost of £60 per patient (150 * 0.4 = £60).

[h] The Staffordshire study conducted on CliniTouch provides a detailed breakdown of the staff time required for delivering their intervention. Since other technologies did not provide the same data, a similar cost of £143.88 per patient was assumed for other technologies given the similarities in mode of delivery.

[i] Resource utilisation reported by Dritsaki et al., 2016 (adjusted for 2022 NHS cost reference) provided an annual cost of £372. The average waiting time for PR is 160.7 days. Average cost per patient on the waiting list (stable patient) = 372*(160.7/365) = £163.78

[j] Previous NICE report for MTG68 used the cost of 13 days on wating list at £40 (cost adjusted for 2022). The average waiting time for PR is 130.8 days. Average cost per patient on the waiting list (people with unstable COPD) = 40*(130.8/13) = £402.46

[k] £26.67 license cost based on company HE analysis presented in the Staffordshire report

[l] Normalised estimate so the overall proportion add up to 100% : (28%/94%)*100

[m] Assumed same as myCOPD and SPACE for COPD i.e., 5%

[n] Aggregate data from 3 sites as reported in submission file. Note, however, as per the poster submitted it is 80%

[0] myCOPD pricing based on 'legacy' contract which is a per patient fee structure starting from approximately [redacted]. Current users may remain on this fee structure in perpetuity if the contract is not reviewed.

[p] Based on the NHS England data from COPD PRIME tool, proportion who starts PR out of COPD population with MRC3 and above = 59,033/667,040 ~ 9% which aligns closely with 10%

11.2.2.1. Cost-consequences balance sheet (in terms of walking distance)

Based on the disaggregated costs and consequences presented in Section 11.2.2, a cost-consequence balance sheet was prepared (Table 11). The balance sheet specifically compares the efficacy of the included technologies to UK national COPD PR audit data, which included outcomes for 6MWT and ISWT. The sheet therefore only includes technologies for which 6MWT and ISWT outcomes were available (namely, Clinitouch, myCOPD, SPACE for COPD and Rehab Guru).

The absolute change in 6MWD from baseline was [redacted]m for Clinitouch[21], 44.9m for myCOPD[15], and 45m for Rehab Guru.[9] For SPACE for COPD[12], the absolute change in incremental shuttle walking distance (ISWD), based on Chaplin 2017, was less than 48m (45m assumed for calculation). Based on the UK COPD PR audit data for face-face pulmonary rehabilitation, the change from baseline was 63.4m for ISWD and 59m for 6MWD, derived as the weighted average of the practice and no practice cohorts.[69]

Comparison with the UK COPD PR audit therefore resulted in a difference of [redacted] for Clinitouch, -14.1 for myCOPD, and -14m for Rehab Guru (in terms of 6MWD) and -18.4m for SPACE for COPD (in terms of ISWD), as presented in Table 11.

Table 11. Cost-consequences balance sheet

	Clinitouch vs F2F PR (UK COPD PR audit)	myCOPD vs F2F PR (UK COPD PR audit)	SPACE for COPD vs F2F PR (UK COPD PR audit)	Rehab Guru vs F2F PR (UK COPD PR audit)
Difference in treatment effect, 6MWD in m	[redacted]	-14.1	NR	-14.0
Difference in treatment effect, ISWD in m	NR	NR	-18.4	NR
Annual cost savings per participant	[redacted] [redacted]	[redacted] first year[b] [redacted] second year[b]	-£218	-£255

Abbreviations: 6MWD = 6-min walking distance; ISWD = incremental shuttle walking distance; m = metres; F2F = face-to-face; NR = not reported.

[a] per participant license fee based on 'legacy' contract

[b] per participant license fee based on pricing model with 10% uptake rate at first year and 20% in the following years

The technologies supporting the digital delivery of PR were therefore slightly less effective compared to face-to-face pulmonary rehabilitation in terms of absolute change in walking distance from baseline (for both 6MWD and ISWD), as they resulted in relatively lower improvements in walking distance post baseline than that observed in the UK COPD PR audit data.

However, all of the technologies resulted in cost savings compared to face-to-face pulmonary rehabilitation as per UK COPD audit. Please note that a 10% uptake rate has been used for myCOPD based on the proportion of COPD population with MRC3 and above who start pulmonary rehabilitation in England (= 59,033/667,040 ~ 9%), as per COPD PRIME tool. Per participant costs of other technologies (namely, Clinitouch, SPACE for COPD and Rehab guru) were assumed not to be impacted by uptake rates. Annual savings per participant were:

- [redacted] based on 'legacy' contract per participant fee and [redacted] in the first year and [redacted] in the following years based on uptake rate linked pricing model provided, for myCOPD
- [redacted] based on per clinician per year cost, and £261 based on per participant license cost of £26.67, for Clinitouch
- £218 for SPACE for COPD
- £255 for Rehab Guru

The primary factor contributing to cost savings is the reduction in staff time required for delivery. The EAG also noted that the cost per patient is influenced by the pricing model for the technology. For instance, in the case of myCOPD, the higher the population covered at trust or service level (owing to higher uptake), then the lower the per participant cost. In contrast, a pricing model based on licenses per patient or clinician, as in Clinitouch and SPACE for COPD, tends to be less sensitive to low uptake rates. It is worth noting that while the cost per patient (without adjustment for uptake and completion rates) for Rehab Guru is relatively low at £177, because of which it could save £254 cost, the efficacy data are premature, as the only study for this technology has not yet reported its final results. The situation is similar with Clinitouch, where the main source of efficacy data relies on the Staffordshire study,

the results of which have not yet undergone peer review (see Section 9 for an interpretation of the clinical evidence).

To enhance the precision of this analysis, it is important to address specific knowledge gaps. For instance, uptake rates informed by real world data will lead to more robust estimations. Exacerbation rates are another key cost driver, as evidenced by the difference in costs between people with stable and unstable COPD (based on the likelihood of having exacerbations) on the waiting list. While the effectiveness evidence for face-to-face pulmonary rehabilitation interventions in reducing exacerbations is mature, there is currently a lack of data on how digital technologies compare in this regard. Closing this knowledge gap is key for a more comprehensive evaluation (see Section 13 for more details).

11.2.3. Complementary analysis: Exploratory cost-effectiveness analysis

An exploratory cost-effectiveness analysis was performed in addition to the reference case analysis. The perspective, time horizon and the source of unit costs were the same as that of the reference case CCA. Cost-effectiveness was expressed as cost per change in functional exercise capacity, as it was one of the outcomes that was reported consistently across digital technology studies (as described in Section 9). Holland et al. 2014[70] described how field walk tests, such as 6MWT, ISWT and ESWT, have demonstrated validity and reliability. They are also strongly associated with measures of exercise performance and physical activity in people with COPD undergoing pulmonary rehabilitation. Previous economic analysis such as Burge et al. 2020[71] also used change in functional exercise capacity – measured as distance walked on 6-min walk test – as their second preferred outcome measure (after health-related quality of life utility scores).

Only four technologies were included in the cost-effectiveness analysis: Clinitouch, myCOPD, Rehab Guru and SPACE for COPD. These were the only technologies for which 1) at least one of the exercise capacity measures was reported and 2) the calculation of cost per participant was feasible (as the outcomes reported were per participant). For myCOPD, Bourne et al. 2017[15] was used as the primary data source, as it was the only study which reported a validated exercise capacity measure, i.e., 6MWT (Crooks et al. 2020[13] reported only number of steps per day

and North et al. 2020[14] reported Veterans Specific Activity Questionnaire (VSAQ), neither of which were validated measures).

Key model inputs and the associated assumptions have been provided in Table 12. Please note that the change from baseline in terms of MCID units were calculated as follows: absolute change from baseline measured through 6MWT or ISWT in metres divided by the MCID for 6MWT or ISWT (54m for 6MWT[54] and 48m for ISWT[55]). As an example, for myCOPD this was calculated as: 44.9/54 = 0.831.

This decision analytic framework used enabled a threshold analysis for the four included technologies. The approach allowed identification of threshold values of key variables – such as change in functional exercise capacity (measured in terms of change in walking distance through 6MWT and ISWT), license fee for digital technologies, uptake rates etc. – above or below which the digital technologies are likely to offer good value for money compared to face-to-face pulmonary rehabilitation. Conducting a threshold analysis was considered appropriate at this stage, given that estimates of cost-effectiveness are unlikely to be definitive owing to the evidence base consisting of a small number of relatively under-powered trials (as discussed in section 8.3).[72]

Deterministic sensitivity and scenario analyses to test the impact of different sources of inputs and assumptions were also performed (Section 11.2.3.2). However, given the sparse availability of measures of parameter variability from trials and the need for several arbitrary assumptions, a probabilistic sensitivity analysis was not performed (as it may cause pseudo-certainty of the results generated which could be misleading[73]).

Table 12. Model inputs CEA

	Annual per participant costs (£)	Uptake, %	Completion, %	Per participant effects (measured as change in functional exercise capacity)		
				Absolute mean change from baseline (6MWD or ISWD in metres)	% change from baseline	Change from baseline measured as MCID units
Digitally supported pulmonary rehabilitation technologies (considering license fee, staff time and training costs)						
Clinitouch (CT)	[redacted] £170.55[b]	10%[f]	[redacted]	[redacted]	[redacted]	[redacted]
myCOPD (MC)	[redacted] (using license fee corresponding to 10% uptake)[e]	10%[f]	62%	44.9[c]	12%	0.831
Rehab Guru	£177	10%[f]	68%	45[c]	18%	0.833
SPACE for COPD	£213.29	10%[f]	47%	45[d]	15%	0.947
Face-to-face pulmonary rehabilitation						
F2F PR – 6MWD based on UK COPD PR audit (without exacerbation costs)	£432	85%	71%	59	22%	1.092
F2F PR – ISWD based on UK COPD PR audit (without exacerbation costs)				63.4	31%	1.320
F2F PR CT control arm	£272.83	70%	55.63%	[redacted]	[redacted]	[redacted]

	Annual per participant costs (£)	Uptake, %	Completion, %	Per participant effects (measured as change in functional exercise capacity)		
				Absolute mean change from baseline (6MWD or ISWD in metres)	% change from baseline	Change from baseline measured as MCID units
F2F PR myCOPD control arm	Assumed same as UK COPD PR audit	95%	72%	28.6	7%	0.530
F2F PR SPACE control arm	Assumed same as UK COPD PR audit	95%	67%	Assumed same as UK COPD PR audit		

Abbreviations: 6MWD = 6-min walking distance; F2F = face-to-face; PR = pulmonary rehabilitation; HCP = health care professional; ISWD = incremental shuttle walk distance; UK = United Kingdom. Note: As F2F arm was not available in the Rehab Guru study, it was assumed to be the same as UK COPD PR audit.

[a] Cost based on confidential per clinical per annum price reported in the company submission.

[b] Cost based on publishable license fee of £26.67.

[c] Clinitouch, Rehab Guru and myCOPD results are expressed as 6MWD.

[d] SPACE for COPD results are expressed as ISWD.

[e] Calculated as: 144+64 (license fee for 10% uptake)

[f] Based on the NHS England data from COPD PRIME tool, proportion who starts PR out of COPD population with MRC3 and above = 59,003/667,040 ~ 9%, rounded up to 10%

11.2.3.1. Key model assumptions

Related to effects:

- Reported exercise capacity outcomes were assumed to be for participants who completed the full digital or face-to-face pulmonary rehabilitation course (i.e. not those participants who did not complete the full course).
- ISWT effects for SPACE for COPD were assumed to be the same as that of the face-to-face arm of the UK COPD pulmonary rehabilitation audit, as Chaplin et al.[12] only reported the baseline data for the control arm. However, ISWT data from Bourne et al. 2022[10] have been tested in a scenario analysis.
- For Rehab Guru, as there was no control arm in its study, it was assumed to be the same as UK COPD PR audit.
- If uptake rates for the trial control arms were not provided, they were calculated as 1 minus the uptake rate in the digital arm. This assumes that there are only two arms in each trial, and if participants are not signed up for the digital arm, then the only choice available is the control arm.
- The completion rate for the control arm in the Staffordshire Clinitouch study was not reported – it was therefore assumed to be the same as that of the intervention arm.
- Mortality and other long-term outcomes (especially in terms of impact on COPD, such as changes in COPD severity) have not been captured owing to the 1-year time horizon of the model and the short follow up in the available clinical evidence.

Related to costs:

- The healthcare professional costs from Staffordshire Clinitouch study were assumed to be the same for all included technologies.
- Where licensing costs were provided per clinician (for instance, for SPACE for COPD), to enable the calculation of per participant costs, 30 patients per clinician was assumed based on clinical opinion to EAG (which itself was based

on NACAP pulmonary rehabilitation benchmark[74], assuming 3 clinicians per site: 15,713 people registered/180 sites*3 clinicians per site ~ 30). The cost per participant calculated for Clinitouch based on this assumption was tested as part of a scenario analysis, as the base case value is drawn from a company submitted economic analysis which included a publishable license fee.

- For deriving myCOPD costs per participant, based on the company provided pricing tool, an uptake rate of approximately 10% for the first year was assumed in the base case. The 10% also aligned with the proportion who starts PR out of the COPD population with MRC score of 3 and above – as per the COPD PRIME tool.). However, myCOPD' s pricing has been offered in two ways to the NHS. One considered to be a 'legacy' pricing with the starting cost per participant of [redacted], while the current approach is based on trust level pricing, where the per participant cost is linked to agreed uptake levels. Owing to this variation in pricing model, a range of pricing as low as the per participant 'legacy' contract fee ([redacted]) reflecting best case scenario and as high as [redacted] corresponding to an uptake rate of 5% reflecting worst case scenario, as per the pricing model provided, was tested in scenario analysis.

- For technologies with no uptake rate linked pricing model (namely, Clinitouch, SPACE for COPD and Rehab guru), per participant costs were assumed not to be impacted by the uptake rates.

- The costs for face-to-face pulmonary rehabilitation were sourced from the literature (see Table 13Table 13). It is to be noted that the costs based on the COPD PRIME tool[76] have been considered in base case following clinical advice to the EAG. Other costs were explored in scenario analyses.

Table 13. Face-to-face PR costs

Source and details	F2F PR costs
Griffiths et al.., 2001[62] costs updated using PSSRU 2022[68]	£1,066 per 6 weeks PR programme per patient for 12 sessions aligned with clinical advice to EAG
PR costs based on COPD PRIME[76] (without exacerbation related costs) and staff costs updated using Agenda for change 2023/24 pay scales[77]	£432 per patient

Source and details	F2F PR costs
PR costs based on COPD PRIME[76] (with exacerbation related costs) and staff costs updated using Agenda for change 2023/24 pay scales[77]	£908 per patient (£432+Average exacerbation cost including hospital admission and primary care £477)

Abbreviations: EAG = External assessment group; PR = Pulmonary rehabilitation; PRIME = Pulmonary Rehabilitation Impact Model on Exacerbations; PSSRU = Personal Social Services Research Unit

11.2.3.2. Model results (base case)

Table 14 to Table 16 present the base case results of the CEA. Results are shown for the following outcomes: 1) absolute change from baseline in exercise capacity, measured as walking distance in metres, 2) percentage change from baseline in exercise capacity, measured as walking distance, and 3) unit change from baseline in MCID of exercise capacity, measured as MCID units (calculated as described in Section 11.2.3). Mean differences in absolute change from baseline between digital and face-to-face pulmonary rehabilitation did not reach MCID for any technology in their respective trials, indicating potential non-inferiority.

The EAG considered that the face-to-face pulmonary rehabilitation data from the UK COPD PR audit are closer to real clinical practice than the control arms of the included studies (see Section 8.2), and hence only the results comparing digital technologies to that of UK COPD PR audit have been presented here. The results using the trial control arms have been presented in the Appendices (Appendix E).

When UK COPD pulmonary rehabilitation audit data were used for the face-to-face pulmonary rehabilitation arm the incremental effects ranged from:

- -18.38 to -0.11 in terms of difference in walking distance from baseline
- -0.387 to -0.002 in terms of difference in MCID units
- -15% to -2% in terms of difference in percentage change in walking distance

The incremental costs ranged from [redacted] to -£261 across the technologies, with SPACE for COPD producing the least savings.

Please note that the results have been presented in terms of cost per outcome of interest. Net benefit measures (INMB/INHB) have not been used as the outcome

here is change in walking distance, for which the willingness to pay threshold is unknown.

Table 14. Cost per change in walking distance – F2F PR UK COPD PR audit

	Costs (per annum per participant)	Effect (Change in walking distance, m)	Digital vs F2F PR		
			Incremental costs	Incremental effect	Cost per ΔWD(m)
Clinitouch (CT)	£170.55	[redacted]	-£261	[redacted]	[redacted]
F2F PR	£431.55	59.01	-	-	-
myCOPD (MC)	[redacted]	44.90	[redacted]	-14.11	[redacted]
F2F PR	£431.55	59.01	-	-	-
SPACE for COPD	£213.29	45.00	-£218	-18.38	£12
F2F PR	£431.55	63.38	-	-	-
Rehab Guru	£176.50	45.00	-£255	-14.01	£18
F2F PR	£431.55	59.01	-	-	

Abbreviations: F2F = Face-to-face; MCID = minimal clinically important difference; PR = Pulmonary rehabilitation; WD = walking distance in meters

MCID reached MCID not reached

Table 15. Cost per unit change in MCID[a] – F2F arm as per UK COPD PR audit

	Costs (per annum per participant)	Effect (change in MCID units)	Digital vs F2F PR		
			Incremental costs	Incremental effect	Cost per unit ΔMCID
Clinitouch (CT)	£170.55	[redacted]	-£261	[redacted]	[redacted]
F2F PR	£431.55	1.093	-	-	-
myCOPD (MC)	[redacted]	0.831	[redacted]	-0.261	[redacted]
F2F PR	£431.55	1.093	-	-	-
SPACE for COPD	£213.29	0.947	-£218	-0.387	£564
F2F PR	£431.55	1.334	-	-	-
Rehab Guru	£176.50	0.833	-£255	-0.259	£983
F2F PR	£431.55	1.093	-	-	-

Abbreviations: F2F = Face-to-face; MCID = minimal clinically important difference; PR = Pulmonary rehabilitation; WD = walking distance in meters [a]1 MCID for 6MWD = 54m and ISWD = 48 m.

MCID reached MCID not reached

Table 16. Cost per % change in walking distance – F2F arm as per UK COPD PR audit

	Costs (per annum per participant)	Effect (% change in walking distance)	Digital vs F2F PR		
			Incremental costs	Incremental effect	Cost per % ΔWD
Clinitouch (CT)	£170.55	[redacted]	-£261	[redacted]	[redacted]
F2F PR	£431.55	22%	-	-	-
myCOPD (MC)	[redacted]	12%	[redacted]	-11%	[redacted]
F2F PR	£431.55	22%	-	-	-
SPACE for COPD	£213.29	15%	-£218	-15%	£1,416
F2F PR	£431.55	31%	-	-	-
Rehab Guru	£176.50	18%	-£255	-4%	£5,902
F2F PR	£431.55	22%	-	-	-

Abbreviations: F2F = Face-to-face; MCID = minimal clinically important difference; PR = Pulmonary rehabilitation; WD = walking distance in meters

MCID reached MCID not reached

11.2.3.3. Sensitivity and scenario analyses

Deterministic sensitivity analyses, including one-way and two-way analysis were, performed to assess the impact of uncertainty associated with the model parameters. Face-to-face pulmonary rehabilitation data from the UK COPD PR audit has been used for all the sensitivity and scenario analysis, as it was found to reflect clinical practice more closely than the control arms in the prioritised studies.

Threshold analysis of change from baseline 6MWD indicated that when a treatment effect of around 60m and above was tested, Clinitouch, myCOPD and Rehab Guru were found to be cost saving as well as more effective compared to face-to-face pulmonary rehabilitation based on UK COPD PR audit (Table 17). Similarly, in terms of change in ISWD, when a threshold value of 65m and above was tested, SPACE for COPD was cost saving and more effective. Below these threshold values (both for 6MWD and ISWD), all the technologies considered were cost saving but less effective compared to UK COPD PR audit based face-to-face PR. Therefore, for these digital technologies to be cost saving as well as more effective compared to

face-to-face pulmonary rehabilitation, a treatment effect of at least 60m (in terms of change in walking distance) may need to be achieved. However, these threshold values are subject to uncertainty based on the change from baseline values in the face-to-face arm. This has been explored further in the sensitivity analysis. As shown in Table 18, Clinitouch would be cost saving and more effective if the change from baseline in the face-to-face arm would have been less than 60m. Similarly, if the change from baseline in the face-to-face arm would have been less than 45m, myCOPD, SPACE for COPD and Rehab guru would be cost saving and more effective.

One-way sensitivity analysis of uptake rates of the digital technologies was also performed, which indicated the uncertainty in costs savings for myCOPD, owing to its uptake rate linked pricing model. As shown in Table 19, the costs savings achieved with myCOPD were relatively more sensitive to uptake rates of up to 15%, compared to more than 15% (with the highest sensitivity noted when the uptake rate was changed to 2.5% from 5%, which reduced the cost savings from [redacted] to [redacted]. However, this was not the case for other digital technologies, as their pricing models were not directly linked to uptake rates.

To explore further the uncertainty of results, while simultaneously varying the change in walking distance (effect) and the per participant cost of the digital technologies (cost), the EAG conducted a two-way analysis for all digital technologies exploring the impact of change in their effects on their respective costs. Results of the two-way sensitivity analysis are presented in Table 20 to Table 23, which indicated that, except for myCOPD, the results were similar for all digital technologies.

In addition, scenario analyses were also carried out to explore the alternative inputs on both costs and effects. The impact of these scenarios on the base case results are shown in Table 24. In terms of scenarios evaluating alternative outcomes used for measuring the effect of treatment, using ISWD from Bourne et al 2022 (for SPACE for COPD) decreased the cost per change of walking distance by 59%. Also, using an alternative MCID cut-off for 6MWT, based on the Clinitouch Staffordshire study, decreased the cost per change in walking distance measured as MCID units by 80%. From the point of view of costs, using the first year price based on 5% uptake rate, as per the pricing model for myCOPD, decreased the cost per change in

walking distance by 40%, owing to reduced savings with a lower uptake rate than base case (10%), which aligns with the similar findings from the one-way sensitivity analysis (Table 19). On the other hand, using the legacy contract pricing increased the cost per change in walking distance by 16%, owing to the associated higher savings compared to base case. It is to be noted that the impact of alternative per participant costs (derived from per clinician costs), for Clinitouch, seem to have only marginal impact on the results (with cost per ΔWD decreasing by 5%).

Table 17. OWSA – Impact of change in walking distance on cost per ΔWD

	Cost per ΔWD			
Change from baseline WD, m	CT	myCOPD	SPACE	Rehab Guru
0	£4	£4	£3	£4
5	£5	£4	£4	£5
10	£5	£5	£4	£5
15	£6	£5	£5	£6
20	£7	£6	£5	£7
25	£8	£7	£6	£7
30	£9	£8	£7	£9
35	£11	£9	£8	£11
40	£14	£12	£9	£13
45	£19	£16	£12	£18
50	£30	£26	£17	£30
55	£65	£56	£26	£64
60	-£264	-£226	£64	-£258
65	-£44	-£37	-£135	-£43
70	-£24	-£20	-£33	-£23
75	-£16	-£14	-£19	-£16
80	-£12	-£11	-£13	-£12
85	-£10	-£9	-£10	-£10
90	-£8	-£7	-£8	-£8
95	-£7	-£6	-£7	-£7
100	-£6	-£5	-£6	-£6

Abbreviations: CT = Clinitouch; OWSA = One-way sensitivity analysis; WD = walking distance

Less costly-less effective vs F2F PR UK COPD audit

Less costly-more effective vs F2F PR UK COPD audit

Table 18. OWSA – Impact of change in walking distance in the F2F PR arm on cost per ΔWD for the technologies

	Cost per ΔWD			
Change from baseline WD F2F, m	CT	myCOPD	SPACE	Rehab Guru
0	-£4	-£5	-£5	-£6
5	-£5	-£6	-£5	-£6
10	-£5	-£6	-£6	-£7
15	-£6	-£7	-£7	-£9
20	-£7	-£9	-£9	-£10
25	-£8	-£11	-£11	-£13
30	-£9	-£15	-£15	-£17
35	-£11	-£23	-£22	-£26
40	-£14	-£46	-£44	-£51
45	-£19	£407	£485	£567
50	-£31	£40	£40	£47
55	-£76	£21	£21	£24
60	£168	£14	£14	£17
65	£40	£11	£11	£12
70	£23	£9	£9	£10
75	£16	£7	£7	£8
80	£12	£6	£6	£7
85	£10	£6	£5	£6
90	£8	£5	£5	£6
95	£7	£4	£4	£5
100	£6	£4	£4	£5

Abbreviations: CT = Clinitouch; OWSA = One-way sensitivity analysis; WD = walking distance

Less costly-less effective vs F2F PR UK COPD audit

Less costly-more effective vs F2F PR UK COPD audit

Table 19. OWSA – impact of uptake rates on cost savings

Uptake rates, %	Cost savings vs F2F PR (UK COPD PR audit)			
	myCOPD (first year)	Clinitouch	SPACE	Rehab Guru
2.5%	[redacted]	£261	£218	£255
5%	[redacted]	£261	£218	£255
10%	[redacted]	£261	£218	£255
15%	[redacted]	£261	£218	£255
20%	[redacted]	£261	£218	£255
25%	[redacted]	£261	£218	£255
30%	[redacted]	£261	£218	£255
35%	[redacted]	£261	£218	£255
40%	[redacted]	£261	£218	£255
45%	[redacted]	£261	£218	£255
50%	[redacted]	£261	£218	£255
55%	[redacted]	£261	£218	£255
60%	[redacted]	£261	£218	£255
65%	[redacted]	£261	£218	£255
70%	[redacted]	£261	£218	£255
75%	[redacted]	£261	£218	£255
80%	[redacted]	£261	£218	£255
85%	[redacted]	£261	£218	£255
90%	[redacted]	£261	£218	£255
95%	[redacted]	£261	£218	£255
100%	[redacted]	£261	£218	£255

Abbreviations: OWSA = One-way sensitivity analysis; WD = walking distance; F2F= face-to-face, PR= Pulmonary rehabilitation;

Table 20. TWSA – Impact of ΔWD versus license fee per participant on cost per ΔWD (Clinitouch)

	Change from baseline WD, m	0	10	20	30	40	50	60	70	80	90	100
Per participant annual technology cost (includes license fee, staff time and training costs)	**£0**	£7	£9	£11	£15	£23	£48	-£436	-£39	-£21	-£14	-£11
	£50	£6	£8	£10	£13	£20	£42	-£386	-£35	-£18	-£12	-£9
	£100	£6	£7	£9	£11	£17	£37	-£335	-£30	-£16	-£11	-£8
	£150	£5	£6	£7	£10	£15	£31	-£285	-£26	-£13	-£9	-£7
	£200	£4	£5	£6	£8	£12	£26	-£234	-£21	-£11	-£7	-£6
	£250	£3	£4	£5	£6	£10	£20	-£184	-£17	-£9	-£6	-£4
	£300	£2	£3	£3	£5	£7	£15	-£133	-£12	-£6	-£4	-£3
	£350	£1	£2	£2	£3	£4	£9	-£82	-£7	-£4	-£3	-£2
	£400	£1	£1	£1	£1	£2	£4	-£32	-£3	-£2	-£1	-£1
	£450	-£0	-£0	-£0	-£1	-£1	-£2	£19	£2	£1	£1	£0
	£500	-£1	-£1	-£2	-£2	-£4	-£8	£69	£6	£3	£2	£2

Abbreviations: TWSA = Two-way sensitivity analysis; WD = walking distance

Less costly-less effective vs F2F PR UK COPD audit Less costly-more effective vs F2F PR UK COPD audit More costly-less effective vs F2F PR UK COPD audit More costly-More effective vs F2F PR UK COPD audit

Table 21. TWSA – Impact of ΔWD versus license fee per participant on cost per ΔWD (SPACE for COPD)

	Change from baseline WD, m	0	10	20	30	40	50	60	70	80	90	100
Per participant annual technology cost (includes license fee, staff time and training costs)	**£0**	£7	£8	£10	£13	£18	£32	£128	-£65	-£26	-£16	-£12
	£50	£6	£7	£9	£11	£16	£29	£113	-£58	-£23	-£14	-£10
	£100	£5	£6	£8	£10	£14	£25	£98	-£50	-£20	-£12	-£9
	£150	£4	£5	£6	£8	£12	£21	£83	-£43	-£17	-£11	-£8
	£200	£4	£4	£5	£7	£10	£17	£68	-£35	-£14	-£9	-£6
	£250	£3	£3	£4	£5	£8	£14	£54	-£27	-£11	-£7	-£5
	£300	£2	£2	£3	£4	£6	£10	£39	-£20	-£8	-£5	-£4
	£350	£1	£2	£2	£2	£3	£6	£24	-£12	-£5	-£3	-£2
	£400	£1	£1	£1	£1	£1	£2	£9	-£5	-£2	-£1	-£1
	£450	-£0	-£0	-£0	-£1	-£1	-£1	-£5	£3	£1	£1	£1
	£500	-£1	-£1	-£2	-£2	-£3	-£5	-£20	£10	£4	£3	£2

Abbreviations: TWSA = Two-way sensitivity analysis; WD = walking distance

Less costly-less effective vs F2F PR UK COPD audit Less costly-more effective vs F2F PR UK COPD audit More costly-less effective vs F2F PR UK COPD audit

More costly-More effective vs F2F PR UK COPD audit

Table 22. TWSA – Impact of ΔWD versus license fee per participant on cost per ΔWD (myCOPD)

	Change from baseline WD, m	0	10	20	30	40	50	60	70	80	90	100
Per participant annual technology cost (includes license fee, staff time and training costs)	**£0**	[redacted]										
	£50	[redacted]										
	£100	[redacted]										
	£150	[redacted]										
	£200	[redacted]										
	£250	[redacted]										
	£300	[redacted]										
	£350	[redacted]										
	£400	[redacted]										
	£450	[redacted]										
	£500	[redacted]										

Abbreviations: TWSA = Two-way sensitivity analysis; WD = walking distance

Less costly-less effective vs F2F PR UK COPD audit More costly-less effective vs F2F PR UK COPD audit Less costly-more effective vs F2F PR UK COPD audit

More costly-More effective vs F2F PR UK COPD audit

Table 23. TWSA – Impact of ΔWD versus license fee per participant on cost per ΔWD (Rehab Guru)

	Change from baseline WD, m	0	10	20	30	40	50	60	70	80	90	100
Per participant annual technology cost (includes license fee, staff time and training costs)	**£0**	£7	£9	£11	£15	£23	£48	-£436	-£39	-£21	-£14	-£11
	£50	£6	£8	£10	£13	£20	£42	-£386	-£35	-£18	-£12	-£9
	£100	£6	£7	£9	£11	£17	£37	-£335	-£30	-£16	-£11	-£8
	£150	£5	£6	£7	£10	£15	£31	-£285	-£26	-£13	-£9	-£7
	£200	£4	£5	£6	£8	£12	£26	-£234	-£21	-£11	-£7	-£6
	£250	£3	£4	£5	£6	£10	£20	-£184	-£17	-£9	-£6	-£4
	£300	£2	£3	£3	£5	£7	£15	-£133	-£12	-£6	-£4	-£3
	£350	£1	£2	£2	£3	£4	£9	-£82	-£7	-£4	-£3	-£2
	£400	£1	£1	£1	£1	£2	£4	-£32	-£3	-£2	-£1	-£1
	£450	-£0	-£0	-£0	-£1	-£1	-£2	£19	£2	£1	£1	£0
	£500	-£1	-£1	-£2	-£2	-£4	-£8	£69	£6	£3	£2	£2

Abbreviations: TWSA = Two-way sensitivity analysis; WD = walking distance

Less costly-less effective vs F2F PR UK COPD audit More costly-less effective vs F2F PR UK COPD audit Less costly-more effective vs F2F PR UK COPD audit

More costly-More effective vs F2F PR UK COPD audit

Table 24. Scenario analysis

	Incremental effect (ΔWD, m)	Incremental effect (ΔWD, MCID units)	Incremental effect (%ΔWD)	Incremental costs, £	Cost per ΔWD, m	Cost per ΔWD, MCID units	Cost per %ΔWD	Change from base case value, %		
								Cost per ΔWD, m	Cost per ΔWD, MCID units	Cost per %ΔWD
Alternative effectiveness data source for SPACE for COPD										
SPACE for COPD (ISWD data source Bourne et al 2022)	-39.18	-0.825	-25%	Same as base case	£6	£265	£889	-59%	-113%	-113%
Alternative 6MWT MCID cut-off										
Clinitouch	Same as base case	[redacted]	Same as base case			[redacted]	Same as base case	-	-80%	-
myCOPD		-0.470				£476				
Rehab Guru		-0.467				£546				
myCOPD annual per participant total cost based on 5% uptake (first year cost)										
myCOPD	Same as base case			[redacted]	[redacted]	[redacted]	[redacted]	-40%		
myCOPD annual per participant total cost based on 'legacy' contract per participant fee										
myCOPD	Same as base case			[redacted]	[redacted]	[redacted]	[redacted]	16%		
Clinitouch per participant costs derived based on per clinician per year										
Clinitouch	Same as base case			[redacted]	[redacted]	[redacted]	[redacted]	-5%		

Abbreviations: WD, walking distance; MCID, Minimal clinically important difference; m, metres; 6MWT, 6-min walk test

12. INTERPRETATION OF THE ECONOMIC EVIDENCE

12.1. Reference case (cost-consequence analysis)

The cost-consequences balance sheet produced for walking distance outcome indicated that though Clinitouch, myCOPD, SPACE for COPD and Rehab Guru were slightly less effective compared to face-to-face pulmonary rehabilitation, they could offer potential cost savings due to reduced healthcare professional time. This finding is also in line with the NICE MTG68,[78] which suggested that the use of myCOPD may result in cost savings (though, subject to high uncertainty).

However, such a comparison was not possible for Active+me REMOTE, Kaia Health and Wellinks, as there were no walking distance outcome data available for these technologies. Though it could be noted that the annual per participant cost of Active+me REMOTE was comparable to other technologies and indicated potential cost savings compared to face-to-face pulmonary rehabilitation, when compared solely based on costs. For Kaia Health and Wellinks, however, the costs of the technologies were not available to derive any inference.

No direct comparison could be made of the included technologies to waitlist or no pulmonary rehabilitation. Cost per participant for waitlist or no pulmonary rehabilitation was found to be generally lower than that of the digital technologies, though it is worth noting that Dritsaki et al. 2016 showed that SPACE for COPD is likely to be more costly and more effective than no pulmonary rehabilitation (over a 6-month study period).

In terms of the costs of digital technologies, EAG would like to highlight that there was high heterogeneity about how the different components were costed. Although, EAG calculated the total costs of the technologies per participant considering as many components as possible such as the license fee, training costs and healthcare staff time, the underlying heterogeneity might still impact the cost savings indicated.

12.2. Complementary analysis (exploratory cost-effectiveness analysis)

The exploratory CEA was performed only for Clinitouch, myCOPD, Rehab Guru and SPACE for COPD. The deterministic base case showed that when trial control arm data were used for face-to-face pulmonary rehabilitation, myCOPD was cost saving and more effective than face-to-face pulmonary rehabilitation. Clinitouch, though, was found to be cost saving and less effective. However, when the UK COPD pulmonary rehabilitation audit data was used for face-to-face pulmonary rehabilitation, all four of the digital technologies considered were found to be cost saving and less effective than face-to-face pulmonary rehabilitation.

Subsequent deterministic threshold analysis also indicated that Clinitouch, myCOPD, Rehab Guru and SPACE for COPD were likely to be cost saving but less effective than face-to-face rehabilitation below the respective threshold values identified for 6MWD (60m) and ISWD (65m). Whereas, above the threshold values the technologies were likely to be cost saving as well as more effective. It is to be noted, however, that the threshold values provided are subject to change based on the observed change from baseline in face-to-face pulmonary rehabilitation arms. For instance, if the observed change from baseline in the face-to-face arm is lower than that of the digital arm, then the threshold values would decrease – otherwise, they would increase.

In terms of uptake rates, myCOPD results were found to be relatively more sensitive to the technology costs per annum as its pricing model has been linked to the uptake rates.

13. EVIDENCE GAP ANALYSIS AND FUTURE RESEARCH

13.1. Evidence gap analysis

Table 25 presents a summary of evidence gaps, focusing on outcomes. The table was populated based on prioritised evidence. Therefore, Active+me REMOTE does not feature as no priority evidence was identified. Narrative commentary on other evidence gaps is provided below the table.

Table 25: Evidence Gap Analysis (based on prioritised evidence only)

	Active +me	Clini-touch	Kaia Health	my COPD	Rehab Guru	SPACE for COPD	Wellinks
Key outcomes							
Exercise capacity measured by a validated outcome measure	Red	[redacted]	Amber	Green	Amber	Green	Red
Health-related quality of life	Red	[redacted]	Amber	Green	Red	Green	Red
Other measures of respiratory function	Red	[redacted]	Amber	Green	Amber	Green	Amber
Intervention completion	Red	[redacted]	Amber	Green	Amber	Amber	Amber
Intervention-related adverse events	Red	[redacted]	Amber	Green	Red	Amber	Red
Acute exacerbations, hospital admissions, readmissions or emergency admissions	Red	[redacted]	Amber	Green	Red	Red	Red
Modelling and economic outcomes							
Effectiveness evidence: Populations/subgroups	Effectiveness data for the digital PR technologies has not been split up by subgroups (for instance by level of breathlessness, rural/urban settings, or with/without comorbidities) and the evidence in this regard is weak currently across all PR technologies. Red						
Effectiveness evidence: Comparative data	Randomised evidence on the effectiveness of digital technologies supporting delivery of PR compared to no PR or waiting list is not consistently available for all the scoped technologies. Red						
Effectiveness evidence: Comparative data	There is currently no evidence on the comparative efficacy of digital PR technologies and there are no head-to head trials which limits the conduct of incremental analysis. Red						
Effectiveness evidence: Long-term effect of PR	Though some studies reported the outcomes beyond duration of PR programme (for instance, at 9 months), robust evidence of sustained efficacy of digital PR is currently unavailable. Red						

Costs/Resource use: Exacerbations	Data on exacerbation related events (ED visits, hospital admissions etc.) pre and post pulmonary rehabilitation were limited and not reported consistently. Amber
HRQoL: Health state utilities	Evidence on health state utilities is currently weak limiting the conduct of a cost-utility analysis. Amber
Costs: Lost productivity	Is there a case for including time off work within economic evaluations of digital PR technologies (outside NICE reference case)? The evidence base contains no data on lost productivity, currently. Red

Green = clear evidence of effectiveness from more than one study; Amber = some evidence but unclear or inconsistent; Red = no or negative evidence. It should be noted that the primary clinical claim for this appraisal is non-inferiority rather than superiority.

There are a number of evidence gaps in respect of the clinical evidence base as it pertains to the decision problem. Key gaps included:

Population gaps

- While most studies were conducted in the UK, studies were not UK-wide and generally focused more on urban areas.
- There were no subgroup analyses presented on rural communities, which may face particular challenges with regard to access to digital technologies.
- Participants in studies on digitally supported technologies are likely to have greater digital literacy, digital access and interest in digital technologies, and be less keen on receiving face-to-face pulmonary rehabilitation than the general clinical population.

Intervention gaps

- There was no published full-text evidence in a population relevant to the decision problem available for Active+me REMOTE, Clinitouch and Rehab Guru.

Comparator gaps

- No studies were conducted which explicitly compared to no pulmonary rehabilitation.
- There is no evidence comparing any of the included technologies against each other.

- Usual care as a comparator may differ between countries and also between NHS trusts. Due to resource limitations and long waiting lists, usual care in NHS settings may not always be face-to-face pulmonary rehabilitation as recommended by guidelines.
- Control arms for myCOPD did not perform at the level of gold-standard face-to-face pulmonary rehabilitation as per the National COPD audit.

Outcome gaps

- Relatively limited information was available for health-reality quality of life, adverse event and hospitalisation or exacerbation outcomes.
- Health-related quality of life was only assessed for some technologies. For other technologies, only disease specific quality of life, not utilities, were presented. Though mapping studies exist for SGRQ to EQ-5D in COPD[79], direct inclusion of EQ-5D in the technology trials would be preferable.
- Many studies did not use validated exercise capacity outcome measures with MCID, such as 6MWT.

13.2. Integration into the NHS

The broader implementation and integration of digitally supported therapies may pose challenges relating to a variety of technical, human, and operational factors. Clinical advice and EAG considerations revealed the following challenges: 1) acquisition of technology and relevant licences, 2) data security, 3) staff attitude to and awareness of digitally supported therapies, 4) staff training requirements including cost and time implications, 5) inertia and changing established treatment pathways, 6) waiting lists, 7) patient preferences, 8) patient digital literacy, 9) patient digital access, and 10) any requirements to provide additional support for those with additional needs or limited access to digital devices. It also needs to be taken into account that treatment protocols and equipment can differ significantly between hospitals and trusts.

13.3. Ongoing studies

Ongoing studies provided in company submissions and correspondence are listed below Table 26. The EAG considers these studies may partially address some of the clinical uncertainties.

Table 26: Ongoing studies from company submissions

Active+me REMOTE	Clinitouch	MyCOPD
A real-world evaluation of Active+me REMOTE at Harefield Hospital, sponsored by Anglia Ruskin University ARU/Chelmsford – data due March 2024[80]	Pulmonary Rehabilitation in Staffordshire – an open service evaluation collecting data on clinical outcomes (such as 6MWT). Data due December 2023, with further analysis of unscheduled admissions likely 2025[81]	PROPEL myCOPD – a RWE study on clinical and cost effectiveness of myCOPD as part of the respiratory discharge bundle, with a primary endpoint of hospital readmissions – data due 2025[82]
A first, full, research ethics committee approved and registered clinical trial of Active+me REMOVE at Harefield – data due December 2023[80]	An analysis of digital and face-to-face pulmonary rehabilitation in participants with respiratory diseases (not just COPD) – same endpoints as above with with an expanded patient base Interim endpoints late 2023[81]	

The EAG additionally identified an RCT for Kaia Health in people self-managing COPD at home (uncertain due date)[83], and two observational studies on Wellinks, one looking at clinical outcomes and quality of life in people with COPD[84], the other looking at hospital readmissions[85] – both studies were predicted to have completed in December 2022.

13.4. Key areas for evidence generation

Given the gaps and issues raised in this section, the EAG presents some specific evidence generation recommendations in Table 27.

Table 27: Evidence generation recommendations

Research question	Possible study design	Outcomes
1. Which technology or technologies are most suitable for NHS use?	Comparative cohort studies of two or more included technologies in a prospective	Exercise capacity, respiratory function, hospitalisation and

	RWE setting; qualitative focus group or interview study	exacerbations, health-related quality of life; patient and clinician perspectives
2. What is the real-world safety profile of scoped interventions?	Observational safety monitoring study in RWE setting	Adverse event frequency, severity and event type profile
3. How long will the effect of PR delivered through digital technologies be sustained?	Longer term follow-up of studies including RCTs	Disease severity, exercise capacity, disease specific and generic HRQoL tools
4. What are the factors which impact participant preferences and the uptake of digital PR technologies?	Preference elicitation from participants (using methods such as discrete choice experiments)	Preferred attributes from the study

Abbreviations: NHS = National Health Service; PR = pulmonary rehabilitation; RWE = real world evidence

13.5. Potential considerations for future economic models

Once the current evidence gaps on digital technologies supporting the delivery of PR highlighted in Section 13.1 have been addressed, a mature model concept could enable a robust full economic evaluation of the digital technologies. Here, the EAG sets out a few considerations in this regard:

- **Model approach/structure**: In terms of a potentially suitable model approach and structure, EAG considers that a cost utility analysis using a long-term Markov cohort model stratified based on subgroups, or a Markov microsimulation model simulating individual patients based on their baseline characteristics and disease severity (preferably defined based on GOLD stages[86]), could adequately capture the long-term effects of PR on adults with COPD. This is because COPD is heterogeneous in nature, and people with the condition are often impacted by a range of related comorbidities, even though pulmonary rehabilitation is a short-term intervention (typically, lasting 6-8 weeks with 2 sessions of 2 hours each week[6]), whether delivered face-to face or supported digitally. Also, a similar approach has been described in Atsou et al. 2016[87] (using the model detailed in Atsou et al. 2011[88]) for a French cohort of COPD patients with and without pulmonary rehabilitation, assessed over their remaining lifespan from a societal perspective. Likewise, Mosher et al. 2022[89] performed an economic evaluation from a societal perspective, comparing

COPD patients undergoing pulmonary rehabilitation to no pulmonary rehabilitation after COPD hospitalisation. This was within the US health care system for a lifetime horizon (though no effect of pulmonary rehabilitation was assumed beyond first year).

- **Consideration of impact of pulmonary rehabilitation on disease severity and mortality**: In order to consider how pulmonary rehabilitation might affect long-term outcomes for people with COPD, especially in terms of their disease severity and mortality (ideally linked to exacerbations), it might be necessary to incorporate lifetime costs. For instance, Mosher et al. 2022[89] considered readmission and death probabilities, conditioned on receiving pulmonary rehabilitation in the first year, and estimated follow-up of COPD population mortality in the subsequent years (based on age, sex, and COPD GOLD disease stages).

- **Time horizon:** In order to capture the long-term effects of pulmonary rehabilitation on disease outcomes, it might again be beneficial to consider a lifetime horizon, although assumptions related to long terms effects of pulmonary rehabilitation may need to be made (informed by expert opinion if otherwise unavailable).

- **Perspective:** A healthcare payer perspective might be able to capture the direct costs of the digital technologies to the health care system. However, a societal perspective would enable consideration of non-health benefits and costs (such as the productivity gains in relatively younger cohorts).

- **Uptake rates for digital technologies:** As the pricing for some of the digital technologies seem to be linked to its uptake rate, it might be beneficial to use real-world utilisation data for the respective technologies where available to reflect the technology costs as accurately as possible.

14. CONCLUSIONS

The two technologies for which the most clinical evidence was available were myCOPD and SPACE for COPD. Trial evidence supports the concept of non-inferiority between digitally supported and face-to-face pulmonary rehabilitation in terms of exercise capacity and respiratory function for these technologies. Therefore, they appear to offer promise as digitally supported pulmonary rehabilitation technologies for COPD. Evidence was more limited for Active+me REMOTE, Clinitouch, Kaia Health, Rehab Guru and Wellinks, and there was insufficient evidence to assess whether they are likely to offer promise. However, across all technologies, it is important to consider whether these findings are generalisable. Trial evidence was focused mainly on urban areas which may have greater access to digital technologies. No subgroup data for rural areas were available.

Clinical expert advice was that there is likely substantial selection bias in favour of participants with greater digital literacy, greater digital access and those who did not favour face-to-face pulmonary rehabilitation. There was also concern about the sub-par performance of control arms. Control groups for myCOPD did not reach gold standard reference values for key outcomes, while in Bourne et al. (2017),[15,21] the control group was designed to provide a non-digital equivalent of the digitally supported intervention rather than gold standard face-to-face pulmonary rehabilitation. In other trials, usual care was the comparator, and some participants are likely to have received waitlist control or GP management rather than the recommended face-to-face pulmonary rehabilitation, due to long waiting lists and resource challenges. Only two trials explicitly used face-to-face pulmonary rehabilitation as the comparator.

Therefore, it is possible that intervention groups over-performed and the control arms under-performed, biasing the observed results in favour of digitally supported therapy. The EAG thought this to be an important consideration.

This weakness in the clinical evidence base impacted the interpretation of the EAG economic analysis. For example, based on the reference case CCA performed using trial data, myCOPD performed better than face-to-face. However, this should be interpreted with caution because the face-to-face control arm is likely to be sub-

optimal. Other digital technologies were found to be either at par or less effective compared to face-to-face pulmonary rehabilitation in terms of consequences, especially when exercise capacity is expressed in terms of walking distance. Given such limitations with the trial control arms, the EAG produced a CCA balance sheet considering the UK COPD PR audit data for face-to-face pulmonary rehabilitation. This exercise indicated lower effectiveness for Clinitouch, myCOPD, SPACE for COPD and Rehab Guru, in terms of walking distance, than that observed in the UK COPD PR audit.

When considering the per participant licence fee, staff time costs and training costs, the included technologies have the potential to be cost saving, compared to face-to-face pulmonary rehabilitation. However, the technology costs were likely to be slightly higher compared to waitlist or no PR, though this should be carefully considered alongside the underlying assumptions in terms of waiting time, associated exacerbation costs etc.

The complementary CEA similarly indicated that the digital technologies are likely to be cost saving but less effective compared to face-to-face pulmonary rehabilitation, derived from the UK COPD PR audit, in terms of cost per change in walking distance. Deterministic threshold analysis performed also confirmed this finding, indicating a threshold value of approximately 60m for 6MWD and 65m for ISWD, below which the technologies are likely to be cost saving but less effective. Above this threshold all technologies considered in the CEA were cost saving as well as more effective. It is worth noting, however, that the threshold values provided are subject to change based on the observed change from baseline in the face-to-face arm. In addition, sensitivity analysis also indicated that myCOPD was found to be relatively more sensitive to its uptake rate as its pricing model was directly linked to uptake rates achieved. However, these findings should only be treated as indicative.

In conclusion, there remains a strong need for addressing the existing evidence gaps for digital technologies supporting the delivery of pulmonary rehabilitation in COPD to enable the conduct of a fully definitive economic evaluation.

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16. APPENDICES

Appendix A: Searches for clinical and cost effectiveness evidence

Table 28: Resources searched for clinical and cost effectiveness studies

Database Name*	Host	Date searched	Results
Medline ALL	Ovid	01/08/23	146
Embase	Ovid	01/08/23	338
Cochrane Database of Systematic Reviews	Cochrane Library: Wiley	01/08/23	9
Cochrane CENTRAL	Cochrane Library: Wiley	01/08/23	157
INHATA	https://database.inahta.org/	01/08/23	11
company websites	Various	01/08/23	11
NICE	https://www.nice.org.uk/guidance	04/08/23	7
SIGN	https://www.sign.ac.uk/our-guidelines/	04/08/23	0
MHRA	https://www.gov.uk/drug-device-alerts	04/08/23	0
MAUDE	https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfmaude/search.cfm	04/08/23	0
Clinical Trials.gov	http://www.clinicaltrials.gov/	03/08/23	9
ICTRP	https://trialsearch.who.int/	03/08/23	17
ScharrHUD	https://www.scharrhud.org/	03/08/23	0
CEA Registry	https://cear.tuftsmedicalcenter.org/	03/08/23	9
Records imported			**712**
Final no of records (after dedupe)			**528**

Ovid MEDLINE(R) ALL

#	Searches	Results
1	exp Pulmonary Disease, Chronic Obstructive/	67012

2	(chronic adj4 obstruct* adj4 (lung* or pulmonar*) adj4 (disease* or disorder*)).ti,kw,ab.	64447
3	1 or 2	96774
4	Rehabilitation/	18690
5	exp Exercise Therapy/	63477
6	Physical Therapy Modalities/	40854
7	Exercise Movement Techniques/	872
8	(pulmonar* adj4 rehab*).ti,ab.	5115
9	or/4-8	123134
10	Digital Technology/	719
11	Mobile Applications/	11550
12	exp Internet/	97734
13	exp Cell Phone/	22449
14	exp Computers, Handheld/	13081
15	Medical Informatics Applications/	2551
16	Therapy, Computer-Assisted/	6973
17	(app or apps).ti,ab.	43223
18	(online or web or internet or digital*).ti.	138461
19	((online or web or internet or digital*) adj3 (based or application* or intervention* or program* or therap* or enabl*)).ab.	81394
20	(phone* or telephone* or smartphone* or cellphone* or smartwatch*).ti.	27106
21	((phone* or telephone* or smartphone* or cellphone* or smartwatch*) adj3 (based or application* or intervention* or program* or therap*)).ab.	16923
22	(mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental).ti.	8503
23	((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental) adj3 (based or application* or intervention* or program* or therap*)).ab.	5889
24	(mobile* adj3 (based or application* or intervention* or device* or technolog*)).ti,ab.	21800
25	or/10-24	344806
26	3 and 9 and 25	123
27	("Active+me" or "Active + Me").af.	4
28	clinitouch.af.	0
29	("Kaia COPD" or "Kaia Health COPD").af.	3
30	"myCOPD".af.	6

31	"Rehab Guru".af.	1
32	"Space for COPD".af.	17
33	"Wellinks".af.	1
34	or/26-33	146

Embase

#	Searches	Results
1	exp chronic obstructive lung disease/	173358
2	(chronic adj4 obstruct* adj4 (lung* or pulmonar*) adj4 (disease* or disorder*)).ti,kw,ab.	93842
3	1 or 2	184452
4	pulmonary rehabilitation/	9291
5	exp kinesiotherapy/	99228
6	physiotherapy/	104987
7	(pulmonar* adj4 rehab*).ti,ab.	9221
8	or/4-7	203902
9	Digital Technology/	4079
10	exp mobile application/	25229
11	exp Internet/	129040
12	exp mobile phone/	47084
13	computer assisted therapy/	4858
14	personal digital assistant/	1826
15	text messaging/	7617
16	(app or apps).ti,ab.	58589
17	(online or web or internet or digital*).ti.	158232
18	((online or web or internet or digital*) adj3 (based or application* or intervention* or program* or therap* or enabl*)).ab.	108839
19	(phone* or telephone* or smartphone* or cellphone* or smartwatch*).ti.	32084
20	((phone* or telephone* or smartphone* or cellphone* or smartwatch*) adj3 (based or application* or intervention* or program* or therap*)).ab.	22539
21	(mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental).ti.	9326

22	((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental) adj3 (based or application* or intervention* or program* or therap*)).ab.	6411
23	(mobile* adj3 (based or application* or intervention* or device* or technolog*)).ti,ab.	26751
24	or/9-23	443859
25	3 and 8 and 24	274
26	("Active+me" or "Active + Me").af.	7
27	clinitouch.af.	0
28	("Kaia COPD" or "Kaia Health COPD").af.	5
29	"myCOPD".af.	20
30	"Rehab Guru".af.	1
31	"Space for COPD".af.	39
32	"Wellinks".af.	10
33	or/25-32	338

Cochrane Library

#1 [mh "Pulmonary Disease, Chronic Obstructive"] 7267
#2 (chronic near/4 obstruct* near/4 (lung* or pulmonar*) near/4 (disease* or disorder*)):ti,ab 13903
#3 #1 or #2 16259
#4 [mh ^Rehabilitation] 1344
#5 [mh "Exercise Therapy"] 19663
#6 [mh ^"Physical Therapy Modalities"] 4759
#7 [mh ^"Exercise Movement Techniques"] 326
#8 (pulmonar* near/4 rehab*):ti,ab 2646
#9 #4 or #5 or #6 or #7 or #8 27298
#10 [mh ^"Digital Technology"] 30
#11 [mh ^"Mobile Applications"] 1580
#12 [mh Internet] 6200
#13 [mh "Cell Phone"] 3146
#14 [mh "Computers, Handheld"] 1375
#15 [mh ^"Medical Informatics Applications"] 38
#16 [mh ^"Therapy, Computer-Assisted"] 1478
#17 (app or apps):ti,ab 9550
#18 (online or web or internet or digital*):ti 16962
#19 ((online or web or internet or digital*) near/3 (based or application* or intervention* or program* or therap* or enabl*)):ab 19822

#20 (phone* or telephone* or smartphone* or cellphone* or smartwatch*):ti 6915
#21 ((phone* or telephone* or smartphone* or cellphone* or smartwatch*) near/3 (based or application* or intervention* or program* or therap*)):ab 9105
#22 (mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental):ti 2769
#23 ((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental) near/3 (based or application* or intervention* or program* or therap*)):ab 29087
#24 (mobile* near/3 (based or application* or intervention* or device* or technolog*)):ti,ab 6461
#25 #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 71825
#26 #3 AND #9 AND #25 144
#27 ("Active+me" or "active + me"):ti,ab,kw 280
#28 clinitouch:ti,ab,kw 0
#29 ("Kaia COPD" or "Kaia Health COPD"):ti,ab,kw 7
#30 "myCOPD":ti,ab,kw 5
#31 "Rehab Guru":ti,ab,kw 1
#32 "Space for COPD":ti,ab,kw 29
#33 "Wellinks":ti,ab,kw 1
#34 #27 or #28 or #29 or #30 or #31 or #32 or #33 323
#35 #34 and #3 28
#36 #26 or #35 166

= 9 reviews and 157 trials

INAHTA

("Wellinks") OR ("Space for COPD") OR ("Rehab Guru") OR ("myCOPD") OR ("Kaia COPD" or "Kaia Health COPD") OR (clinitouch) OR ("Active+me" or "Active + Me") OR (((((mobile* AND (based or application* or intervention* or device* or technolog*)):)[Title] OR ((mobile* AND (based or application* or intervention* or device* or technolog*)):)[abs]) OR ((((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental) AND (based or application* or intervention* or program* or therap*)))[abs]) OR (((mobile health or mhealth or m-health or ehealth or e-health or emental or e-mental))[title]) OR ((((phone* or telephone* or smartphone* or cellphone* or smartwatch*) AND (based or application* or intervention* or program* or therap*)):ab)[abs]) OR (((phone* or telephone* or smartphone* or cellphone* or smartwatch*))[title]) OR ((((online or web or internet or digital*) AND (based or application* or intervention* or program* or therap* or enabl*)))[abs]) OR (((online or web or internet or digital*))[title]) OR (((app or apps))[Title] OR ((app or apps))[abs]) OR ("Therapy, Computer-Assisted"[mh]) OR ("Medical Informatics Applications"[mh]) OR ("Computers, Handheld"[mhe]) OR ("Cell Phone"[mhe]) OR ("Internet"[mhe]) OR ("Mobile Applications"[mh]) OR ("Digital Technology"[mh]))

AND ((((pulmonar* AND rehab*))[Title] OR ((pulmonar* AND rehab*))[abs]) OR ("Exercise Movement Techniques"[mh]) OR ("Physical Therapy Modalities"[mh]) OR ("Exercise Therapy"[mhe]) OR ("Rehabilitation"[mh])) AND ((((chronic AND obstruct* AND (lung* or pulmonar*) AND (disease* or disorder*)))[Title] OR ((chronic AND obstruct* AND (lung* or pulmonar*) AND (disease* or disorder*)))[abs]) OR ("Pulmonary Disease, Chronic Obstructive"[mhe])))

= 11 hits

ClinicalTrials.gov

Search string	Results
“Active+me”/all studies	0
Aseptika/all studies	1
“Clinitouch Vie”/all studies	0
“Spirit Health” AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	0
“Kaia Health” AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	2
myCOPD/all studies	4
myHealth AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	0
“Rehab Guru” /all studies	0
“Space for COPD” /all studies	0
Wellinks AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	2
Total	9

ICTRP (basic search)

Search string	Results
“Active+me”/all studies	0
Aseptika/all studies	0
“Clinitouch Vie”/all studies	0
“Spirit Health” AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	0
“Kaia Health” AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	3
myCOPD/all studies	3
myHealth AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	0
“Rehab Guru” /all studies	1
“Space for COPD” /all studies	9
Wellinks AND “Chronic Obstructive Pulmonary Disease” (condition) /all studies	1
Total	17

CEA Registry

Search string	Results	Searcher
COPD and rehabilitation	9	AL
pulmonary and chronic and rehabilitation	9	AL

ScharrHUD

Digital technologies to deliver pulmonary rehabilitation programmes for adults with COPD [GID-HTE10019]

Search string	Results	Searcher
COPD and rehabilitation	0	AL
pulmonary and chronic and rehabilitation	0	AL

NICE

chronic obstructive pulmonary disease

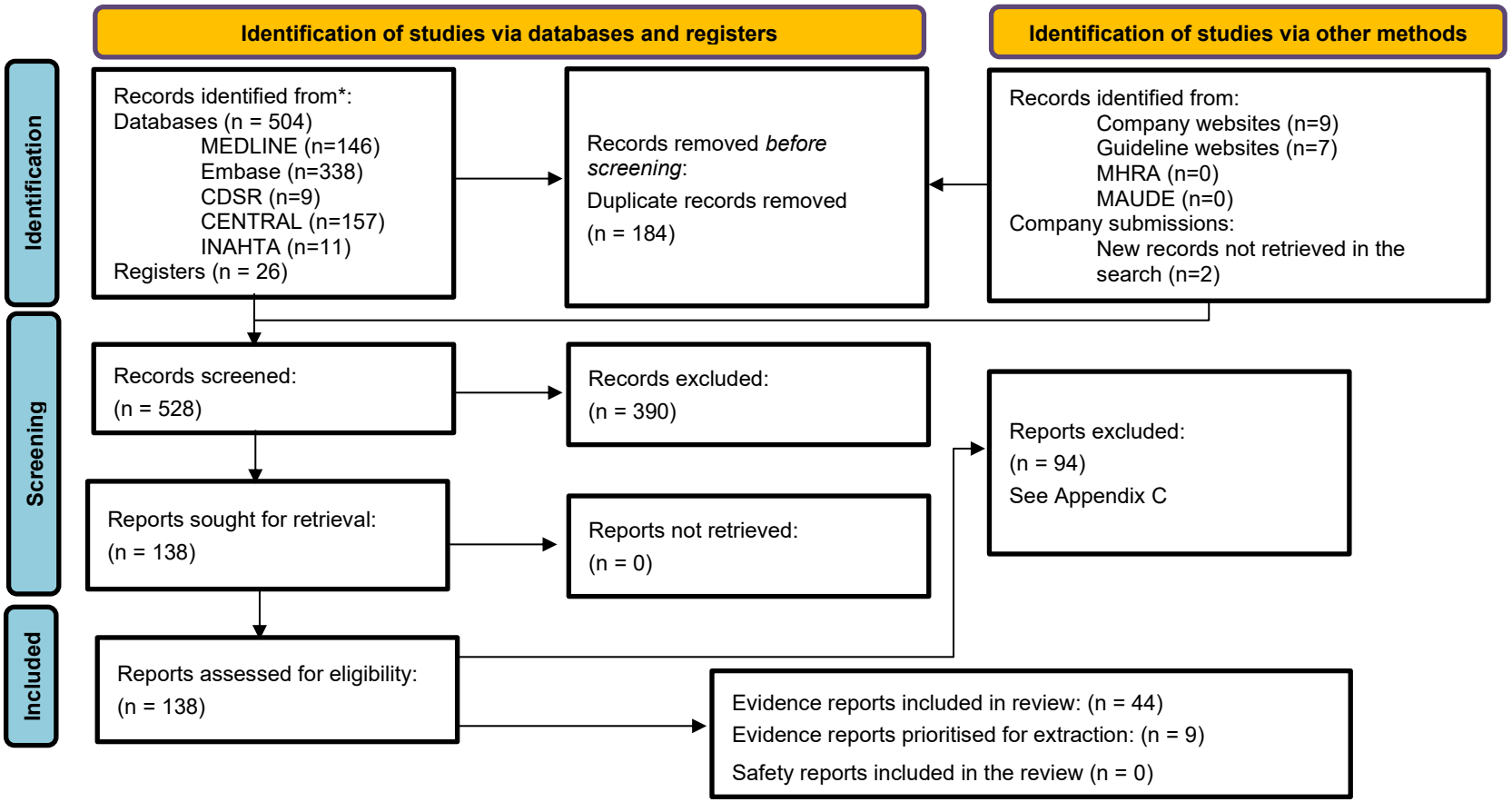
= 162, 7 added to Endnote

SIGN

chronic obstructive pulmonary disease

= **0**

Appendix B: PRISMA flow diagram



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al.. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Appendix C: List of excluded studies

This refers to the exclusion of studies from the full-text screen to reach the list of 44 relevant studies rather than the selection of priority studies. Accordingly, there were 95 excluded publications.

Author	Reason for exclusion
Alqahtani 2021[90]	Study design
Alqahtani 2022[91]	Publication type
Alwashmi[92]	Intervention
Bahadori[93]	Intervention
Barata[94]	Intervention
Barbosa[95]	Publication type
Barnes[96]	Intervention
Bentley[97]	Intervention
Bhatt 2019[98]	Duplicate
Bhatt 2019[98]	Intervention
Bhatt 2022[99]	Intervention
Biset[100]	Intervention
Candy[101]	Intervention
Cerdan-de-las-Heras[102]	Intervention
Chen[103]	Intervention
Chung[104]	Study design
ClinicalTrials.gov [105]	Publication type
ClinicalTrials.gov [106]	Publication type
ClinicalTrials.gov [107]	Publication type
ClinicalTrials.gov [84]	Publication type
ClinicalTrials.gov [108]	Publication type
ClinicalTrials.gov [85]	Publication type
ClinicalTrials.gov [109]	Duplicate
ClinicalTrials.gov [109]	Publication type
ClinicalTrials.gov[110]	Publication type
Cox 2021[111]	Publication type
Cox 2023[112]	Intervention
Davies[59]	Publication type
Demeyer[113]	Intervention

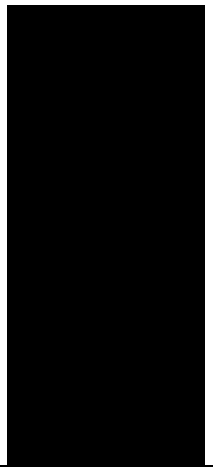
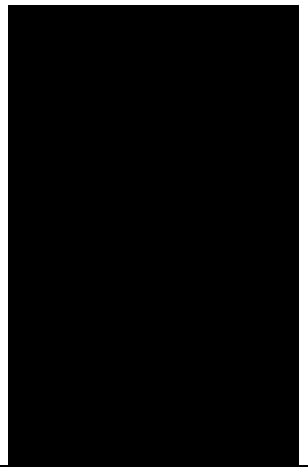
Donner[114]	Publication type
Dos Santos[115]	Intervention
Fekete[116]	Study design
Finkelstein[117]	Intervention
Flynn[118]	Intervention
Frith[17]	Population
Gabriel[119]	Intervention
Galdiz[120]	Intervention
German Clinical Trials Register[83]	Publication type
Ghosh 2016[121]	Study design
Ghosh 2018[122]	Population
Glyde[123]	Outcome
Gotfredson[124]	Intervention
Hoaas[125]	Intervention
Huang[126]	Intervention
Irina[127]	Intervention
ISRCTN[128]	Publication type
ISRCTN[129]	Publication type
ISRCTN[130]	Publication type
ISRCTN[131]	Publication type
ISRCTN[132]	Duplicate
ISRCTN[132]	Publication type
ISRCTN[133]	Publication type
ISRCTN[134]	Duplicate
ISRCTN[134]	Publication type
ISRCTN[135]	Duplicate
ISRCTN[135]	Publication type
ISRCTN[136]	Duplicate
ISRCTN[136]	Publication type
Janjua[137]	Study design
Kiani[138]	Study design
Leal[139]	Intervention
Legaspi[140]	Intervention
Lippi[141]	Study design
Lopez-Lopez[142]	Intervention

Lundell[143]	Study design
Michaelchuk[144]	Study design
Mongiardo[145]	Intervention
Morton-Holtham[146]	Outcome
Nguyen[147]	Intervention
NICE[78]	Duplicate
NICE[78]	Publication type
Park[148]	Intervention
Patil[149]	Intervention
Polgar[150]	Intervention
Raleigh[151]	Population
Robinson 2019[152]	Intervention
Robinson 2020[153]	Intervention
Robinson 2021[154]	Intervention
Saini[155]	Intervention
Santos[156]	Intervention
Slevin[157]	Intervention
Sonnerfors[158]	Intervention
Spielmanns 2021[159]	Publication type
Spielmanns[160]	Duplicate
Spielmanns[160]	Publication type
Threadgold[161]	Intervention
Tsai[162]	Intervention
Vilarinho[163]	Intervention
Vorrink[164]	Intervention
Whittaker[165]	Intervention
Wilcock[166]	Intervention
Williams[167]	Intervention
Winship[168]	Intervention
Wootton[169]	Intervention
Zhang[170]	Study design

Appendix D: Additional study results

Table 29 presents results for clinical effectiveness outcomes. Further details compared to the results presented in the main clinical section are provided where relevant. However, there has been a focus on making the results understandable rather than presenting all minutiae.

Table 29: Study results for clinical effectiveness

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
Active+me REMOTE (number of prioritised studies = 0)						
Clinitouch (number of prioritised studies = 1)						
Staffordshire Report[21] [AIC]						

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	[redacted]	[redacted]	[redacted]			
Kaia Health (number of prioritised studies = 1)						
Spielmanns et al. 2023[8]	**(60-second Sit-to-Stand Test)**	**(CRQ - Total)** No significant difference	**(CAT)** No significant difference between groups at	67 participants randomised (33 to the intervention group and	No significant difference between groups regarding the number of	No significant difference between groups regarding the number of

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	No significant difference between groups at baseline (Intervention group (mean±sd), 19.07±5.77; Control group 16.87±7.07 repetitions; p=0.196). Effect size (95% CI) 0.341 (0.175, 0.853). Significant difference between groups at 3 months (Intervention group (mean±sd), 22.87±8.00;	between groups at baseline (Intervention group (mean±sd), 4.95±1.07; Control group 4.82±0.97 points; p=0.618. Effect size (95% CI) 0.129 (-0.378, 0.636). No significant difference between groups at 3 months (Intervention group (mean±sd), 4.72±1.31; Control group 4.19±1.18 points; p=0.102). Effect size (95% CI)	baseline (Intervention group (mean±sd), 16.53±7.15; Control group 16.00±7.12 points; p=0.773). Effect size (95% CI) 0.075 (-0.432, 0.581). No significant difference between groups at 3 months (Intervention group (mean±sd), 15.53±8.26; Control group 18.70±6.71 points; p=0.109). Effect size (95% CI) -0.421 (-0.931, 0.093). Significant difference between groups at 6 months (Intervention group (mean±sd), 15.13±8.58; Control group 19.72±6.42 points; p=0.024). Effect	34 to the control group). 60 participants included in the analysis (30 in intervention group, 30 in control group). Usage of Kaia app in intervention group [n (%)]: - Total use - activated the app and at least one activity; 29 (97) - training on the app on at least 30 days; 26 (87) - training on the app on at least 60 days; 24 (80) - training on the app on at least 90 days; 20 (67)	adverse events (data not reported).	exacerbations (data not reported). Exacerbation data at baseline: - Exacerbation in the last 12 months [n (%)]: overall, 53 (79.1); intervention group, 29 (87.9); control group, 24 (70.6) - Number of exacerbations treated as outpatient in the past 12 months [mean (SD)]: overall, 1.19 (1.14); intervention group,1.19 (1.33), control group, 1.19 (0.87) - Number of exacerbations treated as inpatient

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	Control group 16.83±7.64 repetitions; p=0.004). Effect size (95% CI) 0.771 (0.243, 1.293). No significant difference between groups at 6 months (Intervention group (mean±sd), 22.66±7.23; Control group 19.45±9.09 repetitions; p=0.143). Effect size (95% CI) 0.390 (0.131, 0.908).	0.429 (0.085, 0.940). No significant difference between groups at 6 months (Intervention group (mean±sd), 4.76±1.30; Control group 4.11±1.26 points; p=0.056). Effect size (95% CI) 0.508 (-0.013, 1.024). **Significant differences between groups at 6 months for dyspnoea points (Intervention group (mean±sd),	size (95% CI) -0.605 (-1.124, 0.080).	- training on the app on at least 120 days; 13 (43) - Sustained use: - an activity in the app in at least 50% of trial weeks; 79% - an activity in the app in at least 75% of trial weeks; 61% - number of active days in the final week of the study; (SD) 3.51 (2.71)		in the past 12 months [mean (SD)]: overall, 1.08 (1.23); intervention group, 1.21 (1.50); control group, 0.91 (0.79). No report on hospital admissions, readmissions, or emergency admissions.

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
		4.54±1.65; Control group 3.69±1.31 points; p=0.033). Effect size (95% CI) 0.570 (0.047, 1.089) and fatigue points (Intervention group (mean±sd), 4.50±1.28; Control group 3.72±1.36 points; p=0.028). Effect size (95% CI) 0.508 (0.586, 1.105).				
myCOPD (number of prioritised studies = 3)						
Bourne et al. 2017[15]	**(6MWT)** No significant difference	**(SGRQ)** No significant difference between groups.	**(CAT)** No significant difference between groups.	90 participants randomised (64 to the Online PR group and 26 to the Face-to-Face PR group).	Online PR: back pain (n=1); muscular skeletal chest pain (n=0); inguinal pain (n=1);	Three participants from the Online PR group withdrew due to exacerbations.

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	between groups. (Baseline: Face-to-Face group (mean±sd), 416.5±118.3; Online group, 388.7±104.4 metres; 7 weeks: Face-to-Face group, 445.1±124.9; Online group, 433.6±102.9). Regression analysis [intention to treat population], adjusted difference (95% CI) 23.8 (-4.5, 52.2); p=0.098.	Baseline: Face-to-Face group (mean±sd), 37.7±17.2; Online group, 42.4±18.6 points; 7 weeks: Face-to-Face group, 39.3±18.5; Online group, 39.3±18.5. Regression analysis [intention to treat population], adjusted difference (95% CI) −3.72 (−10.7, 3.3); p=0.291. Regression analysis [per participant	(Baseline: Face-to-Face group (mean±sd), 17.3±6.7; Online group, 18.1±7.9 points; 7 weeks: Face-to-Face group, 16.2±6.7; Online group, 14.9±7.0). Regression analysis [intention to treat population], adjusted difference (95% CI) −1.0 (−2.9, 0.86); p=0.373 Regression analysis [per participant population], adjusted difference (95% CI) −0.64 (−2.5, 1.2); p=0.569 **(mMRC dyspnoea)** No significant difference between groups.	Online PR: lost to follow-up (n=4); exacerbation (n=3). Face-to-Face PR: lost to follow-up (n=2); exacerbation (n=0); withdrawn (n=3). Online PR attendance: mean 3.9 sessions per participant in week 1; mean 2.5 sessions per participant in week 6. Face-to-Face PR: mean 1.6 sessions per participant in week 1; mean 1.4 sessions per participant in week 6.	common cold (n=1). Face-to-Face PR: back pain (n=1); muscular skeletal chest pain (n=1); inguinal pain (n=0); common cold (n=0).	Data not reported.

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	Regression analysis [per participant population], adjusted difference (95% CI) 15.0 (-13.7, 43.8); p=0.300.	population], adjusted difference (95% CI) −2.5 (−9.3, 4.4); p=0.474.	(Baseline: Face-to-Face group (mean±sd), 2.0 (1.0–2.0); Online group, 2.0 (1.0–3.0); 7 weeks: Face-to-Face group: 1.5 (1.0, 2.0); Online group, 1.0 (1.0, 2.0). Regression analysis [intention to treat population], adjusted difference (95% CI) 0.03 (−0.56, 0.63); p=0.909. Regression analysis [per participant population], adjusted difference (95% CI) 0.04 (−0.54, 0.63); p=0.885.			
Crooks et al. 2020[c13]	**(Steps per day)** Number of steps per day at baseline: myCOPD	**(EQ-5D)** Adjusted mean group difference at 90 days (myCOPD to usual care) -	**(CAT)** Adjusted mean group difference at 90 days (myCOPD to usual care)	60 participants were randomised (n=29 myCOPD; n=31 usual care). Of 29 participants randomised to the	15 adverse events reported by 12 (20%) participants (5 from myCOPD group and 7 from usual care) over the	15 exacerbations were recorded in the 3 months prior to study baseline (12 myCOPD and 3 usual care).

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	group (n=5) (mean±sd), 4948.7±1667.6 steps; usual care group (n=9), 9060±5135.1. Follow-up: myCOPD group (n=4), 5458.3±2266.4 ; usual care group (n=9), 10762±7199.2. Adjusted mean daily step count in the myCOPD group was 2252 steps lower (−10 433.8, 5927.9).	0.04 (95% CI -0.12, 0.05). **(EQ VAS)** Adjusted mean group difference (myCOPD to usual care) 0.86 (-9.46, 11.18).	-1.27 (95% CI -4.47, 1.92); p=0.44 [n=58]. Mean CAT score reduced from 21.5±8.0 at baseline to 19.2±9.0 at 90 days in the myCOPD arm (unadjusted change at 90 days −1.8±5.8, [n=24]). Mean CAT score changed from 19.8±5.4 at baseline to 19.8±7.5 at 90 days in the usual care arm (unadjusted change at 90 days 0.03± 5.5, [n=30]).	myCOPD group, 26 (89.7%) were registered but of those 26, 5 (17.2%) did not activate the app. Of 21 activated users, 18 (86%) were still using the app during the last month of the trial. The app was used (mean±sd) on 44±31.6 days. A total of 87.8±118.7 app activities were recorded. 42.5 were for recording clinical scores and 45.3 for accessing educational videos.	duration of the study. Two participants from usual care reported multiple adverse events. No serious adverse events were reported.	29 exacerbations were recorded during the study (18 myCOPD group and 11 usual care). 3 (10.3%) exacerbation events required emergency department attendance (2 myCOPD and 1 usual care) and 3 (10.3%) required hospitalisation (1 myCOPD and 2 usual care).

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
North et al. 2020[c14]	**(VSAQ)** Baseline (mean±sd): treatment as usual, 1.7±0.8 METS; myCOPD, 2.2±2.6. 90 days: treatment as usual, 2.95±2.43; myCOPD, 2.94±1.54 3-month adjusted between arm difference (95% CI): −0.163 (−1.40, 1.07).	**(SGRQ)** Baseline (mean±sd): treatment as usual, 68.1±13.7 points; myCOPD, 66.4±16.6. 90 days: treatment as usual, 64.1±15.94; myCOPD, 61.9±14.93 3-month adjusted between arm difference (95% CI): −1.48 (−7.82, 4.86).	**(CAT)** Baseline (mean±sd): treatment as usual, 28.0±13.7 points; myCOPD, 26.0±8.5. 90 days: treatment as usual, 25.1±7.24; myCOPD, 20.7±7.35 3-month adjusted between arm difference (95% CI): −2.94 (−6.92, 1.04). **(mMRC dyspnoea scale)** Baseline (mean±sd): treatment as usual, 3.1±1.1 points; myCOPD, 2.9±1.3.	Of the 20 participants randomised to the myCOPD group, 17 (85%) activated the app – all in the first week. Proportion of useds was highest in the first week and lowest in the last week – 8 users (40%). Weekly usage was 4.9 days, which did not significantly change over the course of the study. Highest weekly usage was in week 8; 10 (50%) of users accessed the app 6 out of 7 days.	Treatment as usual (SAEs): respiratory infection other than AECOPD (n=1). myCOPD (AEs): constipation (n=1) myCOPD (SAEs): constipation (n=1), medication side effect (n=1).	**(Number of recorded exacerbations)** Baseline (mean±sd): treatment as usual, 3.2±2.0; myCOPD, 2.9±1.6. 90 days: treatment as usual, 1.88±1.84; myCOPD, 1.06±0.83. 3-month adjusted between arm difference (95% CI): 0.581 (0.315, 1.07). Treatment as usual readmissions (n=7; 33%). myCOPD

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
			90 days: treatment as usual, 2.78±1.11; myCOPD, 2.76±1.35 3-month adjusted between arm difference (95% CI): 0.0183 (−0.759, 0.796).	Lowest weekly usage was in week 6; 11 (55%) of users accessed the app 4.2 out of 7 days. 8 (40%) of users used the app at least once per week throughout the study.		readmissions (n=4; 20%).
Rehab Guru (number of prioritised studies = 1)						
Pilsworth et al. 2021[9]	6MWT: Pre digital PR average 251 metres Post-digital PR average 296 metres Change = +45 metres	Not reported	MRC dyspnoea Pre digital PR average: 4 Post-digital PR average: 3 Change: -1 CRD dyspnoea Pre digital PR average: 2.69 Post-digital PR average:	6–8-week programme completion rates were 81%	Not reported	Not reported

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
			3.37 Change: +0.68			
SPACE for COPD (number of prioritised studies = 2)						
Bourne et al., 2022[10]	**(ESWT)** (mean, 95% CI) 6 months: not significant SPACE: 596.6 (491.1, 702.0) TAU: 467.0 (376.2, 557.7) 9 months: not significant SPACE: 524.4 (417.4, 631.4) TAU: 483.8 (389.3, 578.2) **(ISWT)** (mean, 95% CI) 6 months: not significant	**(EuroQoL)** Data not presented **(CRQ dyspnoea)** (mean, 95% CI) 6 months: not significant SPACE: 3.9 (3.5 to 4.2) TAU: 3.8 (3.5 to 4.2) 9 months: not significant SPACE: 4.0 (3.6 to 4.4) TAU: 3.9 (3.6 to 4.2) **(CRQ fatigue)** (mean, 95% CI)	(**CAT)** (mean, 95% CI) 6 months: p=0.135 SPACE: 16.9 (12.0 to 21.7) TAU: 15.9 (14.4 to 17.4) 9 months: p=0.575 SPACE: 15.8 (12.8 to 18.7) TAU: 14.7 (13.2 to 16.3)	Not reported; however, 6 of 97 dropped out due to inability to attend group sessions, and 2 dropped out as too similar to PR	18 serious adverse events (11 intervention, 7 control); none related to the intervention	Not reported

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	SPACE: 424.9 (380.8, 469.0) TAU: 395.1 (352.8, 437.3) 9 months: not significant SPACE: 401.1 (359.0, 443.1) TAU: 376.3 (335.8, 416.7	6 months: p=0.035 SPACE: 4.8 (4.4 to 5.1) TAU: 4.4 (4.2 to 4.7) 9 months: not significant SPACE: 4.6 (4.3 to 5.0) TAU: 4.5 (4.2 to 4.8) **(CRQ emotion)** (mean, 95% CI) 6 months: not significant SPACE: 5.3 (5.0 to 5.6) TAU: 5.2 (5.0 to 5.5) 9 months: not significant SPACE: 5.3 (5.0 to 5.6)				

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
		TAU: 5.2 (5.0 to 5.5) **(CRQ mastery)** (mean, 95% CI) 6 months: p=0.015 SPACE: 5.9 (5.6 to 6.3) TAU: 5.8 (5.5 to 6.0) 9 months: p=0.011 SPACE: 6.0 (5.7 to 6.3) TAU: 5.8 (5.6 to 6.1)				
Chaplin et al. 2017[12], 2022[11]	**(ESWT)** (mean change±sd) - Web-based: 189±211.1 seconds; usual care:184.5 ±247.4	**(CRQ-D)** (mean change±sd) - Web-based: 0.7 ±1.2 points; usual care: 0.8±1.0	No other statistically significant change.	Over the course of the intervention, 29 participants from the web-based intervention group dropped-out. The average number of weeks to complete	Not reported.	Not reported.

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	P<0.001 for both. Increase in number of steps per day was greater in web-based PR group than the conventional PR group (12% vs 2%), but this was not statistically significant (p=0.2). The pattern of accumulation of physical activity was numerically different between the groups – mainly through 2-minute bouts	P<0.001 for both.		the website was 11±4 with an average number of four logins per week. Participants drop-out at different stages: No WEB introduction completed (n=5); Not registered (n=7); Stage 1 – Introduction to exercising and goal setting, exercise safety quiz, read educational material (n=4); Stage 2 – Introduction of aerobic exercise programme, set walking target, read educational material (n=11); Stage 3 - Introduction of strength training programme, set strength target, continuation of aerobic training and read education material		

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
	of activity in the web-based group and 20-minute bouts in the conventional group, although this difference was not statistically significant (p=0.07).			(n=2); Stage 4 – Maintain strength and aerobic training, review educational material, knowledge quiz (n=0).		
Wellinks (number of prioritised studies = 1)						
Gelbman & Reed 2022[16]	Not reported	Not reported	Participants had an average FEV1% (forced expiratory volume in 1 second as % of predicted for the patient) of 56.2% of predicted (range 23%-113%) and FEV1/forced vital capacity of 65%.	All completed	Not reported	Not reported

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
			COPD severity, as assessed by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) classification, was mild in 2 patients, moderate in 6, and severe/very severe in 11; 9 patients were on home oxygen. During this 8-week study, average use of the spirometer was 2.5 times/week, and the pulse oximeter 4.2 times/week, nebulizer use 1.9 times/week, There was a strong correlation between the FEV1 (r=0.96) and peak flow (r=0.94) measurements recorded by the spirometer compared with the measurements recorded			

Reference	Exercise capacity measured by a validated outcome measure	Health-related quality of life	Other measures of respiratory function	Intervention completion	Intervention-related adverse events	Acute exacerbations, hospital admissions, readmissions or emergency admissions
			by the physician during the office visit closest in time to the at-home collected information			

Table 30: Clinical evidence direction of effect summary table

		Exercise capacity		HRQoL			Respiratory function
Technology	**Study**	**6MWT**	**ESWT**	**EQ-5D-5L**	**CRQ-D**	**SGRQ**	**CAT score**
Active+me REMOTE		–	–	–	–	–	–
Clinitouch	Staffordshire Report[21] [AIC]	[redacted]	[redacted]	[redacted]	–	–	–
Kaia Health	Spielmanns et al., 2023[8]	–	–	–	*Dig: -0.2* *No PR: -0.7*		**Dig: -1.4** *No PR: +3.7*
myCOPD	Bourne et al., 2017[15]	**Dig: +45m** **F2F: +29m**	–	–	–	**Dig: -3.1** *F2F: +1.6*	**Dig: -3.2** **F2F: -1.1**
	Crooks et al., 2020[13]	–	–	**Dig: +0.04** *UC: 0.00*	–	–	**Dig: -2.3** *UC: 0*
	North et al., 2020[14]	–	–	–	–	**Dig: -4.5** **UC: -4**	**Dig: -5.3** **UC: -2.9**
Rehab Guru	Pilsworth et al. 2021[9]	**Dig: +45m** (no control)	–	–	–	–	–
SPACE for COPD	Bourne et al., 2022[10]	–	*Dig: -72m* **UC +16m**	–	**Dig: +0.1** **UC: +0.1**	–	**Dig: -1.1** **UC: -1.2**
	Chaplin et al., 2017[12]; Chaplin et al., 2022[11]	–	**Dig: +189** **UC: +184**	–	**Dig: +0.7** **UC: +0.8**	–	–
Wellinks	Gelbman & Reed, 2022[16]	–	–	–	–	–	–

Abbreviations and key: **bold** = clinical improvement, *italicised* = no improvement or clinical worsening, green = MCID reached, Dig = digitally supported pulmonary rehabilitation, F2F = face-to-face, UC = usual care

Appendix E: Additional trial control arm-based results (CEA)

Table 31-Table 33, presents the cost per outcome results for the digital technologies when trial control arm data have been used for F2F PR.

When using the trial control arm data for face-to-face pulmonary rehabilitation, the incremental effects of digital technologies ranged from:

- -20.7 to +16.3 in terms of difference in walking distance from baseline
- -0.387 to +0.302 in terms of difference in MCID units
- -15% to +5% in terms of difference in percentage change in walking distance

Table 31. Cost per change in walking distance (m) – F2F PR as per trial control arm

	Costs (per annum per participant)	Effect (Change in walking distance, m)	Digital vs F2F PR		
			Incremental costs	Incremental effect	Cost per ΔWD(m)
Clinitouch	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F2F PR	£272.83	[redacted]	-	-	-
myCOPD	[redacted]	44.90	[redacted]	16.31	[redacted]
F2F PR	£294.25	28.60	-	-	-
SPACE for COPD	£213.29	45.00	-£218	-18.38	£12
F2F PR	£275.26	63.38	-	-	-
Rehab guru	£176.50	45.00	-£255	-14.01	£18
F2F PR	£431.55	59.01	-	-	-

Abbreviations: F2F = Face-to-face; MCID = minimal clinically important difference; PR = Pulmonary rehabilitation; WD = walking distance in metres

MCID reached MCID not reached

Table 32. Cost per unit change in MCID* – F2F PR as per trial control arm

	Costs (per annum per participant)	Effect (change in MCID units)	Digital vs F2F PR		
			Incremental costs	Incremental effect	Cost per unit ΔMCID
Clinitouch	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F2F PR	£272.83	[redacted]	-	-	-
myCOPD	[redacted]	0.831	[redacted]	0.302	[redacted]
F2F PR	£294.25	0.530	-	-	-
SPACE for COPD	£213.29	0.947	-£218	-0.387	£564
F2F PR	£275.26	1.334	-	-	-
Rehab guru	£176.50	0.833	-£255	-0.259	£983
F2F PR	£431.55	1.093		-	-

Abbreviations: F2F = Face-to-face; MCID = minimal clinically important difference; PR = Pulmonary rehabilitation; WD = walking distance in metres: *1 MCID for 6MWD = 54m and ISWD = 48 m.

Table 33. Cost per % change in walking distance – F2F PR as per trial control arm

	Costs (per annum per participant)	Effect (% change in walking distance)	Digital vs F2F PR		
			Incremental costs	Incremental effect	Cost per % ΔWD
Clinitouch	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F2F PR	£272.83	[redacted]	-	-	-
myCOPD	[redacted]	12%	[redacted]	5%	[redacted]
F2F PR	£294.25	7%	-	-	-

	Costs (per annum per participant)	Effect (% change in walking distance)	Digital vs F2F PR			
			Incremental costs	Incremental effect	Cost per % ΔWD	
SPACE for COPD	£213.29	15%	-£218	-15%	£1,416	
F2F PR	£275.26	31%	-	-	-	
Rehab guru	£176.50	18%	-£255	-4%	£5,902	
F2F PR	£431.55	22%	-	-	-	

Abbreviations: F2F = Face-to-face; MCID = minimal clinically important difference; PR = Pulmonary rehabilitation; WD = walking distance in meters