Effectiveness of home-based pulmonary rehabilitation

Effectiveness of home-based pulmonary rehabilitation: systematic review and meta-analysis

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ABSTRACT

Introduction: Despite proven effectiveness for people with chronic respiratory diseases, practical barriers to attending Centre-based pulmonary rehabilitation (PR) limit accessibility. We aimed to review the clinical effectiveness, components and completion rates of Home-PR compared to Centre-PR or Usual Care.

Methods and analysis: Using Cochrane methodology, we searched (Jan-1990 to Aug-2021) six electronic databases using a PICOS search strategy, assessed Cochrane risk-of bias, performed meta-analysis and narrative synthesis to answer our objectives and used GRADE to rate certainty of evidence.

Results: We identified 16 studies (1800 COPD patients; 11 countries). The effects of Home-PR on exercise capacity and/or health-related quality of life (HRQoL) were compared to either Centre-PR (n=7) or Usual Care (n=8); one study used both comparators. Compared to Usual Care, Home-PR significantly improved exercise capacity (SMD 0.88; 95%CI 0.32 to 1.44; p=0.002) and HRQoL (SMD -0.62; 95%CI -0.88 to -0.36; p<0.001). Compared to Centre-PR, Home-PR showed no significant difference in exercise capacity (SMD -0.10; 95%CI -0.25. to 0.05; p=0.21) or HRQoL (SMD 0.01; 95%CI -0.15 to 0.17; p=0.87).

Conclusion: Home-PR is as effective as Centre-PR in improving functional exercise capacity and quality of life compared to Usual Care, and is an option to enable access to PR.

PROSPERO registration number: CRD42020220137

Key words: Chronic Respiratory Diseases, Chronic Obstructive Pulmonary Disease, Pulmonary Rehabilitation, Home-Pulmonary Rehabilitation

Take home message

Home-based pulmonary rehabilitation is as effective as centre-based in improving exercise capacity and quality of life, and is an option for people with chronic obstructive pulmonary disease whose access to pulmonary rehabilitation centres is difficult.

INTRODUCTION

An estimated 545 million people globally are affected by chronic respiratory diseases (CRDs) such as chronic obstructive pulmonary disease (COPD), remodelled asthma, pulmonary impairment after tuberculosis (PIAT), interstitial lung disease (ILD), bronchiectasis and cystic fibrosis (CF) [1]. CRDs are associated with breathlessness, fatigue, and muscle dysfunction which contribute to reduced physical activity levels and functional exercise capacity [2], and impaired health-related quality-of-life (HRQoL) [3, 4].

Pulmonary rehabilitation (PR) is an individually-tailored multifaceted intervention that improves the physical condition and psychological well-being of people with CRDs [5-7]. Despite proven effectiveness [8, 9], and guideline recommendations [10, 11], PR is under-utilised. The reasons for poor attendance and completion rates are multifactorial but inconvenient timing of the programmes and geographical distance to PR centres are commonly identified barriers [12-16]. Whilst pertinent even in high income countries [17-19] poor transport infrastructure in low- and middle-income countries (LMICs) exacerbates these barriers [20]. Typically PR is provided in hospital centres (Centre-PR) [21], but community-based centres [22], Home-PR with telephone-mentoring [23], or tele-rehabilitation programmes [24], are attracting increasing interest. The ongoing coronavirus disease (COVID-19) pandemic has necessitated remote delivery of the treatment for reasons of infection control [25].

Evidence of the effectiveness of these options varies. A sub-group analysis in a Cochrane review favoured Centre-PR [8], whilst three systematic reviews concluded that home/community-PR could be as effective as Centre-PR for people with COPD [26-29]. Combining home and community services, however, overlooks the distinction between a community-based group supervised in-person by a healthcare professional and a programme delivered to an individual in their own home. These reviews are also limited by disease (COPD only), although there is evidence that PR is of benefit in bronchiectasis and ILD [30-32]. More recently a Cochrane review concluded that telerehabilitation for people with CRDs, achieved similar effectiveness and safety outcomes to Centre-PR [33]. 'Telerehabilitation', defines the intervention by the means of communication and the review included PR delivered to individuals or groups (either physical or virtual) in any location, including in the patient's home or at a healthcare centre. In contrast, we defined Home-PR as sessions undertaken by individuals by themselves (though a family member may be involved) and typically at home. Apart from baseline and post-PR assessments [32], the patient does not attend a centre (either a hospital centre or a local 'satellite' community centre) and is not supervised face-to-face by a healthcare

professional (though there may be remote communication from a healthcare professional for some or all of the sessions), is not part of an 'in-person' group. In addition, to distinguish from 'exercise training programmes' included in some reviews [26, 27, 32, 33], our definition of PR comprised both exercise and at least one non-exercise component.

We aimed to systematically review the literature to assess the effectiveness, completion rates and components used in effective Home-PR for people with CRDs. Our hypotheses were a) Home-PR was superior to Usual Care, and b) Home-PR was non-inferior to Centre-PR. In people with CRDs, our objectives were to:

1. Assess the clinical effectiveness of Home-PR compared to Centre-PR or Usual Care at improving health outcomes (i.e., exercise capacity [primary outcome], HRQoL [primary outcome], dyspnoea, muscle fatigue, exacerbations, and hospitalisations for CRD)
2. Describe the components of Home-PR that are associated with successful interventions (e.g., intensity of exercise, duration of the programme, education and/or other non-exercise components, frequency of supervision, information/resources, involvement of family members)
3. Compare the completion rate (defined as participating in at least 70% of PR sessions) of Home-PR with Centre-PR

METHODS

We followed Cochrane methodology [34], and used PRISMA guidelines [35] to report our review findings. The review is registered with PROSPERO [CRD42020220137] and the protocol is published [36].

Search strategy

We developed a search strategy to identify randomised controlled trials (RCTs) and controlled clinical trials (CCTs) of Chronic Respiratory Disease AND Pulmonary Rehabilitation AND Home-PR from 1990 (when PR was first recommended by global COPD guidelines [37]) to 12th October 2020, without any language restrictions. We also checked reference lists and conducted forward citation on included studies and on Cochrane reviews of PR [8]. We searched MEDLINE, CINAHL, Cochrane, EMBASE, PeDRO, and PsycInfo (see appendix 1 in the supplementary file). Table 1 describes the PICOS search strategy and our definition of Home-PR and Centre-PR. A pre-publication update was conducted in August 2021 using forward citation of the Cochrane review [8] and all the studies included in this review [38].

Selection process

Following the search, all identified records were loaded into EndNote X9 (Clarivate Analytics, PA, USA) and duplicates were removed. Six trained reviewers (MNU, TJ, JPE, FT, DA, PJ) worked in pairs to independently screen titles and abstracts, followed by full text papers using the inclusion and exclusion criteria, defined by our operational rules (see Table 1). Disagreements were resolved by discussion with the review team (HP, RR, SML, MH, NSH and SC) as necessary. The process is reported in a PRISMA flow diagram (see Figure 1).

Outcome measurement

Our primary outcomes were functional exercise capacity and HRQoL:

- Functional exercise capacity measured with any validated tools such as 6-Minute Walk Test (6MWT) [39], Incremental Shuttle Walking Test (ISWT) [40], or Endurance Shuttle Walking Test (ESWT) [41]
- HRQoL measured with any validated tools such as the St Georges Respiratory Questionnaire (SGRQ) [42], Chronic Respiratory Questionnaire (CRQ) [43], COPD Assessment Test (CAT) [42], Short Form (SF-36 or SF-12)

We were interested in between-group differences at the post-PR assessment (or first follow-up assessment if post-PR assessment was not reported). Where multiple assessment tools for an outcome (exercise capacity or HRQoL) were reported, we used the most frequently reported measure (e.g., 6MWT; SGRQ) in the meta-analysis.

Data extraction and risk of bias assessment

Data extraction was carried out by six reviewers (MNU, TJ, JPE, FTM, DA, PJ) independently working in pairs and checked by a third review author (RR/HP). Data were extracted using a data extraction form in Microsoft Excel spreadsheet and based on Cochrane EPOC guidance [44]. The following data were extracted from included studies:

- Methods: study location, study design, duration of the intervention, duration of each PR session, mode of supervision, follow-up period (if any)
- Participant characteristics: number, mean age, gender, diagnosis, severity of the condition
- Interventions: intervention, comparison
- Outcomes: primary and secondary outcomes specified and collected (at baseline and at the time of intervention completion) and follow-up measures at any other time point reported.

One review author (MNU) transferred data into the Review Manager software (RevMan 2020, version 5.4.1) for conducting meta-analysis and another review author (RR) checked data accuracy. The six

reviewers (MNU, TJ, JPE, FTM, DA, PJ) also independently assessed methodological quality of all included studies using the 'Cochrane Risk of Bias' tool for RCTs [45]. Discrepancies were resolved by discussion within the team. We assessed the risk of bias in the following domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, other sources of bias, and overall risk of bias. We assessed each potential source of bias as high, low or unclear and summarised the 'Risk of Bias' judgements across different studies for each of the domains in a 'Risk of Bias' table. We contacted the author(s) of included studies to obtain any incomplete or missing data but did not perform any statistical calculation for missing data to include in the meta-analysis.

Heterogeneity and reporting bias

We assessed heterogeneity [46], and explored clinical and methodological reasons for substantial heterogeneity (I^2 statistic >50%) in our primary outcome as defined in our *a priori* sub-groups [34], and a sensitivity analyses for the effect of risk of bias. We were not able to pool more than 10 studies and therefore did not create a funnel plot to test for publication bias [47].

Sub-groups and sensitivity analyses

Our *a priori* sub-groups were high/low income countries; CRD diagnosis, severity, intensity of intervention and arrangements for supervision of the Home-PR programme [36]. We undertook a sensitivity analysis of our primary outcomes for the Home-PR vs Centre-PR comparison excluding studies at high risk of bias (there were too few studies for a sensitivity analysis of the Home-PR vs Usual Care analysis).

Data analysis to answer the three objectives

1. Effectiveness of Home-PR: We performed meta-analysis using Review Manager Software (RevMan 2020, version 5.4.1) for the primary and secondary outcomes, comparing Home-PR with a) Centre-PR or b) Usual Care. For continuous data, we calculated the mean difference (MD) (for same scale metric) or standardised mean difference (SMD) (for different scale metrics) with 95% CIs. We used an inverse variance method, and chose random-effects model to account for between-study heterogeneity in the meta-analysis. At least two studies were needed to perform a meta-analysis and measure the effect size. We used pooled mean differences if the same measurement tool was used in the included RCTs, or if the measurement tool varied among trials, we used standardised mean differences (SMDs) for our primary analysis, but reported pooled mean differences for the most commonly used outcome as a sensitivity analysis. A p-value <0.05 was considered

statistically significant for the overall effect For comparison of Home-PR and Centre-PR, if sufficient studies used the same measure for functional exercise capacity or HRQoL, we defined the non-inferiority margin as the minimum clinically important difference (MCID) (e.g., 30 metres for the 6MWT).

2. Components of Home-PR: We identified the components described in internationally recognised guidelines for PR [5, 7, 11, 48] and constructed a matrix comparing components used in the included trials reporting effective interventions vs those reporting no effect.
3. Uptake, adherence, and completion: We used a narrative approach to synthesise reported uptake, engagement, completion and attrition in Home-PR and Centre-PR groups using the following definitions:
    - Uptake: Number of patients who attended the initial/baseline assessment and at least one PR session.
    - Engagement: The proportion of PR sessions attended. This reflects the 'dose' of the intervention received and may be reported as the number of patients who attended a pre-defined proportion of PR sessions (e.g., 70% of sessions).
    - Completion: The number of patients who attended the PR discharge assessment and are regarded as having 'completed' the PR programme (regardless of the proportion of sessions attended)
    - Trial attrition: The number of people who failed to attend for their post-PR follow-up data collection in a trial. Trials of longer duration may have several follow up (FU) assessments and thus several time points for recording attrition.

Assessment of the certainty of evidence

To assess the quality of evidence of included studies, we used the five GRADE considerations (study design, risk of bias, inconsistency, imprecision, and indirectness) for the primary outcomes. Using GRADEpro GDT software [49], we followed the techniques and guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions [50]. We provide footnotes to explain any decisions to downgrade the quality of evidence.

RESULTS

Study selection

We identified a total of 6185 records from six databases (see Figure 1) and found 1133 records from forward citation. After removing duplicates, a total of 5857 titles and abstracts were screened, and 78 full text articles were considered for inclusion by the pairs of reviewers. All disagreements and

decisions were discussed within the multidisciplinary team and 62 articles were excluded (see Supplementary Table S1). We thus included 16 articles in our review [51-66]. No additional papers were added from the pre-publication update.

Characteristics of included studies

Of the 16 included studies, 15 were individually randomised trials, and one was a cluster randomised implementation trial [60]. The latter, whilst relevant to our inclusion criteria, had very different trial design informing the challenge of implementing Home-PR within routine COPD care, rather than providing evidence of effectiveness and we therefore did not include it in the meta-analysis. Eight studies compared Home-PR vs Usual Care [51, 54, 59, 60, 62, 64-66] and seven studies compared Home-PR vs Centre-PR [52, 55-58, 61, 63]. One study compared Home-PR against two different comparators (Centre-PR and Usual Care) and is therefore included in both analyses [53] (See supplementary Table S2 for key characteristics of included studies, main findings and interpretation).

The trials were conducted in Australia (n=3) [51, 57, 60], Brazil (n=2) [53, 64], Spain (n=2) [55, 66], UK (n=2) [58, 59], Canada (n=1) [61], China (n=1) [52], Denmark (n=1) [56], Egypt (n=1) [54], India (n=1) [65], Iran (n=1) [62], and Turkey (n=1) [63]. Of these, nine were from high-income countries [51, 55-61, 66], four from upper-middle income countries [52, 53, 63, 64] and three from lower-middle income countries [54, 62, 65].

All studies were in people with COPD. In total, 1800 people with a range of severity were recruited to the included trials (range 39 to 314 participants). Of the 1733 participants with reported baseline demographic data, 1048 (62%) were male and the mean age ranged from 56 to 79 years.

All PR programmes included either aerobic and/or resistance exercises (aerobic (n=15) [51, 53-66], resistance (n=13) [51-61, 63, 64], both (n=12) [51, 53-61, 63, 64]). Stretching exercises were included in two trials [53, 64] and inspiratory muscle training in one trial [54]. All studies except one [58] had 24 or more exercise sessions; five trials had more than 48 sessions of exercise [51, 54, 57, 59, 65]. All but two [56, 63] of the Home-PR programmes included face-to-face training sessions either as inpatients [54, 62], out-patients [52, 53, 55, 58, 59, 61, 64-66], or home visits [51, 57, 60]. Most of the programmes described some form of supervision of the home-based sessions, most commonly telephone calls [53, 57-60, 62, 64, 66] though one used videoconferencing [56] and one study in housebound individuals provided repeated home visits. Other strategies included provision of a

manual or written information [52, 58, 59, 62, 63] activity diaries [51, 53, 56, 57, 61, 63, 64, 66], pedometers [55, 57, 66], and heart rate monitors [53].

Risk of Bias assessment

Only three studies were at overall low risk of bias (RoB) [56-58]. Two were at unclear/moderate RoB [59, 61] and 11 were at high RoB [51-55, 60, 62-66] (see supplementary Figure S1). Blinding of participants and personnel is impossible due to the nature of the intervention, but only six studies ensured outcome assessors were blind to allocation [55-59, 61]. Computer-generated randomisation sequence was used in 10 studies [52, 53, 56-62] and allocation concealment was described in seven [51, 55-59, 61], the remaining studies did not provide sufficient information on randomisation [54, 63-66]. We were able to compare reported outcomes with published protocols or trial registrations for six studies [52, 53, 56-58, 60], all of which were judged at low risk of selective reporting bias. Without a protocol for comparison, the remaining studies were designated as unclear risk of bias [51, 54, 55, 59, 61-66].

Effectiveness of Home-PR (Objective 1)

Primary outcomes

1. Functional exercise capacity

a) Home-PR vs Usual Care

Out of eight trials that compared Home-PR with Usual Care, seven assessed at least one measure of functional exercise capacity [51, 53, 54, 59, 64-66]. Of these, five trials used the 6MWT [51, 53, 54, 64, 65], one trial used both ISWT and ESWT [59], and one trial used ESWT [66]. In one [53] of the seven studies, data were presented in a format that could not be retrieved for meta-analysis. We thus included six trials [51, 54, 59, 64-66] in the meta-analysis (Figure 2). The pooled estimate showed a statistically significant increase in exercise capacity in Home-PR compared with Usual Care (SMD 0.88; 95% CI 0.32 to 1.44; p=0.002). The only study not at high risk-of-bias, showed no significant between group differences [59].

In a sub-group meta-analysis of four RCTs [51, 54, 64, 65] with available data on 6MWT (see Figure S2 in the supplementary file), the pooled estimate showed a statistically significant increase in the mean difference in distance walked in Home-PR compared with Usual Care, (MD 61.58 m; 95% CI 45.88 to 77.29; p<0.01). Both the mean difference and the lower limit of the confidence interval exceeded the MCID for the 6MWD of 30 metres [67] indicating a clinically significant effect of Home-PR.

b) Home-PR vs Centre-PR

All the eight trials comparing Home-PR with Centre-PR assessed at least one measure of functional exercise capacity [52, 53, 55-58, 61, 63]. Of these, seven trials used the 6MWT [52, 53, 55-57, 61, 63], one trial used both ISWT and ESWT [58], and one trial used both cycle endurance test (CET) and 6MWT [61]. We included all eight trials [52, 53, 55-58, 61, 63] in the meta-analysis (Figure 2). The pooled estimate showed no statistically significant difference in exercise capacity between Home-PR and Centre-PR, (SMD -0.10; 95% CI -0.25 to 0.05; p=0.21). A sensitivity analysis including only the four studies at low/moderate risk-of-bias [56-58, 61] did not change the conclusion (SMD -0.02; 95% CI -0.18 to 0.15; I^2=28%; p=0.85) (see Figure S3 in the supplementary file).

In the meta-analysis of the seven RCTs [52, 53, 55-57, 61, 63] that used 6MWT (see Figure S4 in the supplementary file), the pooled estimates showed no statistically significant difference in the mean difference in distance walked in Home-PR compared with Centre-PR, (MD -6.26m; 95% CI -18.55 to 6.02; p=0.32). This is within the non-inferiority margin of 30 metres for the 6MWT indicating the clinical effect of Home-PR is not inferior to Centre-PR for people with COPD.

2. Health-related quality of life

a) Home-PR vs Usual Care

All the eight trials comparing Home-PR with Usual Care assessed at least one measure of HRQoL [51, 54, 59, 60, 62, 64-66]. Of these, four trials used the SGRQ [51, 60, 64, 66], two trials used CRQ [59, 65], one trial used both SGRQ and CAT score [60], one trial used SF-36 [54] and one trial used SF-12 [62]. We excluded the cluster RCT [60] from the meta-analysis because it informed implementation (as opposed to effectiveness) of Home-PR in routine primary care management of COPD and was thus not comparable with the other trials. We thus included seven trials [51, 54, 59, 62, 64-66] in the meta-analysis (Figure 2) and the pooled estimate (SGRQ-total, CRQ-mastery, SF 36-physical, SF12) showed statistically significant improvement in HRQoL in the Home-PR group compared with Usual Care, (SMD -0.62; 95% CI -0.88 to -0.36; p<0.01). The only study not at high risk-of-bias, showed no significant between group differences [59].

Meta-analysis of the three RCTs that used SGRQ [51, 64, 66] (see Figure S5 in the supplementary file) showed a statistically significant improvement that exceeded the MCID of 4.0 in all the domains except the 'Impact' domain. The effect on overall SGRQ in the Home-PR group compared with Usual Care showed a MD -5.66; 95% CI -7.94 to -3.39; p<0.01 that exceeded the MCID.

Meta-analysis of the two RCTs [59, 65] that used CRQ (see Figure S6 in the supplementary file) showed a statistically significant improvement (p=0.010) that exceeded the MCID of 0.5 in all the domains (dyspnoea, emotion, fatigue, mastery).

b) Home-PR vs Centre-PR

All seven trials comparing Home-PR with Centre-PR assessed at least one measure of HRQoL [52, 55-58, 61, 63]. Of these, four trials used the CRQ [55, 57, 58, 61] and three trials used CAT score [52, 56, 63]. We included all seven trials [52, 55-58, 61, 63] in the meta-analysis (Figure 2) and the pooled estimate (CRQ-mastery, CAT score) showed no statistically significant difference in the HRQoL in Home-PR compared with Centre-PR, SMD 0.01; 95% CI -0.15 to 0.17; p=0.87. A sensitivity analysis including only the four studies at low/moderate risk-of-bias [56-58, 61] did not change the conclusion (SMD -0.00; 95% CI -0.16 to 0.17; I^2=30%; p=0.98) (see Figure S7 in the supplementary file).

Meta-analysis of the four RCTs [55, 57, 58, 61] that used CRQ (see Figure S8 in the supplementary file) showed no statistically significant between-group differences (p=0.21) in any of the domains of CRQ (dyspnoea, emotion, fatigue, mastery).

Meta-analysis of the three RCTs [52, 56, 63] that used the CAT score (see Figure S9 in the supplementary file) favoured Home-PR compared with Centre-PR, MD -1.53; 95% CI -2.81 to -0.24; p=0.02.

Secondary outcomes

1. Dyspnoea

a) Home-PR vs Usual Care

Two trials [60, 66] assessed dyspnoea using mMRC and compared Home-PR with Usual Care. The implementation cluster RCT [60] concluded that mMRC grades were not significantly different between groups. The other RCT also showed no statistically significant changes (p=0.22) in dyspnoea level associated with Home-PR compared to Usual Care [66].

b) Home-PR vs Centre-PR

Two trials [57, 63] assessed dyspnoea using mMRC and compared Home-PR vs Centre-PR. Meta-analysis showed no statistically significant changes between the groups in dyspnoea level (see Figure S10 in the supplementary file) between Home-PR and Centre-PR, MD -0.12; 95% CI -0.44 to 0.21; p=0.48.

2. Anxiety and depression

a) Home-PR vs Usual Care

One trial [60] measured anxiety and depression using HADS and compared the effect between Home-PR and Usual Care. There was no statistically significant between group difference in either anxiety (p = 1.00) or depression (p = 0.09).

b) Home-PR vs Centre-PR

Two trials [56, 58] measured anxiety and depression using HADS and compared the effects between Home-PR and Centre-PR. Meta-analysis showed no statistically significant between group difference in anxiety or depression (see Figure S11 and Figure S12 in the supplementary file) (Anxiety: MD -0.33; 95% CI -1.81 to 1.15; p=0.66; Depression: MD -0.03; 95% CI -1.28 to 1.22; p=0.97).

Association of components of Home-PR with effective interventions (Objective 2)

Table 2 is a matrix of components of Home-PR mapped to effectiveness:

There were no obvious differences in the components of the Home-PR between effective and ineffective studies or in the number of components included, supervision provided or duration of the course.

Uptake, engagement, completion, and trial attrition (Objective 3)

Table 3 shows details of recruitment, uptake, engagement, completion of PR sessions and trial attrition.

Screening and eligibility for the trials

Nine studies [52, 53, 56-62] provided details of the eligibility screening process, reporting recruitment rates between 12% and 56%. Five trials cited the presence of co-morbidity as a reason for excluding between 3% and 14% of screened participants [52, 56-59]. Three studies reported about one in five (22.8%, 18.3%, and 12.0% [56-58]) potentially eligible patients declined to participate because of a strong preference for Centre-PR. In contrast, one trial comparing Home-PR vs Centre-PR excluded 55% because they definitely wanted Home-PR [56]. Distance/travel was cited as a reason for non-participation in two trials [52, 61].

Uptake of PR

The implementation cluster RCT reported an uptake of 66% amongst the 107 patients referred by their GP [60]. Two trials reported that two patients did not attend any PR sessions [51, 66].

Engagement with the programme

Only four studies defined 'engagement' as a pre-determined proportion of PR sessions attended [56, 57, 60, 61]. Using the widely cited 70% threshold [68], Holland 2016 showed that engagement with Home-PR was nearly twice that of Centre-PR (91% vs 49%: RR of non-engagement in Centre-PR: 1.91 (95% CI 1.52 to 2.41). In contrast, two studies [56, 61] showed no between-group difference, although the latter used a lower threshold (≥60%) and reported that >90% of the participants in both groups achieved this threshold. The implementation cluster RCT reported 46% engaged with ≥70% of the PR programme.

Completion of post-PR assessment and trial attrition

In the trial context, completion of the post-PR assessment was generally reported as attrition (i.e., loss to trial follow-up). Rates of attrition at the post-PR follow-up assessment ranged from 0% to 51%, but with no consistent pattern to suggest that mode of delivery affected follow-up.

Quality of evidence

Using GRADE, we judged primary outcomes (functional exercise capacity and HRQoL) of the review to provide low-certainty evidence when Home-PR was compared with Centre-PR and very low-certainty evidence when Home-PR was compared with Usual Care. Downgrading for risk of bias was influenced by performance bias and some concerns in some or most of the domains of included studies. We additionally downgraded for imprecision because of use of SMD to assess the effect and/or small sample size, and for inconsistency due to heterogeneity in Home-PR when compared with Usual Care (see supplementary Table S3).

DISCUSSION

Summary of findings

Our systematic review identified 16 studies involving a total of 1800 COPD patients from 11 different countries. The effects of Home-PR on exercise capacity and/or HRQoL in people with COPD were compared to either Centre-PR (n=7) or Usual Care (n=8). One study had both comparators [53]. Overall, statistically significant improvement was found in functional exercise capacity and HRQoL in Home-PR group when compared with Usual Care, but no statistically significant differences were found in exercise capacity and HRQoL between Home-PR and Centre-PR group. All studies that compared Home-PR with Usual Care were at high RoB except one which was at moderate RoB [59]. On the other hand, among the studies that compared Home-PR with Centre-PR, three were at low

RoB, one at moderate RoB, four at high RoB. No distinguishable patterns were found in exercise components, supervision and monitoring among the three trials [54, 64, 66] that had statistically significant between-group differences and exceeded minimal clinically important differences (MCID) for both the primary outcomes when compared to other included studies. Rates of attrition at the post-PR follow-up assessment ranged from 0% to 51%, but with no consistent pattern to suggest that mode of delivery affected follow-up.

Strength and limitations

A strength of this systematic review is its comprehensive literature search constructed with the help of an expert librarian. We were open to including non-English language papers. We employed a rigorous methodology following a written protocol that has been published [36]. Although, we searched for a wide range of CRDs, the included trials only recruited people with COPD, so the findings are not generalisable to people with other CRDs. We used generic terms for CRDs and named some of the commonest diseases, but our search might have missed some studies as all disease names were not explicitly included in the search strategy. Although we had low (Home-PR vs Centre-PR) or very low (Home-PR vs Usual Care) confidence in our GRADE assessment for primary outcomes, this was influenced by multiple outcomes measures which we presented as an SMD in our meta-analysis. This emphasises the importance of agreed standardised outcomes for trials [69].

Six reviewers worked independently in pairs (as in the traditional model) and ensured that all titles and abstracts were duplicate screened, and disagreements resolved in discussion involving the whole team as necessary. Involvement of six reviewers allowed us to complete the review in a timely manner and without over-burdening any individual. The main limitation is the potential for inconsistency, so before starting screening, 100 articles were selected randomly from the total records by the study librarian and given to each pair to screen as a training exercise. Decisions were discussed within the study team and operational rules clarified and agreed.

Interpretation in the light of published literature

Effectiveness of Home-PR

Our findings show that Home-PR can be a clinically effective alternative to Centre-PR for people with COPD in different settings [8, 27, 70] with the findings that both the mean difference and the lower limit of the confidence interval exceeded the MCID for the 6MWD [67] indicating a clinically significant effect in improving exercise capacity. This extends the findings of the recently published Cochrane review that assessed the effect of telerehabilitation (either delivered in local community centres or at

home) in two ways [33]. Firstly, the home-based programme remained effective despite the lack of the face-to-face group support available in a traditional centre-based PR. This is of particular value in the context of a pandemic when infection control is an important consideration and may preclude group settings. Secondly, most of the telerehabilitation interventions in the Cochrane review [33] used video-conferencing or web-based systems to create virtual groups whereas in our home-based studies over half relied on individual telephone calls, and only one study provided a group-based structured PR programme via video-conferencing [56]. This extends the findings to LMIC countries – and indeed some rural areas of high-income countries - with limited access to reliable internet connections. In addition to improving functional exercise capacity and HRQoL, meta-analysis of secondary outcomes showed that Home-PR improved dyspnoea, anxiety, and depression. These findings hint that Home-PR may reduce stress associated with accessing and participating in Centre-PR [13], as well as helping to develop confidence in the ability to exercise unsupervised [71].

Components of Home-PR

Less than 2% of all patients with COPD globally can be served by the existing Centre-PR programmes [72], and increasing access to and benefit from remote PR remains a significant clinical and research priority [73]. To do this with confidence, providers of PR services will want to know which components they should include and how to adapt them to Home-PR. Although our review did not provide consistent evidence of which components or models of care were associated with effective interventions, others have reported that the intensity of supervision and monitoring increase chances of success in comparison to unsupervised programmes [74, 75]. Most of the interventions in our included studies provided between 24 and 28 home-based sessions with a broad range of arrangements for supervision, but no one approach was associated with effective interventions.

Uptake, engagement, completion, and trial attrition

The terms uptake, engagement and completion are often used interchangeably without clear definition. Data are rarely reported in full; a recent systematic review only identified one trial with comprehensive uptake and completion data [76]. Uptake, defined as the number of patients who attended the initial/baseline assessment and at least one PR session, may be referred to as ‘enrolled’ or in a trial context ‘recruited’ [68]. In our review, uptake was not reported in any of the studies that compared Home-PR to Centre-PR. Engagement is the proportion of PR sessions attended. This is often assessed as the number of patients who have attended a pre-defined proportion of PR sessions (e.g., 70% of sessions) and is sometimes referred to as ‘completion rate’ [56, 57], or ‘adherence’ [61], or ‘compliance’ [51]. Of the included studies, only four trials defined engagement [56, 57, 60, 61] and

only three trials reported this clearly [56, 57, 61]. Engagement with defined sessions in Home-PR varied from 73% to 98% whereas in Centre-PR engagement ranged from 49% to 93%. Completion can also be defined as the number of patients who attended the post-PR discharge assessment and are regarded as having 'completed' the PR programme (even if they attended very few of the sessions). Some trials referred to participants who did not complete as having 'dropped out' of the PR programme [68].

From a trial design perspective, attrition is the number of people who do not attend FU assessments and may be described as having 'withdrawn' from the trial. Trials of longer duration may have several FU assessments and thus several time points for recording attrition. Attrition rates at the post-PR follow-up evaluation ranged from 0% to 51% in our review, but there was no consistent pattern to suggest that mode of delivery influenced follow-up.

Implications for clinical practice and research

This systematic review gives confidence that Home-PR can be an effective option to the traditional models of Centre-PR programmes which could extend access for people with COPD to this effective intervention though the low certainty of the evidence warrants further high-quality evaluation. Specifically, there is evidence that PR improves outcomes in bronchiectasis [30] and ILD [31], but our studies were COPD-specific so further investigation is required to establish whether Home-PR is suitable for CRDs other than COPD. This may be of particular importance in rural areas of LMICs where poor access to investigations mean that the diagnosis may not be clear and limited facilities and travel infrastructure make remote delivery an important option [21].

Whilst we may not have been able to identify specific components that contributed to effectiveness, providers will note that almost all the interventions included aerobic training and resistance training along with a programme of education. Regular remote supervision varied but did not have to be technologically complex – many used telephone calls often supplemented by maintaining an exercise diary. We recommend that future trials address issues of uptake, engagement, completion, and attrition, and adopt standard terminology in order to provide clarity.

CONCLUSION

Our review concludes with low confidence that Home-PR is as effective as Centre-PR in improving functional exercise capacity and quality of life in people with COPD compared to Usual Care. Home-

PR is thus an option that could enable people whose lifestyles or geographical locations make attending a PR Centre difficult or who wish to socially distance to benefit from PR.

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AUTHOR CONTRIBUTIONS

RR and HP led the team who all contributed to the systematic review process. MNU drafted the first version of the manuscript with support from RR and which was revised with contributions from all members of the team (DA, SCC, JE, MH, NSH, TJ, PJ, EMK, FM, HP, RS). All authors have critically reviewed and approved the final manuscript.

DATA STATEMENT

As no data sets were produced during this study, data sharing is not applicable. The data that support the findings of this systematic review are all available in the published papers.

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COMPETING INTERESTS

MH owns a Pulmonary Rehabilitation clinic in Bangladesh. EMK reports grants from Seqirus UK; personal fees from AstraZeneca and GlaxoSmithKline, and is President of the International Primary Care Respiratory Group, UK. All other authors declare no competing interests.

Table 1. PICOS table for the search strategy (reproduced from Uzzaman et al. [36])

PICOS	Description, inclusion	Exclusion criteria	Operational rules
Population	• Adults with primary diagnosis of CRDs. • Age> 18 years. • Comorbidity will not be an exclusion criterion	• Pregnant women and paediatric population • Rehabilitation provided to predominant condition is non-respiratory conditions • Recovery from acute infections or injury (e.g., immediately post-COVID) until the condition has been stable for 6-months • Conference abstract • Lung cancer • Pulmonary hypertension	PR delivered to people with chronic respiratory diseases (CRDs) such as chronic obstructive pulmonary disease (COPD), remodelled asthma, pulmonary impairment after tuberculosis (PIAT), bronchiectasis, interstitial lung disease (ILD), cystic fibrosis (CF), stable post-COVID (but excluding post-ICU rehabilitation) will be studied. We will also include PR delivered to people with more than one CRD, or undifferentiated chronic respiratory conditions. Conference abstracts will be excluded, but will prompt a search for a subsequent published paper.
Intervention	Home-Pulmonary Rehabilitation (PR) which comprises both exercise and at least one non-exercise component for a duration not less than 4 weeks.	Formal hospital or community medical centre-based programmes	**'Home-PR'-** the key criterion is that the sessions are undertaken by individuals by themselves (though a family member may be involved) and typically at home. Apart from baseline and post-PR assessments, the patient does not attend a Centre (either a hospital Centre or a local 'satellite' Centre) and is not supervised face-to-face by a healthcare professional (though there may be remote communication from a healthcare professional for some or all of the session), and is not part of an 'in-person' group. Exercise sessions typically include aerobic, endurance, resistance, and reconditioning exercises, though local resources and preferences may include other exercise modalities. Non-exercise components commonly include patient education, energy conservation training, smoking cessation, psychological support, self-management skill development or other recognised PR interventions along with optimisation of pharmacotherapy
Comparison	Either Population receiving 'Centre-PR' or receiving 'Usual Care'.	No control group	**'Centre-PR'-** the key criterion is that the sessions are under direct healthcare professional's supervision. The 'Centre' can be in a hospital, community setting, or remote facility. Centre-based sessions are normally group-based (though it is recognised that this may be modified in the context of a pandemic). Telehealth services where patients attend a supervised satellite Centre would be considered as Centre-PR.

			'Usual Care'- is the standard care received by individual with CRD in the relevant healthcare system but excluding the exercise components of PR.
Outcomes	Consist of either one of the following outcome measures • Health-Related Quality of Life (HRQoL) • Functional exercise capacity **±** Additional outcome(s) • Uptake of the service, completion rates • Assessment of motivation/others intermediate outcome • Activities of daily living • Physical activity level • Symptom control • Psychological status • Health care burden e.g., exacerbation rates, hospitalisation etc. • Adverse effect	Not including HRQoL or any measurement of exercise capacity as outcome	Any validated instruments will be considered: • HRQoL: e.g.,St Georges Respiratory Questionnaire (SGRQ), Chronic Respiratory Questionnaire (CRQ), EuroQol Five Dimension (EQ-5D) • Functional exercise capacity: e.g., 6-Minute Walk Test (6MWT), Incremental Shuttle Walking Test (ISWT), Endurance Shuttle Walking Test (ESWT). We will also include step tests and sit-to-stand tests that are sometimes used in Home-PR assessments. • Symptom control: e.g.,Modified Medical Research Council (mMRC), Clinical COPD Questionnaire (CCQ), Borg scale • Psychological status: e.g., Hospital Anxiety and Depression Scale (HADS), Patient Health Questionnaire-9 (PHQ-9), State-Trait Anxiety Inventory (STAI), Beck Inventory test
Setting	Any settings		Low or high resource settings irrespective of level of economies of the countries.
Study designs	Randomised controlled trials (RCTs); Clinical controlled trials (CCTs)	Cohort study, case series, case report	We will exclude studies that do not have a control group. We will consider RCTs to answer all of the three research questions (i.e., 1. effectiveness, 2. components, and 3. completion rate of Home-PR.), and consider CCTs to answer research questions 2 and 3.
Language	No language restriction		

Table 2. Matrix of the Home-PR components in the included studies

Author (year)	Exercise type				Edu	PR frequency; duration	Total sessions			Training, supervision and monitoring in the Home-PR group	FEC	HRQoL
	AE	RT	Flex	RMT			< 24	24-48	≥48			
Home-PR vs Usual Care (n=9)												
Ghanem 2010 [54]	✓	✓	X	✓	✓	2x/week; 8 weeks	X	✓	X	1 inpatient training session, then unsupervised home exercise	S*	S*
Pradella 2015 [64]	✓	✓	✓	X	✓	3x/week; 8 weeks	X	✓	X	Outpatient training (1st week), then diary + weekly TC to encourage home exercises	S*	S*
Varas 2018 [66]	✓	X	X	X	✓	5x/week; 8 weeks	X	✓	X	5 outpatient training sessions, then diary + pedometer + weekly TC	S*	S*
Singh 2003 [65]	✓	X	X	X	X	2x/day; 4 weeks	X	✓	X	Outpatient training sessions, then weekly supervision (mode not described)	NS*	S*
Boxall 2005 [51]	✓	✓	X	X	X	Daily; 12 weeks	X	X	✓	Weekly home visits for 6 weeks + diary, then fortnightly home visits	NS*	NS*
Johnson-Warrington 2016 [59]	✓	✓	X	X	✓	3x/week; 12 weeks	X	X	✓	1 face-to-face introductory session and given manual, then fortnightly TC	NS	NS*
Liang 2019 [60]	✓	✓	X	X	✓	NR; 8 weeks	✓	X	X	1 home visit, then weekly TC	NS	NS
Mendes 2010 [53]	✓	✓	✓	X	✓	3x/week; 12 weeks	X	✓	X	1 outpatient education + exercise training session, then diary + heart rate monitor + TC	NR	NS
Mohammadi 2013 [62]	✓	X	X	X	✓	3x/week; 8 weeks	X	✓	X	3 inpatient training sessions, then manual + TC (alternate days)	NR	NS
Home-PR vs Centre-PR (n=8)												
Pehlivan 2020 [63]	✓	✓	X	X	✓	2-7x/week; 8 weeks	X	✓	X	Exercise sessions + daily walking + diary + manual. Supervision NR	S	NS*
Chen 2018 [52]	X	✓	X	X	✓	3x/week; 12 weeks	X	✓	X	1 outpatient education and training sessions, then home exercise + manual. Supervision NR	NS*	NS*
Guell 2008 55]	✓	✓	X	✓	✓	3x/week; 9 weeks	X	✓	X	4 outpatient education and training sessions, then home exercise/walking sessions + pedometer. Supervision NR.	NS*	NS
Hansen 2020 [56]	✓	✓	X	X	✓	3x/week; 10 weeks	X	✓	X	3x/week exercise and education sessions, supervised by video-conference + diary	NS	NS

Holland 2016 [57]	✓	✓	X	X	✓	Most days; 8 weeks	X	X	✓	1 home visit, then home exercise sessions supervised by weekly TC + diary + pedometer	NS	NS*
Horton 2017 [58]	✓	✓	X	X	✓	3x/week; 7 weeks	X	✓	X	1 outpatient training session, then home exercise supervised by TC (x2) + manual	NS	NS
Maltais 2008 [61]	✓	✓	X	X	✓	3x/week; 8 weeks	x	✓	X	Outpatient education and training sessions, then home-based exercise + diary	NS	NS
Mendes 2010 [53]	✓	✓	✓	X	✓	3x/week; 12 weeks	X	✓	X	1 outpatient education + exercise training session, then diary + heart rate monitor + TC	NS*	NR

*Improved above MCID (minimal clinically important difference)

Abbreviations: AE, Aerobic training; RT, Resistance training; Flex, Flexibility training; RMT, Respiratory muscle training; Edu, Education; TC, Telephone call; FEC, functional exercise capacity; HRQoL, Health-related quality of life; S, significant between group difference; NS, not significant between group difference; NR, not reported

Table 3. Recruitment, uptake, engagement, completion of PR sessions and trial attrition

Author (year)	**Screened** [Reasons for ineligibility] **Recruited** Randomised	**Uptake of PR/Usual Care** [reasons for non-start]	**Dose of PR and definition of engagement**	**Engaged with defined number of sessions** [reasons for non-engagement]	**Completed PR programme** [reasons for drop out]	**Trial attrition rate** [Reason for attrition]
Home-PR vs Usual Care						
Boxall 2005 [51] RoB: High	Eligibility screening not reported **60 recruited** • Home-PR: 30 • UC: 30	*Uptake of PR* **Home-PR: 28/30 (93%)** [2 Ill health]	**Home-PR: 11 sessions** (12weeks: 11 visits + daily unsupervised exercise) **Engagement not defined**	Engagement not reported	**Home-PR: 23/30 (77%)** [3 withdrew; 1 died; 1 ill-health]	*Post-PR:* **Home-PR:** 7/30 (23%) [3 withdrew, 1 died, 3 ill-health] **Control:** 7/30 (23%) [2 withdrew, 2 died, 1 ill-health, 2 moved]
Chen 2018 [52] RoB: High	**265 screened for eligibility** [77 lost to contact; 44 distances >44Km; 53 declined; 36 co-morbidity; 38 other] **55 (21%) recruited** • Home-PR: 29 • UC: 26	Uptake not reported	**Home-PR: 36 sessions** 12w: 3 times/week unsupervised exercise **Engagement not defined**	Engagement not reported	**Home-PR: 25/29 (86%)** [3 ill-health; 1 moved] **UC: 22/26 (85%)** [1 ill-health; 3 not serious enough]	*Post-PR:* **Home-PR:** 4/29 (14%) [1 moved, 3 ill-health] **UC:** 4/26 (15%) [1 not serious, 1 ill-health]
Ghanem 2010 [54] RoB: High	Eligibility screening not reported **39 recruited** • Home-PR: 25 • UC: 14	Uptake not reported	**Home-PR: 48 sessions** 8w: Alternate days unsupervised exercise **Engagement not defined**	Engagement not reported	Completion not reported	*Post-PR:* **Home-PR:** 0/25 (0%) **UC:** 0/14 (0%)
Johnson-Warrington 2016 [59] RoB: Moderate	**464 screened for eligibility** 175 declined; 76 not eligible; 49 co-morbidity; 90 lost to contact] **78 (17%) recruited** • Home-PR: 39 • UC: 39	Uptake not reported	**Home-PR: 42 sessions** 12w 6 TCs + 3 times/week unsupervised exercise **Engagement not defined**	Engagement not reported	**Home-PR: 35/39 (90%)** [2 ill-health; 1 preferred Centre-PR; 1 not COPD;] **UC: 36/39 (92%)** [3 died]	*Post-PR:* **Home-PR:** 4/39 (10%) **[**1 wanted Centre-PR; 2 ill-health; 1 not COPD **UC:** 3/39 (8%) [3 died]

Mohammadi 2013 [62] RoB: High	**106 assessed for eligibility** **40 (38%) recruited** • Home-PR: 20 • UC: 20	Uptake not reported	**Home-PR: 24 sessions** 8weeks: 3 sessions then daily TCs + unsupervised sessions 3 /week **Engagement not defined**		Completion not reported	Not reported No attrition reported
Pradella 2015 [64] RoB: High	Eligibility screening not reported **50 recruited** • Home-PR: 32 • UC: 18	Uptake not reported	**Home-PR: 24 sessions** 8weeks: weekly TCs + 3 unsupervised sessions/week **Engagement not defined**	Engagement not reported	**Home-PR: 29/32 (91%)** [1 withdrew; 1 died, 1 AECOPD]	*Post-PR:* **Home-PR:** 3/32 (9%) **[**1 died, 1 withdrew, 1 AECOPD] **UC:** 3/18 (17%) [2 withdrew, 1 AECOPD]
Singh 2003 [65] RoB: High	Eligibility screening not reported **40 recruited** • Home-PR: 20 • UC: 20	Uptake not reported	**Home-PR: 4 sessions** 4weeks: Weekly visits + daily unsupervised exercise) **Engagement not defined**	Engagement not reported	Engagement not reported	*Post-PR:* **Home-PR:** 0/20 (0%) **Control:** 0/20 (0%)
Varas 2018 [66] RoB: High	Eligibility screening not reported **40 recruited** • Home-PR: 21 • UC: 19	*Uptake of PR* **Home-PR: 19/21 (90%)** [2 withdrew]	**Home-PR: 8 sessions** (1x/week + unsupervised exercise x8 weeks) **Engagement not defined**	Engagement not reported	**Home-PR: 17/21 (81%)** [2 did not complete]	*Post-PR:* **Home-PR:** 4/21 (19%) [4 withdrew] **UC:** 3/19 (16%) [3 withdrew] *3-months & 12-months* **Home-PR:** 4/21 (19%) **UC:** 3/19 (16%)
Cluster randomised implementation trial: Home-PR vs Usual Care						

Liang 2019 [60] RoB: High	Cluster RCT: 21 practices/group **1050 screened for eligibility** **272 (26%) recruited** • Home-PR: 157 • Control: 115	*GP referred for PR* **Home-PR:** 107/157 (68%) *Uptake of PR* **Home-PR:** 71/107 (66%)	**Home-PR: 8 sessions** 8weeks: 1 session + weekly TC unsupervised exercise **Engagement defined as ≥70% sessions attended**	*Engaged ≥70% (n %)* **Home-PR:** 49/107 (46%)	Completion not reported	*6-months:* **Home-PR:** 39/157 (25%) **UC:** 21/115 (18%) *12-months:* **Home-PR:** 44/157 (28%) [27 Lost to FU; 15 withdrew.2 died] **UC:** 38/115 (33%) [29 Lost to FU; 7 withdrew.1 moved 1 died]
Home-PR vs Centre-PR						
Guell 2007 [55] RoB: High	Eligibility screening not reported **57 recruited** • Home-PR: 28 • Centre-PR: 29	Uptake not reported	**Home-PR: 27 sessions** 9weeks: 4 sessions + 3 times/ week unsupervised **Centre-PR: 27 sessions** 9w: 3 times/week **Engagement not defined**	Engagement not reported	**Home-PR: 23/28** (82%) [4 dropped out; 1 chest pain] **Centre-PR: 28/29** (96%) [1 dropped out]	*Post-PR:* **Home-PR:** 5/28 (18%) **Centre-PR:** 1/29 (4%) *6-months* **Home-PR:** 8/28 (29%) [4 withdrew; 1 ill-health; 3 lost to FU] **Centre-PR:** 6/29 (21%) [1 dropped out; 5 lost to FU]
Hansen 2020 [56] RoB: Low	**1099 assessed for eligibility:** [608 declined Centre-PR; 251 declined Home-PR; 40 co-morbidity; 66 other] **134 (12%) recruited** • Home-PR: 67 • Centre-PR: 67	Uptake not reported	**Home-PR: 30 sessions** 10weeks: 3 sessions/ week **Centre-PR: 20 sessions** 10weeks: 2 sessions/ week **Engagement defined as ≥70% sessions attended** Attendance defined as participating in the whole session	*Engaged ≥70% (n %)* **Home-PR: 49/67** (73%) **Centre-PR: 42/67 (**63%) *Median number sessions attended (IQR)* **Home-PR:** 25/30 (20-28) **Centre-PR** 16/20 (8/19) OR Home-PR >70% engagement: 1.68 (95% CI: 0.78 to 3.37), p<0.27	**Home-PR: 57/67** (85%) [6 dropped out; 2 ill-health; 1 died; 1 AECOPD] **Centre-PR: 43/67** (64%) [10 dropped out; 8 ill-health; 2 died, 4 AECOPD] OR Home-PR completing: 3.18 (95% CI: 1.37 to 7.35), p<0.01	*Post-PR:* **Home-PR:** 20/67 (30%) **Centre-PR:** 26/67 (39%) *3m FU* **Home-PR:** 29/67 (43%) **Centre-PR:** 26/67 (39%)

Holland 2016 [57] RoB: Low	**295 assessed for eligibility** [27 recent PR; 10 co-morbidities; 5 recent AECOPD; 67 declined (54 wanted Centre-PR); 120 other] **166 (56%) recruited** • Home-PR: 80 • Centre-PR: 86	Uptake not reported	**Home-PR: 8 sessions** 8weeks: visit then weekly TCs + unsupervised sessions **Centre-PR: 16 sessions** 8weeks: twice weekly sessions **Engagement defined as ≥70% sessions attended**	*Mean/total sessions attended (range)* **Home-PR:** 7.4/8 (0 - 8) **Centre-PR** 8.3/16 (0 - 16) *Engaged ≥70% (n %)* **Home-PR:** 73/80 (91%) **Centre-PR:** 42/86 (49%) RR of non-completion in Centre-PR: 1.91 (95% CI 1.52 to 2.41)	**Home-PR:** 73/80 (91%) [1 died; 1 lost to FU 5 declined] **Centre-PR:** 77/86 (89%) [1 died; 1 lost to FU; 7 declined]	*Post-PR:* **Home-PR:** 7/80 (9%) **Centre-PR:** 9/86 (11%) *12m FU* **Home-PR:** 18/80 (24%) [4 lost to FU, 9 declined FU, 5 died] **Centre-PR:** 24/86 (28%) [10 lost to FU, 10 declined FU, 4 died]
Horton 2018 [58] RoB: Low	**1162 assessed for eligibility** [185 DNA; 32 co-morbidities; 606 not eligible; 140 wanted Centre-PR; 100 declined; 199 other **287 (25%) recruited** • Home-PR: 145 • Centre-PR:142	Uptake not reported	**Home-PR: 21 sessions** 7weeks: 3 unsupervised sessions a week **Centre-PR: 14 sessions** 7weeks: twice weekly sessions **Engagement not defined**	Engagement not reported	**Home-PR:** 94/145 (85%) [16 Lost to FU; 16 co-morbidities; 2 died; 2 wanted Centre-PR; 17 other] **Centre-PR:** 84/142 (59%) [30 Lost to FU; 12 co-morbidities; 1 died; 3 wanted Home-PR; 12 others]	*Post-PR:* **Home-PR:** 51/145 (35%) **Centre-PR:** 58/142 (41%) *6-months* **Home-PR:** 70/145 (48%) [7 Lost to FU; 3 DNA; 3 declined; 13 co-morbidities; 3 other **Centre-PR:** 72/142 (51%) [8 Lost to FU; 1 co-morbidity; 3 died; 2 others]
Maltais 2008 [61] RoB: Moderate	**631 assessed for eligibility** [214 declined; 27 transport problems; 1 died; 29 others **252 (40%) recruited** • Home-PR: 126 • Centre-PR:126	Uptake not reported	**Home-PR: 24 sessions** 8weeks: 3 unsupervised sessions /week **Centre-PR: 24 sessions** (4x 8weeks: 3 sessions /week **Engagement defined as ≥60% sessions attended**	*Engaged ≥60% (n %)* **Home-PR:** 123/126=98% **Centre-PR:**117/126=93%	Completion not reported	*Post-PR:* **Home-PR:** 7/126 (6%) **Centre-PR:** 12/126 (10%) *12-months* **Home-PR:** 19/126 (15%) **[**2 Lost to FU; 16 withdrew; 1 died] **Centre-PR:** 17/126 (13%) [2 Lost to FU; 14 withdrew; 1 died]
Pehlivan 2020 [63] RoB: High	71 assessed for eligibility **71 recruited** • Home-PR: 39 • Centre-PR: 32	Uptake not reported	**Home-PR: 32 sessions** 8weeks: 4 unsupervised sessions/week **Centre-PR: 16 sessions** 8weeks: 2 sessions /week **Engagement not defined**	Engagement not reported '4 Home-PR patients were excluded for 'non-compliance'	**Home-PR:** 35/39 4 discontinued **Centre-PR:** 32/32	*Post-PR:* **Home-PR:** 4/39 (10%) **[**4 withdrew] **Centre-PR:** 0/32 (0%)

3-arm trial (Home-PR vs Centre PR vs Usual Care						
Mendes 2010 [53] RoB: High	**216 assessed for eligibility** 65 declined; 32 ineligibles; 2 died **117 (54%) recruited** • Home-PR: 42 • Centre-PR:46 • UC: 29	Uptake not reported	**Home-PR: 36 sessions** 12weeks: TCs + 3 unsupervised sessions/week **Centre-PR: 36 sessions** 12weeks: 3 sessions/week **Engagement not defined**	Engagement not reported	**Home-PR: 35/42 (83%)** [7 'abandoned' the programme] **Centre-PR: 27/46 (59%)** [7 'abandoned' the programme]	*Post-PR:* **Home-PR:** 9/42 (21%) **[**2 Lost to FU] **Centre-PR:** 22/45 (50%) [4 Lost to FU] **UC:** 0/29 (0%)

Abbreviations: 95%CI: 95% confidence intervals, AECOPD: acute exacerbation of COPD, COPD: chronic obstructive pulmonary disease, DNA: did not attend, FU: follow-up, IQR: interquartile range, Km: Kilometres, PR: pulmonary rehabilitation, RoB: Risk of bias, TC: telephone contact, UC: Usual Care.

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