The development and feasibility of an intervention to promote physical activity following pulmonary rehabilitation in people with Chronic Obstructive Pulmonary Disease

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A thesis submitted in partial fulfilment of the requirements of the University of Lincoln for the degree of Doctor of Philosophy

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August 2020

Thesis Abstract

Background: Despite the importance of physical activity to physical and psychological health in chronic obstructive pulmonary disease (COPD), levels of physical activity in COPD patients are significantly lower than age matched healthy individuals. Pulmonary rehabilitation, a structured physical activity intervention, is one of the essential treatments for COPD, and results in benefits such as improved exercise capacity, symptoms, and quality of life. However, this does not translate to an increase in long term physical activity and previous interventions to promote physical activity following pulmonary rehabilitation have had limited efficacy.

Aim: The overarching aim of this thesis was to develop and test the feasibility and acceptability of an intervention to promote physical activity following pulmonary rehabilitation in patients with COPD.

Methods: This mixed methods thesis developed and tested the feasibility of an intervention in line with the stages outlined in the Medical Research Council framework. The intervention was informed by a qualitative systematic review and the development of the intervention was facilitated by the Behaviour Change Wheel and collaboration with stakeholders. The intervention was tested in a feasibility cluster randomised controlled trial with an embedded process evaluation. The primary outcome of the feasibility study was the acceptability of the intervention and secondary outcomes included other feasibility outcomes and a range of clinical measures proposed for a definitive trial. Acceptability of the intervention and the research procedures were also explored via semi-structured interviews with patients and focus groups with personnel involved in delivery of the intervention (health care professionals and WhatsApp leaders). An inductive analysis was conducted to analyse the data. The factors which impacted patients' physical activity were also identified via a deductive analysis of the interviews with patients, and mapped to the capability, opportunity, motivation behaviour change model (COM-B).

Results: A thematic synthesis of fourteen studies revealed that beliefs, social support, and the environment encapsulate the factors which are important in physical activity following pulmonary rehabilitation in patients with COPD. The Behaviour Change Wheel guided the development of an intervention that included the provision of a pedometer and step diary, and the addition of patients to a WhatsApp group populated by fellow pulmonary rehabilitation graduates and a 'WhatsApp leader' for 52 weeks following pulmonary rehabilitation. A total of 74 patients enrolled in the feasibility study (consent rate, 55%) and there was an attrition rate of 35% at 52 weeks. By 52 weeks, 49% had engaged in the step diary, and 58% of participants who had consented to use WhatsApp had sent at least one WhatsApp message to the group. The Control Group had a larger decline in their daily steps at 52 weeks compared to the Intervention Group, MD, -180, (-765, 1126). Participants in the intervention group who engaged in the step diary had a smaller decline in their daily steps at 52 weeks compared to those who did not engage in the step diary, MD, 45.5 (-1796, 1889). Participants in the intervention group who engaged in WhatsApp had a smaller decline in daily steps at 52 weeks compared to those who did not engage in WhatsApp, MD, 730 (-992, 2454). However, results also suggest there was a larger detrimental decline in secondary health outcomes in the Intervention Group compared to the Control Group. WhatsApp leaders adhered to sending a minimum of weekly physical activity messages throughout the 52 weeks period. Common themes from interviews and focus groups were that patients would benefit from more

familiarity with the intervention components (e.g. earlier introduction of the intervention to patients during PR from health care professionals), and that the convenience of the intervention components and research procedures could be improved (e.g. options for participants to use their personal mobile and pedometer devices). Rapport between the patients and WhatsApp leaders was considered important and face to face support should complement social networking following Pulmonary Rehabilitation. Facilitators unique to those with higher intervention engagement related to physical capability and reflective motivation (e.g. reduction in exacerbations following Pulmonary Rehabilitation and the ability to overcome mental obstacles). Barriers unique to those with lower intervention engagement related to automatic motivation and physical opportunity (e.g. low mood and the distance of physical activity opportunities).

Conclusion: This thesis addressed the gaps in previous literature and adopted a step wise approach in the development and feasibility testing of the intervention. The intervention was considered acceptable and feasible, yet modifications are required to optimise the acceptability and feasibility of the study prior to a definitive cluster randomised controlled trial, which are possible during an intervention revision period.

Acknowledgements

First and foremost, I wish to express a huge thank you to my director of studies, Dr Arwel Wyn Jones. You provided tireless support during the entirety of my PhD project, and facilitated a challenging, yet rewarding project during the past four years at the University of Lincoln. Thank you to my second supervisor, Professor Mo Ray. I cannot thank you enough for joining the supervision team and offering fresh insight based on your expertise in Health and Social Care and qualitative research. My thanks extend to Professor Chris Bridle, also a member of the supervisory team, your expertise in research design and intervention development was valuable and much appreciated.

Assistance provided by the wider members of the Lincoln International Institute for Rural Health and the College of Social Sciences was greatly appreciated. Thank you, Ffion Curtis, for sharing your expertise in systematic reviews and thank you, Sam Lewis, for your support involved in research governance and ethical approval. Thank you, Zahid Asghar, for your assistance with statistics.

I wish to acknowledge the continual support from stakeholders included in this thesis. Thank you to health care professionals within Lincolnshire Community Health Services, (Liz Hill, Jo Saul, Mark Baker, Luke Gibbons, Anna Krynicka, Jerri Hammond, Pip Storey, Dave Bareham, Trish Lowe, Robert Westall) who supported the development, delivery, and evaluation of the intervention tested in the feasibility study. Despite your challenging workload, you went above and beyond to support the project, and I will be forever grateful for your warm welcome to PR during the delivery of the feasibility study tested in this PhD. Also, thank you to Jo Strong, for your help in recruitment, and your continual support throughout the study.

Of course, a huge thank you to all lay volunteers who offered their time to develop, deliver and evaluate the intervention (Mark Saunders, Trish Newham, Carol Clayton, Nigel

Saville, Anita Hall), and patients who participated in the study. You continued to inspire me with your kind words and passion in supporting others who have, or will be, diagnosed with a lung condition.

A special thank you to fellow PhD students (past and present), including, but not limited to, the now Dr Alex Jenkins, Dr Laura Simmons, and soon to be ‘Dr Sam Cooke’. You were a pleasure to work alongside and you continually inspired me to progress in my own project.

For my partner, family, and friends, who have provided a tremendous amount of support throughout the previous four years. Thank you for your love, kindness, and your ability to keep me smiling throughout this challenging process.

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List of Abbreviations

APEASE:	Affordability, Practicability, Effectiveness and Cost-Effectiveness, Acceptability, Side-effects and Safety and Equity.
BCT:	Behaviour Change Techniques
BCTv1:	Behaviour Change Taxonomy Version One
BMI:	Body Mass Index
BCW:	Behaviour Change Wheel
CONSORT:	Consolidated Standards of Reporting Trials
CG:	Control Group
CI:	Confidence Interval
COM-B:	Capability, Opportunity, Motivation- Behaviour
COPD:	Chronic Obstructive Pulmonary Disease
CRCT:	Cluster Randomised Controlled Trial
CRQ:	Chronic Respiratory Questionnaire
ESWT:	Endurance Shuttle Walk Test
DPA:	Daily Physical Activity
FEV:	Forced Expiratory Volume
FVC:	Forced Vital Capacity
GOLD:	Global Initiative for Chronic Obstructive Lung Disease
HADS:	Hospital Anxiety and Depression Scale
HRQoL:	Health Related Quality of Life
ISWT:	Incremental Shuttle Walk Test
IG:	Intervention Group
LCHS:	Lincolnshire Community Health Services
LPA:	Light Physical Activity
MCID:	Minimally Clinical Important Difference
MD:	Mean Difference
MET:	The Metabolic Equivalent of Task
MRC:	Medical Research Council
MVPA:	Moderate to Vigorous Physical Activity
M/S^2:	Metre per Second Squared
NHS:	National Health Service
NICE:	UK National Institute for Health and Care Excellence
PA:	Physical Activity
PPI:	Patient and Public Involvement
PR:	Pulmonary Rehabilitation
RCT:	Randomised Controlled Trial
SB:	Sedentary Behaviour
SE:	Standard Error
SD:	Standard Deviation
SURE:	Specialist Unit for Review Evidence
QoL:	Quality of Life
QULY:	Quality Adjusted Life Years
6MWT:	Six Minute Walk Test

Publications and presentations

Publications

Chapter 2: Facilitators and barriers to physical activity following pulmonary rehabilitation in COPD: a systematic review of qualitative studies

- Robinson, H., Williams, V., Curtis, F., Bridle, C. & Jones, A. W. Facilitators and barriers to physical activity following pulmonary rehabilitation in COPD: a systematic review of qualitative studies. *npj Primary Care Respiratory Medicine* 28, 19 (2018).

Chapter 3: Use of the Behaviour Change Wheel to develop an intervention to promote physical activity following pulmonary rehabilitation in patients with COPD

- Robinson, H., Hill, E., Direito, A., Peel, J., Saunders, M., Ray, M., & Jones, A. W (2019). Use of the Behaviour Change Wheel to develop an intervention to promote physical activity following pulmonary rehabilitation in patients with COPD. *Behavioural Science and Public Health Conference Edition* 2019, 3 (2)
- Robinson, H., Jones, A. W., & Emmerich, N. (Ed.). (2020). Ethical considerations and data privacy challenges in the development and delivery of an intervention to promote peer support using social media. *SAGE Research Methods Cases.*

Conferences

Posters

Chapter 2: Facilitators and barriers to physical activity following pulmonary rehabilitation in COPD: a systematic review of qualitative studies

- Primary Care Respiratory Society Annual Conference: ‘What are the patient reported facilitators and barriers to physical activity following pulmonary rehabilitation in COPD? A systematic review of qualitative research’ (September 2018)

Chapter 3: Use of the Behaviour Change Wheel to develop an intervention to promote physical activity following pulmonary rehabilitation in patients with COPD

- East Midlands Thoracic Society Meeting: 'Applying the Behaviour Change Wheel to develop an intervention to promote physical activity following pulmonary rehabilitation in COPD' (October 2018)
- Division of Health Psychology (DHP) annual conference: 'Use of the Behaviour Change Wheel in the development an intervention to promote physical activity after pulmonary rehabilitation in COPD' (July 2019)
- European Respiratory Society annual conference: Patient and public involvement and application of the Behaviour Change Wheel to promote physical activity following pulmonary rehabilitation in COPD: an intervention development study (September 2019)

Chapter 4: Methodology and general methods

- PhD conference at Liverpool John Moores University: 'A feasibility study of an intervention to promote physical activity following pulmonary rehabilitation for individuals with Chronic Obstructive Pulmonary Disease (COPD)' (July 2018)
- Behavioural Science Public Health Network (BPSHN) annual conference: 'Intervention to promote physical activity following pulmonary rehabilitation for individuals with COPD' (February 2019):

Oral presentations

Chapter 2: Facilitators and barriers to physical activity following pulmonary rehabilitation in COPD: a systematic review of qualitative studies

'What are the patient reported facilitators and barriers to physical activity following pulmonary rehabilitation in COPD? A systematic review of qualitative research', has been presented at various stages of research:

- The British Sociological Association Sport Study Group PG Conference, (The University of Lincoln, September 2017)
- The British Psychology Society Conference, East Midlands Branch (Derby, September 2017)
- The Community of Health and Research Unit and Lincoln Institute for Health Research Seminar Series (The University of Lincoln, October 2017)
- Primary Care Respiratory Society Annual Conference (Telford, September 2018)

Internal presentations

'The Behaviour Change Wheel' has been presented to various audiences within the University of Lincoln:

- The Lincoln Institute for Health (The University of Lincoln, January 2017)
- The Community of Health and Research Unit and Lincoln Institute for Health Research Seminar Series (The University of Lincoln, January 2019)

Introduction

Chronic obstructive pulmonary disease (COPD) is a common and preventable condition, characterised by persistent respiratory symptoms and airflow limitation that is caused by significant exposure to noxious particles or gases (GOLD, 2019). Physical activity (PA) is important for patients' physical and psychological health, yet PA in COPD is significantly lower than age matched healthy individuals. Pulmonary Rehabilitation (PR) is a structured PA intervention and results in benefits such as improved exercise capacity, symptoms, and disease specific Quality of Life (QoL). However, this does not translate to an increase in long-term PA. There are various gaps in our knowledge of how best to support individuals to stay active following PR. These factors include limited understanding of the determinants of PA following PR; limited understanding of the processes that contributed to the efficacy of interventions; limited application of theory and behaviour change frameworks in intervention development; and limited involvement of Patient and Public Involvement (PPI) in previous interventions.

Aims, research questions and objectives

Aims:

The overarching aim of this PhD was to develop and test the feasibility of an intervention aimed to promote PA following PR in chronic obstructive pulmonary disease (COPD).

Research questions:

1) What are the patient reported facilitators and barriers to PA following PR in COPD? (Chapter 2)
2) What is an acceptable and feasible intervention to promote PA following PR in COPD? (Chapter 3)

3) What is the feasibility of the developed intervention? (Chapter 5)
4) What are the likely effects of the intervention on PA and other health outcomes following PR? (Chapter 5)
5) What is the acceptability of the intervention and research procedures for patients, patient volunteers, and health care professionals? (Chapter 5)
6) Are there differences in the facilitators and barriers of PA of patients with higher engagement in the intervention compared to those with lower engagement in the intervention? (Chapter 6)

These research questions were addressed in the following objectives:

Objectives:

- Chapter 2: To conduct a systematic review: "Facilitators and barriers to PA following PR in chronic obstructive pulmonary disease (COPD): a systematic review of qualitative studies". This systematic review will inform the development of the feasibility study of an intervention aimed to promote PA following PR in COPD.
- Chapter 3:To conduct a behavioural analysis and diagnosis to inform intervention development.
- Chapter 5: To conduct a feasibility cluster randomised controlled trial of the intervention and report the quantitative outcomes: recruitment rates, consent rates, attrition rates and intervention fidelity, PA, anxiety and depression and quality of life.
- Chapter 5: To conduct a process evaluation to assess the acceptability of the intervention and research procedures for patients, patient volunteers, and health care professionals?
- Chapter 6: To integrate the qualitative and quantitative results to identify and understand differences between patients with higher engagement in the intervention, compared to those with lower engagement in the intervention.

1 Chapter 1: Literature review

1.1 Introduction

This chapter introduces the concepts discussed in this thesis, including Chronic Obstructive Pulmonary Disease (COPD); physical activity (PA); Pulmonary Rehabilitation (PR), and complex interventions. The following text outlines the gap in knowledge and the limitations in previous research that this thesis aims to address. This chapter concludes with an outline of the rationale of the thesis.

1.2 COPD

Definition

COPD is a common and preventable condition, characterised by persistent respiratory symptoms and airflow limitation that is caused by significant exposure to noxious particles or gases.[1] COPD is treatable but there currently is no cure.

Prevalence

Based on figures in 2016, an estimated 1.2 million people were living with COPD in the UK, and 4% of people over 40 were diagnosed with the condition.[2] Findings from the global disease burden study stated that there were approximately 251 million people living with COPD worldwide.[3] There are large discrepancies between studies when predicting prevalence, though a systematic review and meta-analysis conducted in 2015 reported that there were 384 million people living with COPD in 2010.[4] However, there is an overwhelming consensus that these figures are rising.[3–5]

Mortality

Globally, COPD is the third leading cause of death and a leading cause of mortality and morbidity following heart disease and stroke.[6,7] However, due to the predicted underdiagnosis in COPD (attributed to the discrepancies in the methods used to assess symptoms), the global

burden of the disease is under represented by these figures.[8] Approximately 30,000 people in the UK die every year from COPD, and mortality rates are increasing.[9]

Risk factors

Risk factors for COPD include environmental and behavioural factors. Prevalence of the disease varies across countries and cultures due to a complex interplay of external and internal factors, for example long term exposure to noxious gases and particles, genetics, lung growth during childhood and airway hyper-responsiveness.[10,11] Tobacco smoking is a behavioural factor that is directly related to the prevalence of COPD, but environmental factors such as indoor and outdoor pollution also represent a major risk.[12–14] However, in the UK, the main lifestyle risk factor is smoking.[1,9] COPD is also related to age, and generally affects older adults.[1]

Economic and social impact

COPD constitutes large economic and social costs[15,16], which is predicted to continue to grow.[17,18] The UK alone spends £11 billion each year on COPD and was believed to represent almost 1% of the UK GDP in 2014.[19] Due to the prevalence of COPD and the associated symptom burden, this condition represents a significant economic challenge for health care systems globally. Research published in 2014 reported that COPD accounts for more than half of the costs spent on respiratory diseases within the European Union[20], with hospitalisations contributing to the majority of associated costs. In the UK, annual hospital admissions for COPD are over 140,000 and include one million bed days, accounting for 1.7% of all hospital admissions and bed days. Almost all hospital admissions are for emergency care.[9]

The severity of COPD is therefore positively associated with the economic burden to the NHS. In addition, the progressive and sometimes debilitating nature of the condition impacts individuals' social network. For example, patients may require further support with

daily activities, and patients' family, friends or partners are often appointed carers for patients.[21] Whether full or part time carers, this role may impact their ability to work and therefore earn money. Caregivers are also more vulnerable to anxiety and depression, thus potentially increasing the burden on the health care system[22,23], as well as the demand and reliance on local council and governments for financial support.[24]

Although respiratory diseases represent approximately 9% of the total economic burden of illness, expenditure in health research directed at respiratory conditions is much lower (at approximately 2%).[19] More research is therefore necessary to identify methods of reducing the negative impacts of COPD on patients, as well as reducing the wider social and economic burden.

Symptoms and health burden

Common physical symptoms of COPD include dyspnoea (breathlessness), coughing and sputum production. Less common symptoms include wheezing and chest pain. Wheezing and chest tightness can be variable, and sometimes varies across the same day. Chest tightness often follows PA upon exertion.[1] Chronic breathlessness, which means difficult or laboured breathing over a long period of time, represents the most characteristic symptom of COPD and the main reason that patients seek medical attention.[1] However, individuals may also experience acute breathlessness.[1] This symptom can be disabling for many individuals due to its effect on mobility and psychological wellbeing. Coughing is a common symptom, which is often, though not always, coupled with sputum production. Some individuals with COPD are also predisposed to frequent exacerbations, known as 'an acute worsening of respiratory symptoms that result in additional therapy'.[26,27] Exacerbation risk significantly increases with COPD severity.[1] Other symptoms of COPD, classically in more severe cases, may include, though are not limited to, weight loss, fatigue and anorexia.[1,29]

Comorbid conditions

It is also common for individuals with COPD to have comorbid conditions[1], particularly as COPD is associated with older age.[1] The number of comorbidities is positively associated with mortality and hospitalisations, specifically when there are three or more comorbidities.[29] Common comorbidities include both physical and psychological conditions and include, but are not limited to, cardiovascular disease, skeletal muscle dysfunction, osteoporosis, depression and anxiety.[1]

The presence and number of comorbid conditions, as well as the frequency, duration and severity of COPD exacerbations are not the same for any one individual.[25] Symptoms vary between individuals, and often vary across the day and seasonally.[30] Additionally, the way that individuals perceive and experience their physical symptoms differs. For example, some patients may experience all symptoms daily, whereas others may not even notice some symptoms.[31] Unfortunately, exacerbations are negatively associated with QoL.[32]

Quality of Life

COPD can have a significant impact on individuals' psychological well-being. Psychological well-being includes 'the ability to maintain a sense of autonomy, self-acceptance, personal growth, purpose in life and self-esteem.[33] COPD can restrict patients' mobility, mood, and independence, and there is a large body of research outlining the negative impact that COPD has on individuals' QoL[34].

Anxiety and Depression

Mental health disorders contribute to increased disability and impaired QoL.[35] Mental health disorders such as anxiety and depression are higher in COPD than the general population[34,38] and a high prevalence of individuals with COPD live with either diagnoses or symptoms of anxiety and/or depression.[38] Previous studies report that depression is almost doubled in COPD compared to healthy controls[40], and that the development of anxiety is much higher in COPD compared to those without COPD. Clinical anxiety in COPD has been found to range

between 13-46%[38], with depression between 8-80%[41], yet there are differences between their estimated prevalence due to differences in diagnostic tools.[41] Anxiety and depression are associated with poorer physical and social functioning, combined with low help seeking behaviour and adherence to COPD treatment.[41] For example, increased smoking, insomnia, fatigue, loss of social functioning, exercise capacity and emotional liability are associated with anxiety and depression.[42]

Causes of anxiety and depression in COPD vary between individuals.[34] However, a common cause of fear, hopelessness and panic attacks includes breathlessness[43] and patients have reported anxiety and emotional vulnerability as being directly linked to events of acute breathlessness.[43,44] A common phenomenon often reported in COPD patients is known as the vicious cycle between breathlessness upon exertion, a reduction of PA to avoid uncomfortable symptoms, and worsening of physical capacity and worsening of breathlessness.[43] This avoidance of PA is also connected to diminished levels of autonomy and self-esteem, which negatively effects patients' ability to cope.[45] The complexity surrounding the causes of COPD mean that recognition, treatment and adherence to treatment remains sub-ideal.[34]

Activities ranging from participation in sport and structured exercise, to daily activities such as getting out of bed, washing, and going up the stairs can be limited by COPD. The range of activities affected may have a detrimental impact on individuals' sense of independence, which may lead to a decrease in motivation to be active and activate a self-perpetuating cycle of reduced PA and QoL.[1,25]

1.3 Physical Activity

PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, generally measured by kcal per unit time.[48] The level of activity varies for everyone and can be divided into subsets of activities, e.g. sleep, occupational, leisure and

conditioning. PA is different to 'exercise' which is a subcategory of PA, and is defined as 'PA that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective'.[48] Different PA intensities include sedentary, light, moderate, vigorous, and very vigorous intensities, which can be identified via measurement of the Metabolic Equivalent of Task (MET). For example, one MET is equivalent to sitting, light physical activity (< 3 METS) is equivalent to activities such as light walking, moderate activity (3 to 6 METS) is equivalent to activities such as yoga and vacuuming, and vigorous (≥6 METS) is equivalent to tasks such as aerobic exercises such as jogging and dancing.[49]

There are various methods to measures PA which can be divided into objective and subjective measurements. Objective measures assess at least one dimension of PA and can use a variety of metrics such as intensity and time.[50] Objective measures include the quantification of PA by an external device such as an accelerometer or a pedometer. Subjective measurements are based on the individual self-reporting their PA, for example via a PA diary or a questionnaire. There are benefits and limitations associated with each method. For example, subjective measures such as questionnaires are often low cost and can easily be distributed to many people. However, subjective measurements are often open to recall bias and participants can misinterpret questions and forget periods of short bursts of PA. Subjective measures can therefore have limited reliability and validity.[51] Comparatively, objective measures are beneficial as they are often more precise, and can capture various PA dimensions, such as PA intensity and type.[52] However, objective measures can be less accessible due to high cost and use of specific software.[53]

Physical activity prevalence in COPD

There is a large body of evidence which identifies that PA in COPD is significantly lower than age matched healthy individuals[54,55], which is consistent across settings and cultures.[55]

Previous research has reported that healthy controls consistently achieve higher daily PA and higher levels of exercise intensity than patients with COPD[54], with the exception of one study, which reported that COPD patients more time in higher intensity activities, such as brisk walking.[56] Evidence suggests that COPD patients participate in just over half the amount (duration) of DPA, and two thirds of the intensity of the DPA compared to healthy controls.[54]

To understand the relationship with COPD and PA, researchers have studied the impact of disease severity on PA.[56–65] Most studies reported that higher levels of PA were positively associated with lung function (e.g. FEV_1% predicted). However, the relationship between the rate of lung decline and lower PA levels has not been consistently reported.[55] In a review of the level of daily PA in individuals with COPD compared with healthy controls, the results outlined that that there were no strong associations between the severity of COPD and DPA[54], **Table 1:1**.

However, the outcome measure of PA widely varies across these studies, and these include both subjective and objective measures. Objective measures include measures such as accelerometers; uniaxial[54,61,64,67], ;biaxial[64,68]; triaxial[59,60,69]; and pedometers[62], and subjective measures include questionnaires[57,70,71], **Table 1:1**. Compared to objective measures, the subjective measures often result in higher reported changes in PA.[54] The wide variety in outcome measures adds heterogeneity across the studies and thus may contribute to differences in outcomes.[53] This has been attributed to limited agreement in the implementations guidelines of outcome measures such as activity monitors.[53] Currently, accelerometery is considered the most reliable measure of physical activity, specifically triaxial accelerometers such as the Dynaport MiniMod, Actigraph GT3X and SenseWear Armband, which measure postural changes.[53,72]

Further research is necessary to identify and validate activity monitors in COPD research.[53] Use of solely objective or subjective outcome measures have been criticised as they do not thoroughly capture all aspects of physical activity in COPD. To address this limitation, a hybrid tool including an accelerometer and a patient-reported questionnaire, known as the PROactive instrument, has recently been developed.[73]

Table 1:1: Comparison of PA between COPD patients and healthy controls, and the relationship between PA and exercise tolerance and/or lung function in COPD

Study ID	Patients (COPD/ Control)	PA/ Exercise tolerance/ Lung function outcome measures	Comparison of PA between COPD patients and healthy controls	Relationship between PA and exercise tolerance in COPD/ Relationship between PA and lung function in COPD
Coronado (2003)[66]	25 (15/10)	Time spent in inactivity, low and medium level activity (%); Uni-axial accelerometer (Self-Contained Activity Monitor (SCAM)) 6MWT FEV_1 (% pred)	The control group were more active and spent more time walking and in low and medium intensity activity than COPD patients	PA was positively correlated with exercise tolerance PA was not correlated with pulmonary function
Hernandes (2009)[60]	70 (40/30)	Time spent in different activities and body positions (walking, standing, sitting or lying); intensity of the movement during time spent walking; Tri-axial accelerometer (Dynaport Activity Monitor [DAM]) 6MWT FEV_1 % pred/ FEV_1/ FVC	The control group spent more time walking per day and spent more time in higher PA intensity than COPD patients	PA was positively correlated with exercise tolerance Time spent standing per day was positively correlated with pulmonary function but walking time per day was not significantly correlated with pulmonary function
Lores (2006)[69]	35 (23/12)	Activity counts; Tri-axial accelerometer	The control group had more activity counts than COPD patients	n/a
Pitta (2005)[74]	88 (62/26)	Time spent in different activities and body positions (walking, standing, sitting or lying); intensity of the movement during time spent walking; Tri-axial accelerometer (DynaPort activity monitor) 6MWT, Wmax, Peak VO_2 % pred	The control group walked for longer than COPD patients and had higher movement intensity when walking. COPD patients were inactive	PA was positively correlated with exercise tolerance PA was positively correlated with pulmonary function

		FEV_1, FEV, FRC, TLC, $T^{L,CO}$ % pred		
Schonenhofer (1997)[62]	50 (25/25)	Activity counts; Pedometer (Fitty 3) P_a,O_2; P_a,CO_2; FEV_1; FVC; *P*I,max; PE,max: ;*f*R; *V*T; *t*I/t_{tot}	The control group were more active than COPD and CRF patients	PA was positively correlated with pulmonary function
Singh (2001)[56]	20 (11/9)	Activity counts; Uni-axial accelerometer (Z80-32k V1 INT activity monitors) FEV_1	The control group were more active than COPD patients, though COPD patients spent more time in higher intensity activity than the control group.	PA was positively correlated with pulmonary function, but not statistically significant
Troosters (2010)[64]	100 (70/30)	Daily steps; time spent in mild and moderate PA; Multisensor armband (SenseWear) FEV_1 % pred	The control group spent more time in mild, moderate, and high intensity activities	PA was reduced early in the disease progression. Patients reduced their moderate intensity activities before reducing their lighter intensity activities
Walker (2008)[63]	51 (33/18)	Activity counts; Uni-axial accelerometer (Dynaport Activity Monitor) 6MWT FEV_1	The control group spent more time in daily activities and higher intensity activities	PA was positively correlated with exercise tolerance PA and pulmonary function were positively correlated
Eliason (2011)[67]	44 (28/16)	Activity counts; Uniaxial accelerometer (model GT1 M) 6MWT FEV_1, FVC	The control group were more active than patients with moderate and severe COPD	PA was positively correlated with exercise tolerance
Van Gestel (2012)[68]	70*	Steps; time spent active; PAL; Accelerometer; SenseWear ProTM armband	n/a	PA was not reliably predicted by exercise tolerance

		6MWT, STST, Zutphen Physical Activity Questionnaire (TEE_{ZPAQ}).		
Osadnik (2018)[75]	236*	Daily steps; DynaPort MoveMonitor (DAM) 6MWT and CPET FEV_1, FEV, FRC, TLC, TL,CO, % pred	n/a	PA was positively correlated with exercise tolerance PA was positively associated with pulmonary function
Cheng (2003)[58]	5707*	Standardised questionnaire MTT FEV_1, FEV	n/a	PA was positively associated with pulmonary function
Pitta (2008)[59]	40*	Time spent in METS; Accelerometer (SenseWear Armband) 6MWT MVV, IC, FEV_1	n/a	PA was positively associated with pulmonary function
Steele (2000)[61]	47*	Activity counts; Triaxial movement sensor (Tritrac R3D) 6MWT FEV_1 % pred	n/a	PA was positively correlated with exercise tolerance PA was positively associated with pulmonary function
Watz (2008)[65]	170*	Daily steps; energy expenditure; Accelerometer (SenseWear Pro Armband) FEV_1 % pred	n/a	PA was negatively associated with disease severity

*COPD patients only

6MWT: six-minute walk test; FEV_1% pred: Forced Expiratory Volume percentage predicted; FVC: Forced Vital Capacity; VMU: Vector Magnitude Units; FRC: Functional Residual Capacity: TLC: Total Lung Capacity, $T^{L,CO}$ % pred: Total carbon monoxide diffusion capacity; P_a,O_2: arterial oxygen tension; P_a,CO_2: arterial carbon dioxide tension; *P*I, max: peak expiratory mouth pressure; PE, max: peak inspiratory mouth pressure *f*R: respiratory frequency; *V*T: tidal volume; tI/t_{tot}: ratio of inspiratory time to the duration of the total breathing cycle; m/s^2: metre per second squared; STST: Sit To Stand Test; CPET: Cycle Ergometer Cardiopulmonary Exercise Test; MTT: maximal treadmill test; IC: inspiratory capacity; CRF: chronic respiratory failure

Physical activity guidelines

PA guidelines are tailored to individuals' age range. People with COPD tend to be older adults, over the age of 40.[76] The UK government guidelines for PA for 18-64 years states that adults should: aim to be active daily; aim to strengthen their major muscle groups (two days a week); meet up to at least 150 minutes of moderate intensity activity, or by doing 75 minutes of vigorous activity or even shorter durations of very vigorous activity (or a combination of activity intensities) spread across the week; and finally, to minimise sedentary time.[77]

The guidelines for individuals who are 65 years and above state that individuals should also: undertake PA to improve balance and co-ordination at least two days a week and to reduce sedentary time by introducing light activity or even standing.[78] The focus has shifted from the total measures of PA per day, to the importance of PA across the whole day, also considering the pattern of sleep.[82–78]

Physical activity guidelines for COPD

There is limited research on specific PA recommendations in COPD.[83] Due to the rate of disease progression and the large individual differences between individuals' disease stage and aerobic fitness levels, individualised recommendations have been suggested as more appropriate than general recommendations.[83] This is particularly true for individuals with more severe COPD or with limited mobility, as it is possible that the national government guidelines are too high. For example, a study to measure daily step counts in patients with COPD found that the average daily step count was 5680.[84] However, baseline measures of daily steps in more recent studies (prior to a PA intervention) ranged between 1644-8069 steps per day[51,84–92], outlining that PA widely varies between individuals with COPD. Thirty minutes per day of moderate vigorous PA is roughly equivalent to 7,000-10,000 steps per day.[93] Although some studies have identified COPD cohorts with daily steps higher than 7000[86,94], most studies have reported that COPD patients walked less than 7,000 steps per day.[84,83,91,91]

The minimally clinical important difference (MCID) refers to an effect that the patient may recognise as either positive or negative, which may then implicate the management of the condition.[98] In studies reporting the MCID for PA in COPD, research initially reported that an increase in 600-1100 daily steps[96] was associated with a reduced risk in hospitalisation. However, more recent research has reported the MCID as between 350-1100 daily steps[99], suggesting that a much smaller change in steps may be associated with a reduction in risk of hospitalisation.

Importance of physical activity

PA is a lifestyle behaviour that is important for general well-being.[77] Physical inactivity represents a global public health issue and is believed to be a key leading cause of death

worldwide, especially within non-communicable diseases such as COPD.[100] Physical inactivity is both a cause and consequence of chronic diseases[55] and reductions in PA are associated with the development of various chronic conditions such as cancer and physical disability.[55] However, PA is capable of reducing health burdens of non-communicable diseases, as well as improving the general populations' QoL.[77,95–97]

In a recent study to estimate the cost effectiveness of regular PA compared to a sedentary lifestyle in COPD in the UK, the results supported the likelihood of total cost savings for the NHS[103], based on the likelihood of PA resulting in lower mortality and fewer hospitalisations. These results provided support of the relevance of PA in the management of COPD, providing savings to the NHS, as well as improved QoL in patients.[103]

Benefits of physical activity in COPD

PA is particularly important in COPD, as inactivity is associated with reduced QoL, risk of hospitalisation and mortality.[71,104–101] The pattern of PA behaviour over 24 hours is believed to relate to changes in physical and psychological well-being in COPD. For example, spending more time in higher intensity PA and more time sleeping has been associated with benefits in HRQoL and less symptoms[82], whereas spending more time sedentary has been associated with more COPD symptoms and lower HRQoL.[107] This evidence supports the suggestion of the health benefits of substituting sedentary time for time spent in light activities throughout the day.[108]

Rationale for physical activity interventions

A priority of COPD management is to equip patients with the necessary skills and confidence to self-manage their condition, thereby increasing patients' general well-being and decreasing incidences of exacerbations and hospitalisations.[1,52] Promotion of PA in COPD is a priority in COPD management due to its beneficial impact on patients' overall health.[1]

1.4 Pulmonary rehabilitation

One of the leading treatments for COPD is pulmonary rehabilitation (PR), defined as "a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behaviour change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviour".[109]

PR course characteristics such as setting, intensity and duration differ slightly according to contexts. Recommendations state that patients should attend at least twelve sessions of PR for optimal benefits. However, in programmes shorter than 6 weeks, sessions should be tailored to the individual.[110] The setting ranges between programmes, for example

some are delivered within hospitals, whereas others are community or home-based programmes. Hospital based PR is the most common type of programme, yet barriers such as funding and travel issues for patients limit the availability and appropriateness of these. Community based PR is an alternative for those patients who can only travel a short distance. Home based programmes are therefore an alternative for those who cannot travel to community centres or for patients who have mobility issues. Importantly, these types of PR are found to result in similar benefits to patients.[111–113] The recommended intensity and duration also range between programmes, but the general recommendation is to deliver two exercise sessions per week.[110] Optimum benefits of programmes are believed to be achieved for PR programmes delivered for at least 6-8 weeks.[114] PR delivered within hospitals and other areas of the community are group based, including approximately 8-16 patients.

The exercise component of PR includes a variety of activities, dependent on the setting but usually contains an aerobic exercise component and resistance exercises. For example, hospital-based settings may have specialist equipment. However, community programmes require minimal equipment (e.g. 'sit to stand' exercises using a chair), so they are transferable to the home. Home based PR is tailored to the equipment individuals have at home and patients are encouraged to engage in regular PA five times weekly, for 30 minutes.[110] The educational component of PR contains information on various topics, such as the benefits of regular PA, and the management of exacerbations and breathlessness. The team delivering PR is multidisciplinary and includes a clinical lead and other trained HCPs such as nurses and physiotherapists. The impact of PR is assessed by a change in exercise capacity and QoL based on assessments pre and post PR. These assessments include the Incremental Shuttle Walk Test (ISWT)[115], Endurance Shuttle Walk Test (ESWT)[116], Chronic Respiratory Disease Questionnaire (CRQ)[117] and the Hospital and Anxiety Depression Scale (HADS).[118]

Benefits of pulmonary rehabilitation

The key benefits of PR include clinically important improvements in breathlessness, QoL, and exercise capacity and reductions in anxiety and depression symptoms.[110–122] It is recognised as one of the leading cost-effective treatments provided by the NHS, with the cost per quality-adjusted year (QULY) as £2000-£8000.[123] Evidence for the impact and benefits of PR are widely recognised in a series of systematic reviews that compare PR to usual care. The consistent evidence in this area have led to the consensus that PR is beneficial to patients, and that research is no longer warranted to test whether PR alone has beneficial impact on patient outcomes.[119] Findings from the clinical and organisational audits of PR services in England and Wales 2017 (National Asthma and COPD Audit Programme

2018) identified clinical outcomes for those who complete PR are excellent.[124] PR is recognised as successful in increasing patients' exercise capacity and the audit identified a medium improvement in the incremental shuttle walk test (ISWT) and six-minute walk test (6MWT). However, these benefits appear return to baseline (pre-PR levels) within 6-12 months.[125,127]

1.5 Physical activity following pulmonary rehabilitation

Exercise capacity has been regarded by some to be key to modifying PA in COPD.[128] However, increased exercise capacity is not necessarily accompanied by an increase in daily PA and the benefits of PR decrease over time.[1,127] One recent study examined the relationship between baseline exercise tolerance (prior to PR) and PA maintenance following PR and found a positive association between performance on the 6MWT and PA improvement.[75] These findings are contested by results in a longitudinal study which identified a decline in PA despite the maintenance of exercise capacity over time.[129] However, there have been many studies which identify that PA is not maintained in the long-term following PR.[55,128] This evidence suggests that PR is not yet successful at achieving long term behaviour change in patients, which represents a global challenge of PR.[1]

Physical activity options following pulmonary rehabilitation

Usual care following completion of PR generally includes discharging patients and referring them to their primary care provider with no formal follow-up or support to maintain the benefits of PR.[110] The latest GOLD (Global Initiative for Chronic Obstructive Lung Disease) report and the British Thoracic Society guidelines on PR in adults states that patients should be offered a maintenance programme or sufficiently supported to engage in daily PA.[1,105] Patients are generally encouraged to maintain PA and to explore their options post PR, for example to discuss their home exercise plan, to identify local exercise and PA 'follow on' groups and classes suitable for the participant.[110] However, the method for supporting patients beyond PR is not made clear and the referral of the patient back to their GP makes it difficult to ensure maintenance of PA.

Evidence suggests that behavioural interventions to promote PA can help support patients to stay active following PR[130], yet these interventions have not been adopted by the NHS. One 'follow on' option for patients includes structured exercises classes. Following completion of PR, HCPs may refer eligible patients (those not meeting the recommended PA guidelines) to an exercise referral scheme. An exercise referral scheme includes an assessment from a HCP to determine whether an inactive person, with an existing health condition, would benefit from the opportunity to participate in a PA programme.[131] The exercise referral scheme should include techniques outlined in the 'Behaviour change:

individual approaches' NICE public health guidance, such as the recognition when people are more open to change, agreement of goals and the development of action plans to facilitate behaviour change.[132] Though exercise referrals are a positive option for patients[133], barriers such as time constraints impacted HCPs likelihood of making referrals[134] and limitations associated with the service, e.g. including cost, travel and general maintenance. However, the levels of patient uptake and adherence in the general population is limited, which can be attributed to various factors[133], such as age and gender. For example, females were more likely to uptake exercise referral schemes, though males were more likely to adhere to the scheme, and increasing age was positively linked to both uptake and adherence.[133] Furthermore, evidence suggests that patients enjoy the peer social support in PR[137,127], and limited uptake and adherence of the exercise referral scheme is possibly based on the limited peer support this scheme enables.

Follow on groups are another option for patients following PR. One such follow on group includes Breathe Easy groups, support networks of the British Lung Foundation (BLF), which are voluntary support groups which aim to promote self-management.[138] Evidence suggests that individuals gain beneficial advice from these groups. Previously, the NHS were involved in integrating Breathe Easy groups into a respiratory pathway, however this has not been streamlined. There has also been evidence of limited discussion of Breathe Easy groups from HCPs during PR, which represents a barrier for patients in accessing these groups.[139]

Another option for patients is to join a non-formal exercise group (those which are not supported by the BLF), which are generally formed by patients who have already completed PR, and hence provide peer social support for group members. These groups offer a continuation of peer support following participation in PR. However, lack of formal supervision from HCPs means that there are variations in the focus of PA. For example, some groups may focus on social support, whereas others may focus on maintenance of PA. Due to limited research on non-formal exercise groups, it is not possible to report the prevalence and popularity of these groups post PR.

Understanding the determinants of physical activity in patients with COPD

Previous research has attempted to identify the factors that affect patients' PA levels[140] and reports themes which include, but are not limited to, peer social support, interactions with HCPs, mobility and transport limitations, loneliness, anxiety and depression.[137,127] The large number of factors that affect peoples' PA reflects the complexity of PA behaviour.

These findings are reflected in the results from previous systematic reviews which identified the factors that impacted PA before and during PR for patients with COPD and general lung conditions[140,143]. For example, facilitators included social and professional support, recognition of improvements, the environment and opportunities following PR. The barriers

included lack of support, fear, or apprehension of changes in health and environmental factors. Results from these reviews highlighted the multitude of factors associated with PA and PR, and that individual differences exist regarding perceived facilitators and barriers to PA.

Despite the research in this area[140], PA is not maintained following PR. This could be attributed to limited understanding of the patient reported facilitators and barriers of PA of those that attend and complete PR. No review has addressed the factors which influence the maintenance of PA and long-term behaviour change following PR, where the focus shifts to self-management of PA. The themes reported in previous reviews may not represent patients who attend and complete PR. These patients may represent a subgroup who are proactive and motivated to engage in a programme to enhance self-management of their condition. It is possible that interventions based on existing research have been unsuccessful due to limited insight of the target population. Specific factors are proposed to be involved in maintenance of behaviour, different from those involved in behaviour initiation.[144] However, these factors have not been explored in this specific population. Understanding behavioural factors is key in designing a successful intervention aimed at maintaining PA behaviour.[145]

1.6 Interventions to promote physical activity in patients with COPD

There is an accumulation of research which has investigated the efficacy of interventions aimed to promote PA in patients with COPD.[130,140] In 2014, the official European Respiratory Society's statement on PA in COPD reported key areas for further research.[55] These included conducting research to understand the factors that optimise the impact of non-pharmacological interventions to promote PA in COPD and to incorporate behaviour change strategies such a self-monitoring and goal setting.[55]

A more recent systematic review and a meta-analyses of interventions demonstrated the efficacy of counselling in conjunction with PR to improve PA.[130,140] Assessment and feedback of PA levels, tailored motivational messages and individualised PA goals were also considered effective behavioural strategies[130] in promoting PA.

These results support recommendations from the ERS.[55] Interventions to promote PA in COPD including only bronchodilators, non-invasive ventilations or dietary lifestyle changes, have not been considered efficacious in promoting PA. However, they may facilitate interventions if combined with counselling.[130,141] Whilst there was limited evidence to support the efficacy of interventions such as inspiratory muscle training, walking and high intensity interval training, researchers have called for these strategies to be explored.[130]

However, studies not included in these reviews, or recent studies conducted following the publication of these systematic reviews, provide conflicting results, and the incorporation

of pedometers and counselling have had mixed results.[82,83,91,92,90,137] For example, some studies which have incorporated pedometer and/or counselling as an intervention component have been successful[86,87,94,148], though others have not.[91,92]

Interventions to promote physical activity following pulmonary rehabilitation

The results from a systematic review of interventions to modify physical activity in COPD outlined that most interventions that were combined with PR programmes resulted in increased PA levels.[130] It is possible that the intensity of an intervention also impacts the efficacy of the intervention in promoting PA, which may explain why PR combined with counselling results in more beneficial outcomes. This evidence was based on the identification of studies which had a positive effect of on patients' PA, yet there was no meta-synthesis to identify the intervention components which were associated with better patient outcomes, due to large levels of heterogeneity across the included studies.[130] Despite these results, interventions to promote long term PA following PR have reported limited efficacy.[130,140] Research has measured the impact of the length of PR on long-term PA, and evidence suggests that longer-lasting PR programmes are more effective than shorter programmes in increasing PA levels[130], perhaps because the translation of exercise capacity to PA requires a longer training period.[74] Evidence suggests that exercise training has short-term increases in PA.[146,149] However, interventions solely based on exercise training do not appear to support long term PA in COPD.[109,146,150]

Interventions with a primary aim to promote PA following PR often include intervention components such as counselling[91] (often based on motivational interviewing principles)[85,88], pedometers[84,91,90,137], step diaries[91,90], goal setting[91,90] and social support.[84,84,91,90] These components are often grouped together, for example pedometer and counselling/social support methods are often reported strategies.[84,91,90] Though some of these studies reported a statistically significant impact of the intervention on PA[85,94,148,151], this was not unanimous across studies[84,91,143], questioning the appropriateness of these intervention components. The heterogeneity of these studies (including wide variation in the context, duration, and frequency of these interventions) add complexity into the measurement of intervention efficacy. For example, intervention providers varied between studies and included physiotherapists[94,148], trained counsellors[85], and/or the research team themselves.[84,91] Duration ranged from 12 weeks to 12 months and the frequency of components delivered across the intervention, such as counselling, widely ranged between the studies.[84,84,91] The context of the interventions also varied, for example many interventions were delivered in conjunction with PR[84,84,91,90,137,143], a programme which also varied in setting, duration and frequency.

Methodological limitations of previous interventions

The results of previous interventions should be considered alongside their methodological limitations. Previous systematic reviews of interventions to promote PA have reported general low quality of evidence, including a lack of randomised controlled trials, allocation concealment, small sample size and blinding procedures.[130,140] Lack of information about important intervention characteristics, such as patients' prior completion of PR, also prevented researchers from understanding potential moderating factors.[153] Small sample sizes of studies were the primary concern for one author[153], who called for further larger scale trials to corroborate the true effects on intervention components such as counselling.

Furthermore, researchers reported a lack of long-term interventions.[130,140] Although there has since been a number of interventions delivered for longer than 6 months[82,84,91,137,145,142], there has been very few interventions which have been delivered for up to one year.[86,148] Though longer-term interventions may acquire additional resources (time; cost), components such as pedometers and technical/telephone support would contribute to relatively low-maintenance interventions.[86,87,94] Longer term application of intervention with these components therefore represent a feasible option for HCPs and warrant further investigation.

Limited efficacy in previous interventions has been attributed to limited understanding and insight into the patient reported facilitators and barriers of PA following PR in COPD.[155] This is because the methods used to measure the impact of previous interventions relied on objective measures of PA such as device measures (activity monitors).[130,140] Application of qualitative research can gain insight into the acceptability of interventions and their mechanisms of action. Use of mixed methods enables researchers to gain a comprehensive understanding of the effectiveness of health interventions, providing complementary data to explain quantitative findings in randomised controlled trials. For example, a qualitative study investigating the application of mobile health in self-management in COPD[156] enabled researchers to identify patients' concerns, transitions and experiences of mobile health, and the reasons why the majority of individuals ultimately accepted the intervention. Also, a qualitative study on patient views on self-management programmes in COPD enabled researchers to identify the importance of factors such as social support and practical, physical and emotional barriers to attendance.[157] Results from these studies highlight the value of qualitative methods[158], as they were able to capture individuals' insights and experiences from interventions, as they go beyond objective data that is collected in quantitative studies, such as randomised controlled trials.

1.7 Development of Complex Interventions

Interventions to promote behaviour change are often categorised as complex.[159,151] Limited efficacy in the promotion of PA following PR in COPD may reflect the challenges involved in the development of a complex intervention, which lead to methodological limitations.[130,140,152] Interventions can be classed as complex for various reasons, for example when there are: interactions between intervention components; variability of outcomes and flexibility/tailoring of the intervention and various behaviours of those delivering and receiving the intervention.[159] Researchers are required to take steps in the development and evaluation of the interventions to account for this complexity. The Medical Research Council (MRC) provides guidance on the development and evaluation of complex interventions and outlines four intervention stages: development, feasibility and piloting, evaluation and implementation.[159] The steps involved in intervention development include the identification of the evidence base, the identification/development of an appropriate theory; and finally, modelling the process and outcomes (**Figure 1:1**). In other words, the intervention developers need to have a theoretical understanding of how the intervention may cause change. The next stage includes the feasibility and piloting of an intervention, which is beneficial as it enables an assessment of the recruitment and retention rates within an intervention, as well as the fidelity and overarching acceptability of an intervention. This stage therefore enables the identification of any teething problems prior to the design and completion of a full-scale trial.[145]

The evaluation of an intervention requires consideration of the study design, outcome measures and follow up periods. Process evaluations are recommended by the MRC as these enable the identification of how and why an intervention may or may not be successful, for example by identifying the contextual factors that may have impacted the outcomes, as well and the quality of intervention implementation (**Figure 1:2**).[160]

The MRC framework reports the importance of theory in the development of a complex intervention[159], but does not direct intervention development towards a specific theory.[161] Theory has previously been defined as “a set of statements that organise, predict and explain observations”.[144] Use of theory in the development and evaluation of interventions is beneficial as it enables the researcher to systematically identify what needs to change, how this needs to change, and the outcomes that need to be evaluated. However, evidence outlines limited use of theory in health behaviour interventions. In a systematic review and meta-analysis to investigate the extent and role of theory in the effectiveness of the health behaviour interventions, the results outlined limited reporting of a theory base (approximately half of the studies reported theory).[162] Of these studies, the majority (90%)

did not clearly link their chosen behaviour change strategies (active ingredients of the intervention) with a theoretical construct. This prevents researchers understanding the role of specific theories in the development of interventions, and how a specific construct may contribute to intervention efficacy.[145] Limited role of theory in this area reflects a gap between intervention design recommendations and research practice.

A recent review of the role of theory in the effectiveness of PA interventions in adults with chronic disease reported the promising impact of theory in intervention development.[163] Also, in a recent systematic review of the role of behaviour change theory in interventions to enhance adherence in chronic respiratory disease, the results support the role of behaviour change theory in intervention efficacy.[164]

Despite the beneficial role of theory, only few behavioural interventions aimed to promote PA following PR in COPD have referred to theory.[84,84,92,90,165] The extent to which these interventions are based on theory is not well understood. For example, one study reported that their intervention was based on the Social Cognitive Theory[166], whereas others report using Motivational Interviewing techniques[85,88], but they do not describe the extent to which theory contributed to the development of the intervention. Limited detail of the theoretical constructs further contributes to low understanding of the role of specific theory in the efficacy of interventions.

1.7.1 Behaviour change theories

When selecting a behaviour change theory to apply to the development and delivery of an intervention, it is important to consider the strengths, limitations, and relevance of the types of theories available. Behavioural theories are selected based on the relevance of the constructs in explaining the target behaviour. Early models, such as social learning theory[167] and the Health Belief Model[168], are extremely prevalent in behaviour change literature[169] and their simplistic design provide an understandable explanation for behaviour. However, one limitation of these models is that they are reductionist in nature and focus on the role of beliefs and intentions on health behaviour[170], while ignoring factors such as motivation and external factors. More recent models, including the social cognitive theory[166] and the transtheoretical model[171] build upon these limitations. For example, the social cognitive theory recognises the importance of socio-structural factors[166] and the transtheoretical model[171] recognises that behaviour change is dynamic and does not occur in a linear fashion. However, these models are still contested. For example, the social cognitive theory continues to omit factors such as habits and emotions and the transtheoretical model may ignore factors such as the role of factors such as socioeconomic status in behaviour change.

Evidence suggests that there are a wide range of factors that may prevent or support people with COPD to be active.[140] However, there is still limited understanding of the specifc factors that impact patients' PA following PR.[128,155] When little is known about the factors that determine an individuals' behaviour, it is important to select a model which is sufficiently broad enough to capture a wide range of behavioural sources.[145] More recent models, such as the COM-B (Capability, Opportunity, Motivation- Behaviour) model, which is situated at the core of a behaviour change framework known as the Behaviour Change Wheel (BCW)[145], recognises the potential impact of various behavioural sources.

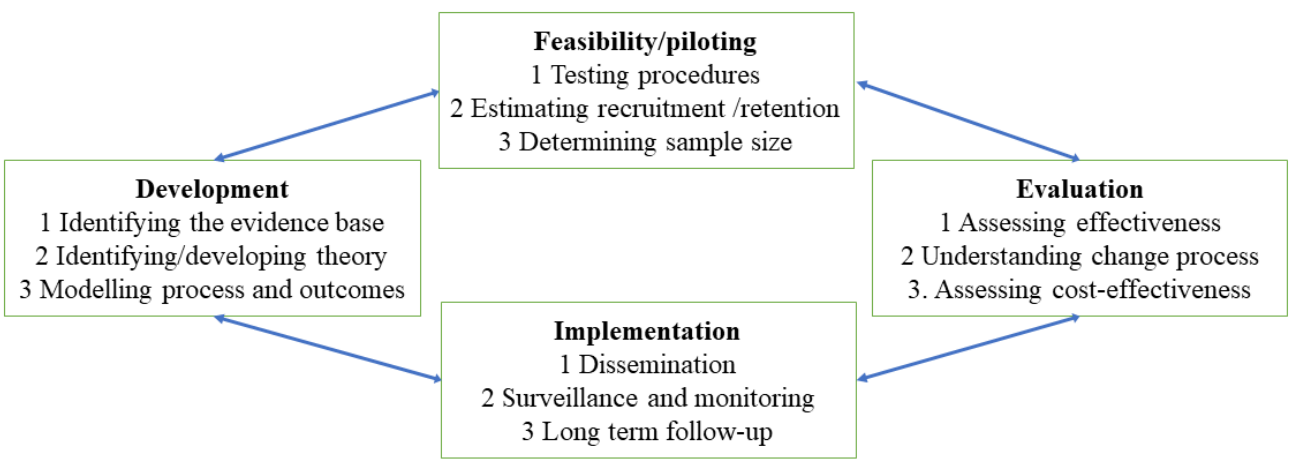

Figure 1:1: The key elements of the development and evaluation process of a complex intervention, as reported in the MRC guidance

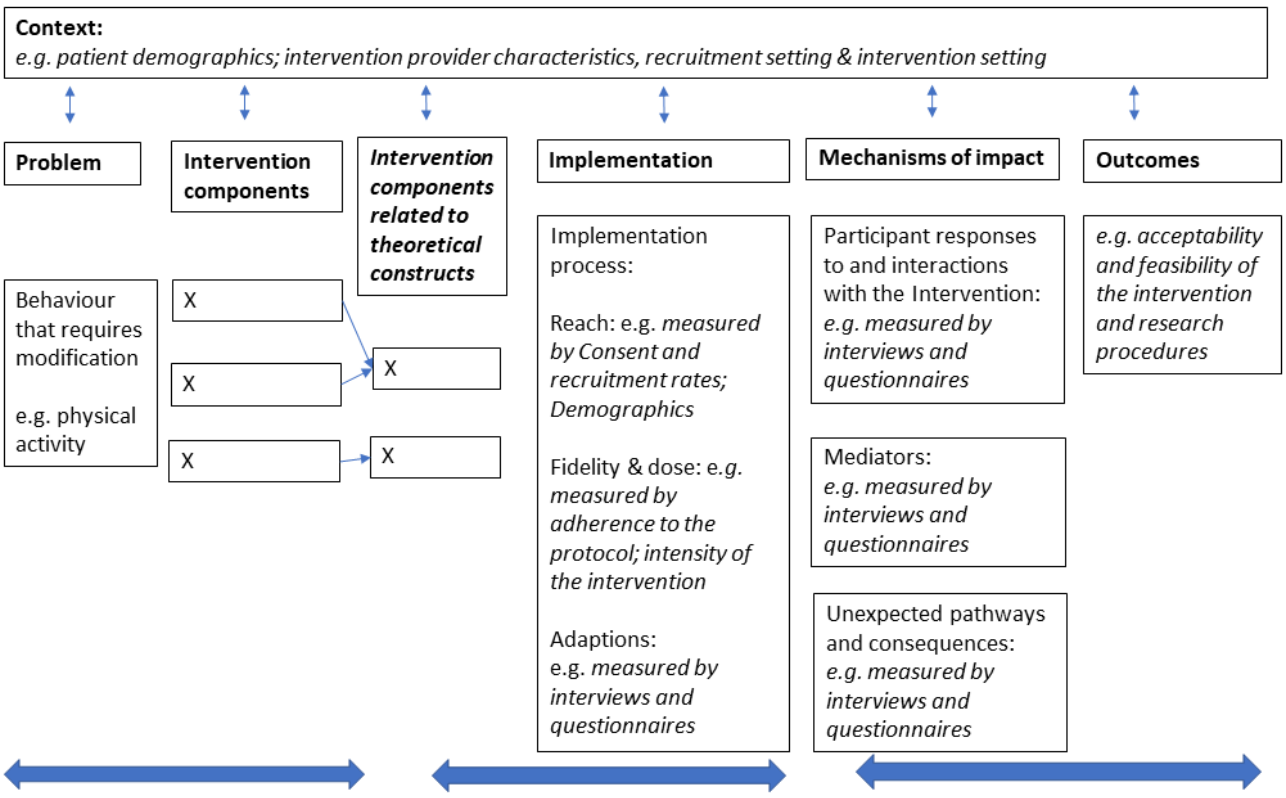

Figure 1:2: An edited MRC diagram which outlines the behavioural constructs linked to an intervention and highlights the key functions of process evaluations and the relationships amongst them

1.7.2 Behaviour Change Frameworks

The MRC states that intervention development should be a systematic process, based on a coherent and relevant theoretical framework[159], using the best available evidence. Despite this guidance, many previous interventions are believed to simply be the result of intervention designers' belief that they 'seemed like a good idea at the time'.[145] There is limited detail reporting the rationale and evidence base and it is not clear how these interventions are the result of prior evidence development.[145]

The development of an intervention requires many decisions to be made, which are not just limited to the content. The diversity and complexity of interventions makes the evaluation of their effectiveness challenging.[145] For example, interventions can be single or multicomponent and the content, intensity, duration, and fidelity of interventions all differ. This means that identifying the active ingredients of interventions is challenging. These decisions may be guided by the target behaviour (e.g. PA) but are also underpinned by contextual factors such as setting and available resources (e.g. time and money). Behaviour change frameworks are developed to facilitate the design of interventions by drawing attention to the range of options available, specifically those that may complement the behavioural target, and subsequently using the framework to systematically design an intervention. By implementing a systematic approach to the development of interventions, this removes the likelihood of designing interventions based on favoured theory or a 'common sense approach', based on individuals' previous experiences without explicit use of evidence-based theory.[145]

1.7.3 The Behaviour Change Wheel (BCW)

Behavioural frameworks such as Mindspace[172] and Intervention Mapping[173] are popular frameworks which can provide intervention development guidance. However, the comprehensiveness of these frameworks are limited, for example they are not necessarily linked to a model of behaviour change and/or applicable to a broad range of behaviour.[145] The BCW addresses previous limitations of behaviour change frameworks and is considered a comprehensive tool to aid in intervention development.[145]

The BCW originated from the synthesis of 19 frameworks of behaviour change.[145] At the core of the model, there are three components which represent sources of behaviour: capability (psychological and physical); opportunity (social and physical) and motivation (reflective and automatic) **Figure 1:3**. These components are directly related to behaviour, and it is stated that one or more of these components need to be altered for behaviour change to occur. The ring surrounding these sources of behaviour list intervention functions and the third (and final) ring surrounding the intervention functions list the seven policy categories

that one can use to deliver a certain intervention function. The final step in the BCW, which is not illustrated on the wheel, is the identification of behaviour change techniques (BCTs) and the mode of delivery included in an intervention. The APEASE criteria guides the movement between the stages in the BCW by encouraging informed decisions of an intervention's Affordability, Practicability, Effectiveness and Cost-Effectiveness, Acceptability, Side-effects and Safety and Equity.[145]

The BCW has been used in the development and evaluation of interventions to modify PA behaviour in COPD and there have been calls for further adoption of this framework within intervention development in the area.[165,175] However, it has limited application in the development of interventions to promote PA following PR.[176]

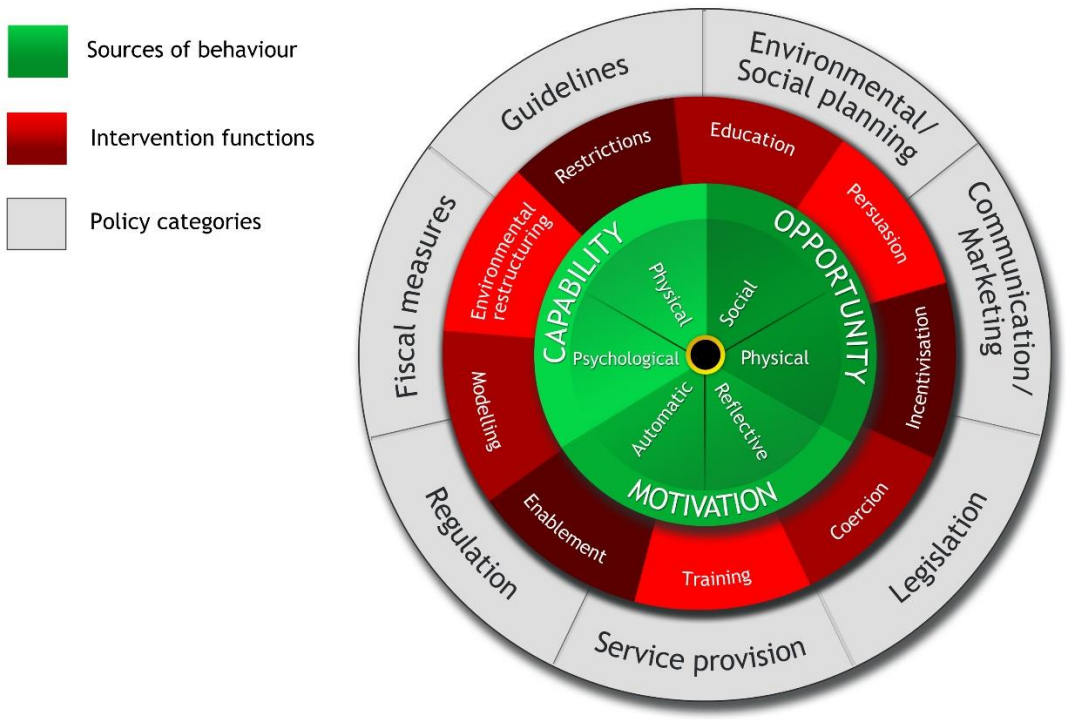

Figure 1:3: The BCW, illustrating the COM-B behaviour change model, Intervention Functions and Policy Categories.[145]

1.8 Stakeholder involvement in research

The MRC guidance reports that the inclusion of stakeholder interviews can also facilitate the identification and development of appropriate theory.[159] The inclusion of patient and public in the research process, typically known as 'patient and public involvement' (PPI) or 'lay involvement' provides numerous benefits at different stages of the development and evaluation process. PPI is considered as a partnership between researchers and/or members of the public and patients[177] and PPI may include individuals who are, or have, used health and social care services and those who are interested in a particular topic.

1.8.1 Benefits of PPI in research

PPI is gaining prevalence in grant applications and study protocols[178] and has been widely recognised by those involved in the research process, for example including funders, regulators and publishers.[177] PPI facilitates research at various stages of the development-

evaluation-implementation process of complex interventions.[159] For example, PPI can facilitate the identification and prioritisation of research topics such as study design, and PPI can contribute to writing patient information sheets, recruitment and the evaluation and dissemination of research results.[178,179] PPI has had a positive impact on the quality and appropriateness of research.[178,179] For example, in a systematic review of the role of PPI in clinical trials, authors found that PPI significantly increased the odds of participant enrolment.[180] Evidence also suggests that involvement of individuals with personal experiences of the condition was associated with higher enrolment of participants.[180]

1.8.2 PPI in COPD research

The limited efficacy of previous interventions to promote PA following PR in COPD has been attributed to limited understanding of the determinants of PA behaviour.[155] In a recent study to understand what matters for people with COPD[181], researchers brought patients, carers and HCPs together in workshops to consider strategies to benefit patients. HCPs benefitted from witnessing the lived experiences of patients and gaining wisdom that can improve the efficacy of further interventions.[182] This study highlighted the importance of PPI within research, particularly when new knowledge can be disseminated between different groups of stakeholders.

There are various challenges involved in applying PPI across all processes involved in the development, evaluation, and implementation of interventions. For example, challenges include the time-consuming nature of PPI; potential clashes of opinions between stakeholder groups; and limited guidance and understanding on how to report PPI.[178] However, evidence from previous studies which involve patients and HCPs in the development[183,184] and delivery[185–188] of interventions clearly supports the beneficial role of PPI in all process of research. The involvement of PPI is therefore a clear priority in further research.

1.8.3 Lay volunteers in health research

Inclusion of patients and the public within the delivery of health interventions also represents a potential strategy to improve the impact of an intervention. Evidence supports the inclusion of social support via HCPs to promote PA following PR in COPD.[84,84,91,90,143] However, there has been limited investigation of the inclusion of peer support as an intervention component following PR, despite the perceived importance of peer support. One study has conducted focus groups and interviews with COPD patients to inform the development of a peer supported PR programme.[189] Similar to previous research[190,221,191,192], patients considered support after PR as critical to maintaining the beneficial effects of the programme.

Recent evidence has provided support for the feasibility and acceptability of peer support in the PR pathway, specifically prior to and during the programme. White et al

(2019)[185] recently tested the feasibility of recruiting and training PR graduates (COPD patients) to become lay health workers and support the uptake and completion of PR. The results of the study outlined that there was high engagement of PR graduates in the lay health worker scheme (almost 40%). Feedback from this study suggested that COPD patients and lay health workers found the intervention acceptable. A similar approach has also been adopted in non-COPD populations. For example, in the promotion of healthy behaviour in a smoking cessation intervention, whereby individuals received social support via WhatsApp and Facebook from a trained moderator, the intervention was effective in reducing relapse.[193]

Training of lay volunteers in the delivery of health interventions is an approach which has previously been adopted[185] and it is both recommended and adopted within intervention delivery for health management.[185–188] It has been adopted in COPD management, for example, research into the acceptability of PR found that patients welcomed the support of patients who had already completed the treatment.[185,189] In a recent study to investigate the impact of a peer educator in the maintenance of health and functional outcomes after PR, evidence supports the inclusion of lay volunteers in future research.[189]

1.9 Summary

Despite the importance of PA to patients' physical and psychological health, PA in COPD is significantly lower than age matched healthy individuals. PR, a structured PA intervention, is an important treatment for COPD, and results in benefits such as improved exercise capacity, symptoms, and disease specific Quality of Life (QoL). However, this does not translate to an increase in long- term PA and previous interventions to promote PA following PR have had limited efficacy. There are currently a range of factors that contribute to gaps in our knowledge of how best to support individuals to stay active following PR. These factors include limited understanding of the determinants of PA following PR; limited understanding of the processes that contributed to the efficacy of interventions; limited application of theory and behaviour change frameworks in intervention development; and limited involvement of Patient and Public Involvement (PPI) in previous interventions. There is a clear need for a step wise approach to the development of an intervention to promote PA following PR in patients with COPD.

2 Chapter 2: Facilitators and barriers to physical activity following pulmonary rehabilitation in COPD: a systematic review of qualitative studies

2.1 Abstract

Background: PR has short-term benefits on exercise capacity and QoL in COPD, but evidence suggests that this does not translate to increased daily PA on a patient level. This is attributed to a limited understanding of the determinants of PA maintenance following PR.
Aim: This chapter reports the systematic review of qualitative research to understand COPD patients' perceived facilitators and barriers to PA following PR.
Methods: Electronic databases of published data, non-published data and trial registers were searched to identify qualitative studies (interviews, focus groups) reporting the facilitators and barriers to PA following PR for people with COPD. Thematic synthesis of qualitative data was adopted involving line-by-line coding of the findings of the included studies, development of descriptive themes and generation of analytical themes.
Results: Fourteen studies including 167 COPD patients met the inclusion criteria. Seven sub-themes were identified as influential to PA following PR. These included: intentions, self-efficacy, feedback of capabilities and improvements, relationship with HCPs, peer interaction, opportunities following PR and routine. These encapsulated the facilitators and barriers to PA following PR and were identified as sub-themes within the three analytical themes, which were beliefs, social support, and the environment.
Conclusion: The findings highlight the challenge of promoting PA following PR for patients with COPD, provide complementary evidence to aid evaluations of interventions already attempted in this area, but also adds insight into the future development of interventions targeting PA maintenance in COPD.

2.2 Introduction

As reported in the literature review (Chapter 1), PA is a complex behaviour[137,140,188–193], but thus far, syntheses of the research surrounding PA following PR is predominantly based on randomised controlled trials (RCTs) using quantitative methods alone.[197–199] These methods do not capture individuals' insights on how and why interventions did, or did not promote PA. The use of qualitative methods enables researchers to gain a comprehensive

understanding of the effectiveness of health interventions, providing complementary data to quantitative findings in RCTs. Systematic reviews of qualitative studies have provided evidence towards understanding COPD patients' subjective view of the impact of PR[137], and the barriers and enablers to participation in structured PA (i.e. exercise/PR programmes).[140] Such evidence does not address the factors which influence the maintenance of PA and long-term behaviour change following PR, where the focus shifts to self-management of PA. Specific factors are proposed to be involved in maintenance of behaviour, different from those involved in behaviour initiation[144], however, these factors have not been explored in this specific population.

There is a need for a better insight into the patient subjective experience of PA following completion of PR to inform future practice and policies surrounding support of long-term adherence to health-enhancing behaviour in COPD. The aim of this systematic review was to therefore provide a comprehensive synthesis of the patient reported facilitators and barriers of PA following completion of PR, among individuals with COPD.

2.3 Methods

2.3.1 Protocol

The Protocol for this review was registered on the international prospective register of systematic reviews (PROSPERO) (CRD42017058274). This review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[200] guidelines and Enhanced Transparency of Reporting the Synthesis of Qualitative Researchframework.[201]

2.3.2 Eligibility criteria

Study design: Qualitative studies (Interviews, focus groups) or mixed methods designs which included qualitative data.

Participants: Adults with a diagnosis of COPD who have completed PR.

Exposure: Discussion of PA, which was defined as any bodily movement produced by skeletal muscles that results in energy expenditure[48], for example experience of structured exercise such as fitness classes or walking groups, to activities of daily living such as shopping, meal preparing or housework following PR.

Outcomes: Facilitators and barriers to PA following PR in COPD.

2.3.3 Searching

A comprehensive search strategy was used between February 2017 and October 2017 to identify all relevant available studies. DARE, PROSPERO, Cochrane Airways and Cochrane Database of Systematic Reviews (CDSR) were searched for ongoing and published reviews. For published original studies the following databases were searched: MEDLINE, Embase, Web of Science, CINAHL, ASSIA, PsycINFO and SPORTDiscus. An example of a full search strategy for one database (MEDLINE) is provided in Appendix A, (p285). Database searches were also supplemented with internet searches (e.g. Google Scholar) and contact with study authors and experts when required. Forward and backward citation tracking from included studies and review articles were also conducted to identify relevant papers. ClinicalTrials.gov, and Current Controlled Trials were searched for completed and ongoing trials. DART Europe E theses, EThOS, Open Grey, The New York Academy of Medicine, ProQuest Dissertations, theses.org and Conference Proceedings Citation Index (Web of Science) were searched for unpublished data. All references were exported and stored in EndNote.

2.3.4 Study screening

Two reviewers independently screened the titles and abstracts for inclusion against the defined eligibility criteria. Full text articles were retrieved for articles that were not excluded based on title or abstract. Further independent screening of full texts was performed to determine eligibility with any disagreement between two reviewers resolved by consensus.

2.3.5 Data extraction

Data from the included papers was extracted by two reviewers and was completed using a bespoke data collection form for qualitative research based on the UK National Institute for Health and Care Excellence (NICE) universal template.[202] To facilitate synthesis of qualitative data, all studies were uploaded on to NVivo 11 Pro.[203]

2.3.6 Critical appraisal

Two reviewers independently performed a critical appraisal of each included study, through use of the Specialist Unit for Review Evidence (SURE) checklist (2015).[204] This checklist is adapted and updated from the former Health Evidence Bulletins Wales checklist with reference to the NICE Public Health Methods Manual (2012) and previous versions of the Critical Appraisal Skills Programme checklists. Discrepancies were resolved through discussion between two reviewers. Studies were not excluded or weighted based on the quality assessment.

2.3.7 Data synthesis

Thematic analysis was the inductive approach used for synthesising the data from each study, an approach used to identify themes and patterns in qualitative research.[205] This approach has previously been adopted to synthesise qualitative data in systematic reviews.[200–205] Thematic synthesis was completed in three stages: the coding of text 'line-by-line', the generation of 'descriptive themes' and the generation of 'analytical themes'.[210] Initially, the review question was put to one side to enable an analysis that was close to the data of the original studies and prevented reviewers imposing the data on to an existing framework. Participant quotations within the findings/results section of each included study were coded according to meaning and content. A 'bank' of codes were derived from the studies, and new codes were formed when necessary. Similarities and differences between the codes were explored, and codes were placed into a hierarchical structure and these represented the descriptive themes.

The final stage of analysis involved engaging with the descriptive themes to answer the review question. This was an iterative process, which involved making inferences from the data about the facilitators and barriers to PA following PR, as well as considering implications regarding intervention development. To reduce bias, three reviewers independently coded the extracted data, produced descriptive themes, and reviewed and discussed analytical themes.

2.4 Results

2.4.1 Study selection

Following removal of duplicates, searching identified 2392 records for eligibility assessment, of which 2340 were excluded based on title and abstract (**Figure 2:1**). Full text screening of the remaining records resulted in 18 records that were eligible for the review. A full list of excluded studies, together with reasons for exclusion can be found in Appendix B, p287. However, only 14 studies were included within the synthesis (n=12 published articles; n=2 theses). In two cases, records referred to the same study[214–216] and the remaining studies[205,219] (n=2) were presented only as conference abstracts. These were identified as relevant to the research question of this review, but not eligible for inclusion within the synthesis of the results due to lack of availability of participant quotations.[205] Authors of these studies were contacted for more information, however there was no response from authors.

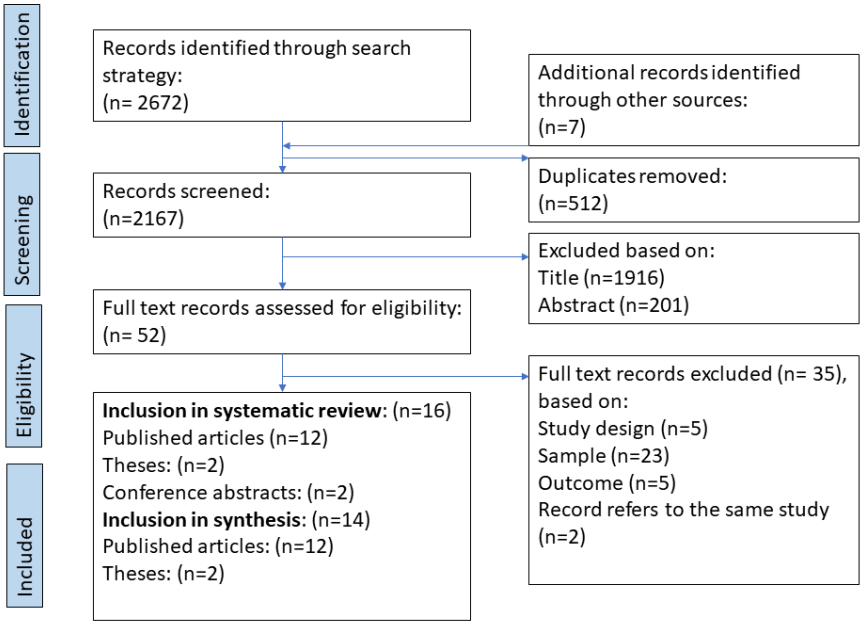

Figure 2:1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart representing the study screening process

2.4.2 Study characteristics

Twelve studies were of a qualitative study design only, and two studies were of a mixed-method design[214] (Appendix C, p290). Studies were conducted in Canada[216,211,221], Norway[214,213,224], Netherlands[225], England[187–230], USA[230,187] and Sweden[233] between 1998-2017. All studies collected data using either semi-structured interviews[211–215,219,230 ,235], open-ended interviews[232], or focus groups.[214,216,216–235] The type of analysis ranged from thematic analysis[214,216,221,213,217], template analysis[235], qualitative content analysis[233,225]; analysis methods informed by grounded theory[216,219,230], methods informed by phenomenology[221,226], and one reported that their analysis adhered to "established guidelines".[215]

Overall, there were a total of 167 individuals diagnosed COPD across the studies (male = 92, female = 75). All participants had previously completed PR, but the treatment varied on setting and duration. The duration of the PR ranged from 4 -12 weeks and individuals attended either inpatient[214,216,211,221,187] and outpatient PR venues[213,215,216,235,230] or the setting was not reported.[224,217,235] Most individuals were not involved in PA maintenance

interventions[219,187,235,227–231,233,225], however some were involved in post-rehabilitation programmes, such as a six-month community exercise maintenance programme[216], a two-year tele-rehabilitation intervention[221] and approximately half of individuals within one study[192] had received input regarding ongoing exercise programmes post-rehabilitation.[192] The context of data collection after completion of PR also varied across studies. The data collection typically occurred at either the individuals' home[211,224,219, 187], the rehabilitation centre[221,215, 187], or a combination of both[213,215,230,235] and data collection settings were not reported in some studies.[216,217,235] All but two of the studies collected data just once following PR. One study conducted two semi-structured interviews[222] and the other conducted three focus groups.[221] Data collection took place between 1-2 weeks and 42 months following completion of PR.

2.4.3 Critical appraisal

Critical appraisal of the studies was conducted by two reviewers, and the results are summarised in **Table 2:1**. All studies were interpreted as having a clearly focused research question or hypothesis, as having an appropriate research design, appropriate justification of sampling strategy, well described method of data collection and an explicit discussion of ethical issues. For each criterion, most studies were interpreted as good quality, with the exception of conflicts of interest and sponsorships, which were reported in eight studies.[221,224,216,217,219–187] In four studies it was unclear how well the researchers knew the participants[216, 221,213,230], and in two studies, no description of the relationship between participant and researcher was reported.[227,233] In one study, the analytical method was not found to be clearly justified.[225] Credibility of two studies were unclear, due to minimal quotations to support themes[215,236] or discussion that was restricted to evaluation of theoretical models, without reference to previous studies.[225] In two studies there was a lack of primary data provided within the text to support the deducted themes and subthemes from the

study. In three studies, authors did not identify limitations[215,235, 187], and in two studies, there were incongruities between the conclusions within the abstract and discussion.[224,187]

Table 2:1: Critical appraisal of the studies (risk of bias)

	Camp (2000)	Desveaux (2013)	Desveaux (2017)	Halding (2011)	Hoaas (2016)	Hogg (2012)	Lewis and Cramp (2010)	Norweg (2008)	Rabinowitz (1998)	Rodgers (2007)	Stewart (2014)	Sundfor (2010)	Williams (2009)	Zakrisson (2014)
Clearly focused question/ hypothesis?	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Is the choice of qualitative method appropriate?	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Is the sampling strategy clearly described and justified?	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Is the method of data collection well described?	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Is the relationship between the researcher(s) and participants explored?	+	?	?	?	+	+	-	?	+	+	+	+	+	-
Are ethical issues explicitly discussed?	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Is the data analysis/ interpretation process described and justified?	+	+	+	+	+	+	+	+	+	+	?	+	+	+
Are the findings credible?	-	+	+	?	+	+	-	+	+	+	+	?	+	+
Are there and sponsorships/ conflicts of interest reported?	+	+	-	-	+	-	-	-	-	+	+	-	-	+
Did the authors identify any limitations?	+	+	+	+	+	+	+	+	-	-	-	+	+	+
Are the conclusions the same in the abstract and discussion?	+	+	+	+	+	+	+	+	?	+	+	?	+	+

(+) = yes; (-) = no; (?) = unclear

2.4.4 Data synthesis

During the synthesis of the data from the fourteen studies included in this review, seven sub-themes were identified as influential to PA following PR, which were organised into three analytical themes including beliefs, social support, and environment. The theme 'beliefs' has three sub-themes, including intentions, self-efficacy and feedback of capabilities and improvements. The theme 'social support' has two sub-themes, including relationship to HCPs and peer interaction and the final theme 'environment' also has two sub-themes, including opportunities following PR and routine (**Figure 2:2**). Facilitators and barriers to PA within these analytical themes are presented within **Table 2:2**, alongside a selection of participant quotes from included studies to reflect these themes. A line of argument, depicting the key analytical themes and sub-themes are reported.

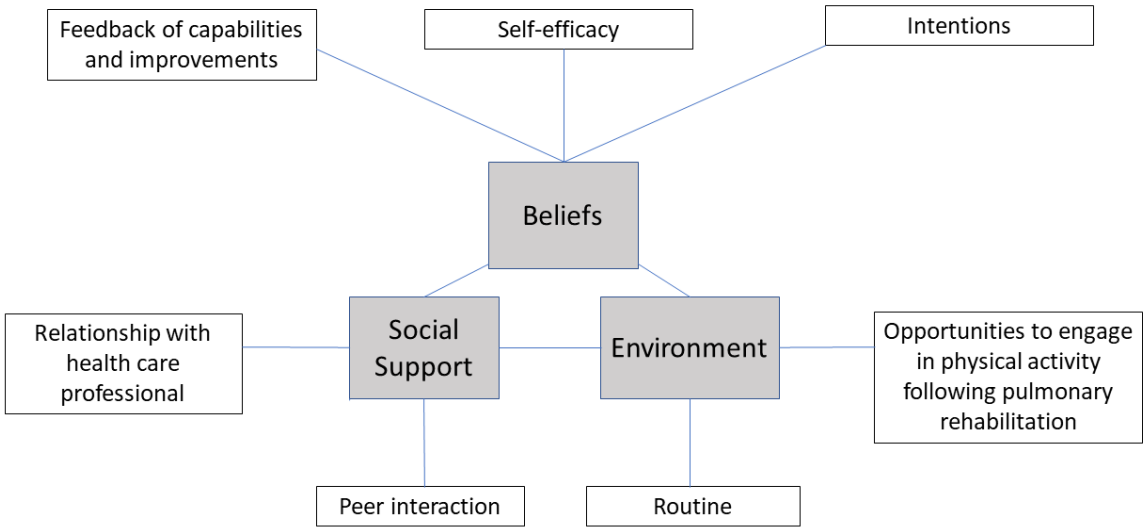

Figure 2:2: Concept map illustrating the key analytical and sub-themes of the facilitators and barriers of PA following PR in patients with COPD

2.4.5 Theme: Beliefs

Thoughts surrounding the importance of PA, previous experiences prior to PR, recognition of improvements following PR and confidence influence individuals' intentions and motivation towards maintenance of PA following PR.

Sub-theme: Intentions

Many individuals held the belief that PA was enjoyable and important for their physical and psychological well-being.[214,213,215,230,187] Individuals' beliefs towards PA often manifested into intentions to be more physically active.[214,213,215,230,187] These beliefs were often influenced by individuals' lifestyles prior to COPD diagnosis. For example, regular engagement in PA prior to COPD diagnosis facilitated positive intentions towards maintaining PA following PR.[231,225] Information and education on PA was also identified as a facilitator to PA following PR, as it increased individuals' understanding of the health benefits associated with PA.[213–216,235,230, 235]

Intentions to be more physically active did not always translate into behaviour change. For example, in one study, individuals repeatedly indicated positive intentions towards PA following PR [232], however they were labelled as non-exercise compliant, highlighting an intention-behaviour gap in PA.

Sub-theme: Self-efficacy

Self-efficacy was a common theme throughout the data, referring to individuals' beliefs in their ability to engage in PA. A barrier to PA maintenance was negative beliefs surrounding PA and health.[224,216,235] These negative beliefs often stemmed from individuals' previous experiences of PA that negatively affected their confidence and perceived capability of engaging in PA following PR. For example, individuals reported PA as too hard and that they were too restricted by symptoms such as breathlessness.[192] Exacerbations and symptoms often led to psychological distress, for example individuals reported feeling overwhelmed, saddened and frustrated by their restrictions due to COPD[214,216,213,224,216,235,187], and these

experiences negatively influenced individuals' confidence to be active. Breathlessness and anxiety were repeatedly reported throughout the studies[213,224,216,187], and this anxiety represented a barrier to PA after PR when individuals were attempting to maintain PA at home or by themselves, especially when individuals felt socially isolated.[222,232] Avoidance was a strategy developed to manage anxiety associated with breathlessness[221,187,226] and individuals did not want to draw attention to themselves by exercising outside of the house.[221] However, confidence to apply stress and breathing management techniques was often a reported facilitator to maintaining PA after PR.[211,213,224,216,219,230] These skills were often learnt during PR, and were associated with feelings of increased self-efficacy and a sense of empowerment,[221,230] and the newfound confidence also coincided with a more positive outlook on life.[215]

Sub-theme: Feedback of capabilities and improvements

Feedback refers to monitoring and providing informative or evaluative information on the performance of PA behaviour.[145] When individuals noticed their personal improvements, or recognised their capabilities[230], they were often more engaged or motivated by the outcomes, and felt empowered to maintain PA.[214,216,215,216,219–235]

This motivation was facilitated by long-term feedback from health professionals, for example in a maintenance tele-rehabilitation study[221], individuals reported that they had improved throughout the course, and felt a sense of accomplishment when discussing their progress, reporting that an upward feeling was important in motivating them to be active.[221] Those who had noticed improvements in health wanted these benefits to be maintained, and reported that they wanted the exercise classes to continue.[192] Positive feedback therefore promoted beliefs of improvement and encouraged individuals to stay active following PR. However, not recognising improvements was perceived as a barrier to PA maintenance, as

individuals became unmotivated as they believed that the exercises were not worthwhile or helpful.[221,226]

2.4.6 Theme: Social support

Other people played a significant role in individuals' journeys following PR. The perception of feeling cared for, valued, and assisted within the home and the community were important, in addition to relating to others who are in similar situations.

Sub-theme: Relationship with health care professionals

Individuals' relationships with others had a large impact on their outlook and PA behaviour following PR, which extended beyond gaining feedback about their condition. Support from HCPs was commonly reported as being important for individuals, whereby their authority instilled a sense of trust, and individuals felt safe and comforted by their presence after PR.[214,216,221,213,215,216,230–235] Individuals were less fearful of being overwhelmed by their symptoms, were comforted by the opportunity to ask questions, and were encouraged by their interest in their personal health.[220] A barrier to PA was the lack of maintained support from HCPs, and individuals reported feeling unmotivated, for example by a lack of encouragement, incentive, and uncertainty regarding transferring these exercises to a different environment, such as their home.[192]

Sub-theme: Peer interaction

Interaction with peers was commonly reported as beneficial and it was considered a facilitator to the maintenance of PA, as it made PA more enjoyable and helped individuals conquer feelings of loneliness.[214,216,221,213,215–,235,187,235] The opportunity to discuss symptoms and compare notes with others in similar situations also helped reduce distress associated with symptoms. However, individuals reported having a sense of loneliness that was difficult to manage following PR[216,217,235], and a lack of peer interaction following PR was considered a barrier to PA.[217,187,226]

Individuals appreciated the ease of connecting with peers, even when in different countries.[221] Throughout the studies, interest was expressed in the maintenance of interaction with peers with COPD after PR[217,187,226], as well as socialising with individuals with mixed conditions and other members of the community.[216] Despite this, peer interaction was also recognised as a barrier to PA, as it elicited fear in individuals as others' conditions were an unwanted reminder of the progressive nature of COPD.[222,227,232] This response motivated individuals to avoid peers in attempt to deny the illness and return to normality.[227]

2.4.7 Theme: Environment

Individuals' surroundings influenced their opportunities to engage in PA following PR. In addition, individuals' physical and social environment influenced their experiences and approach to maintaining a PA routine and successfully establishing habits following PR.

Sub-theme: Opportunities to engage in PA following PR

Individuals often expressed the importance of structured and unstructured PA sessions after PR[215,187,235], in particular they would like access to PA maintenance.[220,222] However, unclear information regarding maintenance sessions did not allow for individuals to consider alternative ways to be active, and this was a barrier to PA.[235] Barriers to attendance in maintenance sessions also involved issues surrounding cost and proximity[216] and restrictions imposed by family and work responsibilities.[233] There were mixed views on home exercises, as some individuals responded positively to them[221], whereas others did not feel like they would be helpful[192], reflecting individual differences in preferences of PA. Walking and cycling[225] were considered enjoyable activities, as well as simply being outside to enjoy the scenery.[232] Individual differences regarding their preferred PA meant that having various opportunities to engage in a variety of activities was therefore considered a facilitator to PA, whereas restricted choice was considered a barrier to PA.

Sub-theme: Routine

Ongoing contact with HCPs and peers through maintenance groups also provided a sense of structure following PR and the expectation and pressure to conform to pre-set times and activities was appreciated and regarded as a facilitator to maintaining PA.[221] However, without access to ongoing structured PA sessions, individuals largely reported that a barrier to maintaining PA was falling back into old habits.[213,224,217,187] Routine was considered an important facilitator by individuals throughout the studies.[213,216,230,235] However, this routine was influenced by individuals' home life. For example, families' understanding of COPD and their recognition of the importance of PA was identified as a facilitator to PA as they were able to provide support and encouragement[225], whereas attention sometimes added too much pressure to individuals dealing with COPD.[221,226] For example, individuals did not appreciate their family telling them to exercise.[232] Social isolation due to restricted access to structured PA groups, lack of motivation[192], as well as simply forgetting to be active[232] were also all reasons why individuals fell back into their previous routines. In addition, establishing a successful routine was considered a long process which required patience[224], placing emphasis on the challenge faced by many individuals to avoid falling back into old habits established prior to PR.[214,213,235,230]

Table 2:2: Analytical themes and sub-categories with reference to quotations within primary studies

Beliefs	Social Support	Environment
Intentions - Information and education within PR influences attitude towards PA (+/-)[213–216,235,230,235] *"I became aware that I need not feel so frightened when out of breath and that was the most important. I felt that I got sufficient information to make me calm and less frightened when I lose my breath"*[233] Beliefs surrounding PA and health influences intentions: - PA is enjoyable/associated with health benefits [214,213,215,230,187] (+) *"I have always enjoyed [exercising]. Only the cycling I don't really enjoy, especially in the winter. But I realize now that particularly cycling means a lot to my physical condition and it would've been worse if I hadn't cycled"*[225] - PA is difficult/uncertainty regarding health benefits: [224,216,235](-) *"I went and bought a bike, it's downstairs. Bike is hard, bike is hard if you don't know how to do it and how much to do it."*[192] Self-efficacy - Previous experiences influence beliefs of capability and confidence: (+/-) - Exacerbations and symptoms lead to psychological distress[214,216,213,224,216–235,221] (-)	Relationship with health care professionals - Contact regarding PA maintenance groups led to participation in weekly activities [222] (+) *"The physiotherapist called me, and she asked me if I would like to continue with a group. Now I exercise with them every Thursday. I have planned to join other activities as well!"* [222] - Delivery of information via leaflets and the internet about PA was difficult to follow/not well accepted[235](-) *"But I do find leaflets what you've been given here or there they're not exactly in plain English and they do take a lot of understanding"*[235] - Provide a sense of security and comfort: helps overcome anxiety regarding symptoms[214] (+) *"It meant, I like the fact that they allowed you to learn or go at your own pace. Nobody's pushing or pulling."*[216] *"One of the best things with the project has been to meet the [tele-]physiotherapist once a week, and get to ask questions about everything that is on your mind"* [221] - Continued support after PR regarded as beneficial[216, 221,213,215,216,–235,230](+) *"They give you confidence … to push yourself a bit, to*	PA opportunities - Individuals feel the need for clear information regarding exercise groups post PR [220] (+) *"Just to know where these places are would be a big benefit and how to get into them."* [220] - Individuals want and appreciate access to structured maintenance sessions after PR [220,226,227](+); *"The best thing for me would be a mini-program, like we had in rehabilitation"*[225] - Access to maintenance sessions affected individuals participation in PA: [216,221,216,187] (-) - Individuals were not motivated to exercise at home[192] (-) *"…it's just difficult to get the motivation to do it at home"* [192] - Cost and proximity to sessions[216] (-) *"… I have to go a little bit of a distance to get there, which I'm quite willing to do, if it isn't going to cost me money. But I want something closer to home if I have to do this on a regular basis, which I do".*[216] - PA venue is important; hospital based programmes regarded as safe/supportive as they are associated with the health care system [220] (+) *"Because you know that the healthcare system is interested in what's going on with your exercise program"* [220] - Social environment of the PA venue is important. Public gyms can feel intimidating[221] (-) *"If I want to go to the gym, it is a 60km drive from my house. Moreover, I would have felt weak in front of others. They would have looked at me, and thought: He cannot do anything.."*[221]

Table 2:2: Analytical themes and sub-categories with reference to quotations within primary studies

Beliefs	Social Support	Environment
"Come out of hospital and just feel and just feel sorry for yourself and not want to do anything" [227] - Breathlessness is associated with anxiety [213,224,216,221] (-) *"...I don't want to go through things like that, if I can avoid it. I get nervous when I feel I can't breathe, it's scary, it gets very scary"* [232] - Confidence to apply breathing and self-management techniques [211,213,224,216,219,230] (+) *"I saw the light one day. I was using the oximeter while cleaning the house, and I discovered that I was sooo low. I didn't use the oxygen while doing housework before, but I do now"* [221] Feedback Awareness of change/self-monitoring health influences motivation (+/-) - Recognition of improvements increased motivation to be active: [214,216215,216,219–235] *"...I'm doing my own hoovering which I wasn't doing because he did it, I'm cleaning windows, which he did, I do, you know there is, yeah, definitely sharing the jobs more"* *' ... definitely doing more than I was …… (Williams)* - Noticing health decline/lack of upward feeling negatively affected individuals outlook on PA: [221,226] (-) *"When you don't see results, you kinda say, ahhh... I don't know"* [232]	*try to do a bit more."* [192] - Support ends after PR negatively affects PA participation: [220,226,232] (-) *"I don't have the incentive and I don't have anybody to kick my ass and tell me to get it done."* [220] Peer interaction - Provide a sense of solidarity and support after PR: [214,216,221,213,215–235,221,235] (+) *"The people that I know at the gym, we've all done pulmonary rehab and we all have a cup of tea after we exercise together and that encourages me to go, cos I think 'Ooh if I don't go today … they'll wonder where I am'"* [192] - Peer interaction within PR affected individuals' confidence following PR: Pre-PR: *"[I do] nothing really, only stopping in the house really and listen to the radio and television' (Pt4.1; 37-38)* Post-PR: *"…they have given me more confidence by being with people and going out twice a week for about 3/4 hours, go there and come back you know, and meet people"* [229] - Individuals struggle when peer interaction ends: [222,226,232](-) *"Exercises are all right in groups. However, to do it on your own.... I guess I don't manage "* [222] - Reminder of disease progression is uncomfortable/can lead to avoidance: [222,227,232] (-) *"The meetings wouldn't do me any good right now. I would feel like that could be me, you*	- Social isolation can be a barrier to managing negative emotions [216213,217,235] (-) *"Exercises are all right in groups. However, to do it on your own.... I guess I don't manage."* [222] - Access to preferred activity influences intentions and motivation to be active[225] (+) *"The cycling not so much, I do that because I have to, but the walking. I enjoy walking a lot. I don't need motivation to do that."*[225] Routine - Establishing routine after PR facilitates PA maintenance: [214,224,216,230,235](+) *"It's like I get up, I brush my teeth, I get dressed and I get on the treadmill before I even go downstairs . . . I know if I'm going to do it, I've got to get into a routine…."*[230] - Family understanding of importance of PA:[225] (+) *"If my husband wouldn't have been here, I would've needed help at home because I couldn't manage alone. He also stimulates me to exercise."*[225] - Home responsibilities; caring for partner limits PA opportunities: [233](-) *"Now my husband is at home all the time, and since last winter when he fell ill he is too weak to go for walks so this winter there haven't been any"* [233] - Negative pressure from relatives and family leads to avoidance of PA[221,226] (-) *"They're always yelling at me, Ma, you know. And I say, Leave me alone, I don't tell you what to do, don't you tell me what to do."* [232] - Combination of both means individuals fall back into old habits: [213,224,217,187](-)

Table 2:2: Analytical themes and sub-categories with reference to quotations within primary studies		
Beliefs	Social Support	Environment
- Self-monitoring allowed individuals to acknowledge capabilities [214,230] (+) *"I have become more aware of what I do through registrations of my workouts. I am more engaged in my own health"*[221]	*know, getting that bad— I don't want to give in, so I feel it would drag me down more"* [227]	*"Anyway, you will fall back to the old way of doing it. Because you have done so many times. It is difficult."*[224]
(+) = facilitators; (-) = barriers		

2.5 Discussion

2.5.1 Summary of the results

The purpose of this review was to identify the patient reported facilitators and barriers of PA following PR. The analytical themes developed were beliefs, social support and environment that encapsulated the identified patient reported facilitators and barriers of PA following PA. Key facilitators identified within this review were the perception of continued support from HCPs, continued peer interaction, the sense of accomplishment gained through self-monitoring and feedback, as well as opportunities to access PA maintenance groups following PR that enabled individuals to form routines and establish habits. Key barriers to PA were symptoms that evoked anxiety and fear, for example breathlessness upon exertion, restricted access to social support and structured maintenance sessions following PR and lack of positive feedback regarding health which led to individuals being less likely to establish routines incorporating PA, and were more likely to return to previous habits formed prior to PR.

2.5.2 Strengths and limitations of this review

Extensive searches for existing and ongoing systematic reviews suggest that there are no other systematic reviews to synthesise qualitative studies of COPD patients' experiences of PA following PR. This systematic review followed a pre-specified protocol, conducting a comprehensive search strategy that yielded fourteen studies. Language, date and publication restrictions were not imposed in the search strategy, unlike previous qualitative systematic reviews in relevant areas, whereby inclusion criteria was either restricted to articles published in English[140,143] or a selection of languages[137] and included only peer reviewed articles.[137,140,143] Unpublished data proved valuable in this review, with a large amount of original qualitative data that provided clear insight into patients' perspectives regarding PA following PR.

Therefore, the inclusion of unpublished evidence was considered a key strength of this review. Systematic reviews of qualitative studies that do not adopt this approach are at risk of publication bias and excluding data relevant to their research question. The resulting context within the included studies was diverse in terms of individuals' PR settings, PA experiences following PR and the cultural setting within each country, meaning that it was possible to achieve a higher level of abstraction in the synthesis.[237] Two records retrieved in the search strategy were conference abstracts[205], and based on the available information were deemed to meet the inclusion criteria. It may be considered a limitation that the data from these studies are not included in the synthesis, however, as findings largely reflected existing themes, it was unlikely that access to the full studies would change the conclusions drawn in this review.

The approach to data (thematic) synthesis were in line with established methodology for systematic reviews of qualitative evidence[210], an interpretative approach which enables a summary of the descriptive themes from the primary studies, with a subsequent production of analytical themes through applying a higher level theoretical framework to answer the research question. This approach was beneficial, as transparency between the developed themes within this review and the text from the primary studies was maintained. It has previously been suggested that qualitative synthesis such as meta-ethnography can de-contextualise the findings from the primary studies.[192] However, efforts to preserve context, in line with previous methods in thematic synthesis[210], were taken to consistently refer to primary studies to check for contextual factors that could affect transferability. Additionally, by adoption of key principles of systematic reviews (extracting and tabulating study characteristics), facilitators and barriers reported in included studies can be considered alongside their specific clinical and methodological characteristics.

Like quantitative research, there are no standardised criteria for assessing the quality of all qualitative research.[201] This systematic review yielded studies with varied designs, methodological and analytical approaches, meaning that a key challenge was assessing the quality of research.[204] This systematic review adopted an approach of appraising study quality by assessment of study conduct using a previously used critical appraisal tool.[204] In accordance with approaches in systematic reviews of quantitative evidence, and with limited evidence to suggest that quality of reporting is associated with the credibility and transferability of the findings in qualitative studies[240], we did not feel there was sufficient justification for exclusion or weighting of study data according to quality. For each criterion within the chosen critical appraisal tool[204] the majority of the studies were appraised favourably, however the limitations in some of the included studies should be considered. For example, credibility was often jeopardised by the small amount of qualitative data provided throughout the studies and it was not possible to conclude whether selected quotes were biased towards researchers' pre-existing views regarding their research question.

2.5.3 Comparison to previous reviews

No previous systematic review has synthesised qualitative data regarding facilitators and barriers to PA following PR. Meta-analyses of RCTs have provided limited success in demonstrating efficacy of interventions to improve PA in COPD, as the effects are typically modest and short-term.[197,199] However, current proposals of the likely greater impact of longer duration PR programmes on modification of PA[130] would support a key theme presented in the review, namely that ongoing support from both HCPs and peer interaction was a facilitator to PA maintenance. The importance of social support has previously been reported in systematic reviews researching individuals' participation in PR[128,143] and facilitators and barriers to PA in other lung conditions.[140,143] Feeling supported by family throughout PR has been identified as a facilitator to PA during PR[137], but the results from this

study suggest that family, friends, partners and peers interaction are also important in the maintenance of PA. During PR, it has previously been suggested that environmental and personal factors, in addition to social factors, have been recognised as influential to PA in patients with COPD.[140] Environmental factors such as transportation and options regarding the type and intensity of PA were also considered influential factors to PA maintenance, as were personal factors associated with identity, for example previous experiences with PA and previous lifestyles which affected individuals' PA beliefs. In this review, a larger emphasis was placed on access to information regarding opportunities to engage in PA following PR, likely due to the responsibility of PA maintenance being shifted from HCPs to patients after completing PR. Establishing a healthier routine is often reported to be a key benefit during PR[137], however, the findings from this review identified both the importance and difficulty of maintaining these PA routines and forming habits following PR. Interestingly, the length of the PR programme has previously been recognised as a barrier to PA[140], with less patients being likely to attend longer programmes, however the findings in this review suggest that a barrier to PA maintenance is the loss of structure and contact with other people.

Unlike previous findings of key barriers to PR[140], smoking status was not identified as a barrier to PA maintenance in this systematic review. It may be argued that a greater proportion of COPD patients included in the present review (i.e. who completed PR) were less likely to be smokers who are associated with poorer completion rates in PR and hence have other important personal factors. The findings suggest that COPD patients often reflect on their health. Positive feedback regarding PA and health was recognised as a facilitator to PA maintenance, whereas some became unmotivated if they did not recognise any improvements in their condition. This suggests that self-efficacy is an influential factor in PA motivation, complementing findings of previous systematic reviews that reported goal

achievement as a facilitator to PA during PR, and the benefits of adding pedometer-based counselling to multidisciplinary PR.[140,193]

2.5.4 Conclusions

This systematic review identified and synthesised the data referring to the patient reported facilitators and barriers to PA following PR, which provided an in-depth understanding and insight into patient experiences regarding the maintenance of PA behaviour. The results from this systematic review highlight the complexity of behaviour change, and the challenge of promoting PA following PR on a population level. The results provide clear guidance for future research design, as well as recommendations regarding the content of future interventions.

3 Chapter 3: Use of the Behaviour Change Wheel to develop an intervention to promote physical activity following pulmonary rehabilitation in patients with COPD

3.1 Abstract

Background: Pulmonary rehabilitation (PR) is a programme of exercise and education that has benefits on breathlessness, exercise capacity and quality of life in COPD. However, these benefits do not necessarily translate to an increase in daily physical activity (PA) and long-term behaviour change. Previous interventions to promote PA following PR have had limited efficacy.

Aim: This chapter reports the systematic and comprehensive development of an intervention to promote PA following PR for patients with COPD, using the Behaviour Change Wheel (BCW).

Methods: The eight steps outlined in the BCW were followed to develop an intervention. Stakeholder discussions facilitated the development of the intervention by considering and evaluating the intervention's affordability, practicability, effectiveness and cost-effectiveness, acceptability, side-effects and safety and equity (APEASE).

Results: The final intervention targeted patients' capability, opportunity, and motivation, incorporating four intervention functions delivered via four policy categories and thirteen Behaviour Change Techniques (BCTs). The final intervention included 52 weeks of support through provision of a pedometer and step diary, and addition of patients to a WhatsApp group populated by fellow PR graduates and a 'WhatsApp leader'.

Conclusion: The BCW enabled a systematic and comprehensive development of a novel, multicomponent intervention to promote PA following a community PR programme in patients with COPD.

3.2 Introduction

As reported in previous chapters (Chapter 1 and 2), interventions to promote PA following PR have had limited efficacy and have only resulted in modest, short-term increases in PA.[146,149] Behaviour change following PR is a complex phenomenon and it is therefore crucial to develop interventions using evidence and theory-based methods.[241]

The results from the systematic review of the patient reported facilitators and barriers of PA following PR in COPD (Chapter 2), outlined various factors which impacted patients' behaviour, and these were encompassed by patients' beliefs, the environment and social support. The systematic review represented the first step in the development of a complex intervention, including the identification of the evidence base.[159] The next step involves the identification of relevant theory to develop an intervention to target the promotion of PA following PR in patients with COPD.

The Medical Research Council (MRC) framework for complex interventions states that intervention development should be a systematic process, based on coherent and relevant theory and the best available evidence.[159] Though there are various intervention frameworks which can provide intervention development guidance[172,173], the comprehensiveness of these frameworks are limited, for example they are not necessarily linked to a model of behaviour change and/or applicable to a broad range of behaviour.[145] The BCW was developed to address these limitations. The BCW has been used in the development and evaluation of interventions including modifying PA behaviour in COPD and there have been calls for further adoption of this framework within intervention development in the area.[165,175] The BCW has not yet been used to develop interventions for promoting PA in the post-PR setting. This chapter describes the application of the BCW in the development of an intervention to promote PA following PR in patients with COPD.

3.3 Methods

3.3.1 Settings

PR service in Lincolnshire Community Health Services (LINCs) NHS Trust is an 8-week programme delivered to patients with chronic respiratory disorders who are symptomatic and functionally limited by their condition (MRC score 2 or more) or had a recent hospitalisation (e.g. acute exacerbation of COPD). The programme includes eight weeks of twice weekly, 1-

hour exercise and education sessions. The exercise component of the programme includes activities requiring minimal equipment (e.g. 'sit to stand' exercises using a chair) so that these can be performed at home during and following PR. The educational component contains information on various topics, such as benefits of regular PA, management of exacerbations and breathlessness. Once patients' complete PR, they are discharged and referred to primary care with no formal follow-up or support to maintain the benefits of PR.

3.3.2 Design

The BCW was applied to the development of an intervention to promote PA following PR in patients with COPD. The intervention was developed in accordance with three key stages of the BCW.[145] Briefly, stage 1 includes understanding the behaviour; stage 2 includes the identification of intervention options, for example intervention functions and the policy categories which may deliver these and, finally, stage 3 includes the identification of content and implementation options.

3.3.3 Stage 1

Stage 1 included four steps, step 1: defining the problem in behavioural terms; step 2: selection of the target behaviour; step 3: specifying the target behaviour and step 4: identification of what needs changing via the model of behaviour that forms the core of the BCW, known as the COM-B.[145] Specifically, based on the results of a qualitative systematic review (Chapter 2), step 4 involved conducting a behavioural analysis using the COM-B model. This model has three components which represent sources of behaviour: capability (psychological and physical); opportunity (social and physical) and motivation (reflective and automatic). This method identified the sources of behaviour that were involved in PA following PR and resulted in a 'behavioural diagnosis'.

3.3.4 Stage 2

Stage 2 included two steps, step 5 (the identification of intervention functions) and step 6 (identification of policy categories). Decision making at steps 5 and 6 were informed by the matrix of links, which is a table within the BCW framework for moving between steps.[145] For example, in stage 2, the matrix of links is a table that reports the intervention functions that are likely to bring about change to specific behavioural sources. In addition, similar to previous studies[242], application of the APEASE criteria and discussions with stakeholders, including patient groups such as Lincoln Breathe Easy[138], HCPs and academic experts in behaviour change, facilitated the development of an intervention that was acceptable to all in the local setting (Lincolnshire). **Table 3:1** provides further details of the discussions with stakeholders. The Chief Investigator led discussions during each meeting and used the APPEASE to review the feasibility of the intervention strategies. Results and actions from the meetings were noted by the Chief Investigator.

Identification of intervention functions in step 5, i.e. the functions that an effective intervention is likely to serve, were based on the behavioural sources (COM-B components) selected in Step 4 as needing to change. Intervention functions listed in the behaviour change wheel include education; persuasion; incentivisation; coercion; training; restriction; environmental restructuring; modelling and enablement.

Identification of policy categories in step 6, i.e. how the intervention functions will be implemented, was based on the intervention functions selected in step 5. Policy categories listed in the behaviour change wheel include communications/marketing; guidelines; fiscal measures; regulation; legislation; environmental/social planning and service provision.[145]

3.3.5 Stage 3

Stage 3 included two steps, step 7: the identification of Behaviour Change Techniques (BCTs) (active ingredients of the intervention) and step 8: the identification of the mode of

delivery. Similar to stage 2, these steps were also informed by the matrix of links and discussions with stakeholders (**Table 3:1** and **Table 3:2**) with application of the APEASE criteria.

In step 7, the research team selected BCTs based on the intervention functions selected. For each intervention function, the BCW guide lists the most and less frequently used BCTs according to the Behaviour Change Taxonomy version 1 (BCTv1).[243] This was used to facilitate the selection of relevant BCTs.

For step 8, the research team selected modes of intervention delivery (e.g. individuals or groups of people, face to face or online) based on the previous steps (intervention functions and policy categories). The research team sourced and trialed specific intervention components (e.g. devices), summarised in **Table 3:2**.

Table 3:1: Stakeholder discussions to inform intervention development in Steps 5-8

	Methods	**Results**	**Actions**
Attendees: Chief Investigator, Academic Supervisor and Breathe Easy Group members (n=10) **Location:** Lincoln **Communication:** Face to face meeting **Date:** August 2017	The Chief Investigator and their Academic Supervisor attended the Lincoln Breathe Easy Group to discuss the development of the intervention to promote physical activity. The results of the systematic review and proposed intervention strategies were shared with the group (Table 3.1).	Breathe Easy Group members supported the addition of a pedometer to provide feedback regarding step counts. Individuals stated that they appreciated support from others who have similar conditions and reported their willingness to continue to meet with others following pulmonary rehabilitation. Some individuals stated that they would prefer meeting others face to face and wished to have more opportunities regarding social activities and options regarding physical activity classes after pulmonary rehabilitation. However, access to online forums or networks, where they could interact with others in similar situations, was considered favourably.	To identify acceptable intervention strategies to build upon patients' willingness to socialise with other patients following pulmonary rehabilitation and to have more opportunities regarding physical activity classes etc.
Attendees: Chief Investigator, Academic Supervisor and Lincolnshire Community Health Services (Respiratory Team) (n=9) **Location:** Boston **Communication:** Face to Face meeting **Date:** August 2017	The Chief Investigator and their Academic Supervisor attended the Lincolnshire Community Health Services (Respiratory Team) monthly meeting to discuss the development of the intervention to promote physical activity. The results of the systematic review and the findings from the meeting with the Lincoln Breathe Easy group were shared to identify acceptable intervention strategies.	The Respiratory Team provided support for the proposed intervention and identified social networking as a possible intervention strategy to promote social support following pulmonary rehabilitation.	To explore the feasibility of using social networking applications in an intervention e.g. considering ethical issues.
Attendees: Chief Investigator, Academic Supervisor and Health Care Communications Officer (n=3) **Location:** Lincoln	The Chief Investigator and their Academic Supervisor attended a meeting with an NHS Communications Officer in Lincolnshire to explore the possibility of promoting social support via social networking as an intervention	All attendees concluded that there would not be a "one size fits all" approach to social networking. However, attendees agreed that WhatsApp may be the most accessible platform due to the popularity of the application e.g. it was agreed that many participants and/or family members may be	To explore the target populations' familiarity with online social networking applications such as WhatsApp. To address data privacy

Table 3:1: Stakeholder discussions to inform intervention development in Steps 5-8			
	Methods	**Results**	**Actions**
Communication: Face to Face **Date:** September 2017	strategy. The various social networking platforms (e.g. WhatsApp and Facebook) and practicalities of using these were discussed.	familiar with the application. All attendees agreed that actions needed to be taken to address data privacy policies.	policies in social networking applications.
Attendees: Chief Investigator, Academic Supervisor and local respiratory support group members (Happy Breathers, Lincoln Breathe Easy and an informal pulmonary rehabilitation follow on group in Lincoln) (n< 30) **Location:** Lincoln and Spalding, Lincolnshire **Communication:** Face to Face **Date:** September – November 2017	The Chief Investigator and their Academic Supervisor attended community respiratory patient groups to identify individuals' level of familiarity and acceptability of Smartphones and Social media as an intervention strategy.	Many individuals owned smartphones or were familiar with these due to family or friends' influence. Nevertheless, many individuals in the patient follow-on groups were not familiar with WhatsApp and use of social media. Therefore, attendees agreed that education and information regarding the intervention was extremely important.	To consider the delivery of education on the use of smartphones and social networking for the target population. To produce appropriate guidelines and instructions towards using social media applications.
Attendees: Chief Investigator and Behaviour change experts (n=3) **Location:** n/a **Communication**: email **Date:** November 2017	The Chief Investigator contacted two behaviour change experts (the Behaviour Change Lead at the British Lung Foundation and an expert in Behavioural Science based at University College London) to provide an overview of the intervention development project and to discuss collaboration.	Both behaviour change experts agreed to collaborate in the project, and individually evaluated the steps undertaken to develop the intervention e.g. the relevance of the chosen intervention functions and BCTs to change physical activity. They also facilitated the production of the messages to be delivered within the WhatsApp group by providing suggestions for messages in the WhatsApp guidelines.	To use the study materials (e.g. WhatsApp guidelines and booklet) in a pilot study to assess the clarity and acceptability of the study materials.
*The Chief Investigator led discussions during each meeting and used the APPEASE to review the feasibility of the intervention strategies. Results and actions from the meetings were noted by the Chief Investigator.			

Table 3:2: Stakeholder discussions to inform intervention development in step 8

	Methods	**Results**	**Actions**
Attendees: Chief Investigator, Academic Supervisor and Breathe Easy Group members (n=10) **Location:** Lincoln **Communication:** Face to face meeting **Date:** August 2017	The Chief Investigator and their Academic Supervisor attended a Lincoln Breathe Easy meeting to identify the acceptability of pedometers. Samples of the pedometer (Yamax CW700/701 model), were shared with the group and group members were encouraged to provide feedback on the acceptability in terms of size, user-friendliness, and comfort.	The pedometer (Yamax CW700/701 model) was considered acceptable to the group.	To trial the pedometer in a pilot study.
Attendees: Chief Investigator, Academic Supervisor and Lincoln Breathe Easy group members (n=5) **Location:** Lincoln **Communication:** Face to face **Date:** September 2017 onwards	The Chief Investigator purchased samples of the Alcatel Pixi 4 (Appendix D) and organised to meet with the Lincoln Breathe Easy Group Committee to identify the acceptability of the mobile phone, and to facilitate the development of the study materials.	Attendees agreed that the mobile phone required pilot testing and agreed that it was important to provide clear instructions on how to use the pedometer, mobile phone, and WhatsApp.	To use the study materials in a pilot study to assess the clarity and acceptability of the study materials.
Attendees: Chief Investigator, Academic Supervisors (n=2) and PhD students (n=2) from the Lincolnshire Institute for Health.	The pedometers and mobile phones were pilot tested by colleagues within the LIH (Lincoln Institute for Health) (n=4). Individuals were provided with an early version of the study manual and one person volunteered to act as a 'WhatsApp leader', which involved one person following an early version of the WhatsApp guidelines and	Pilot study group members reported the poor functioning of the phone, though successfully used the phone to send and receive messages on WhatsApp. The WhatsApp leader volunteer adhered to the WhatsApp guidelines and manual.	To identify and source other mobile phones which are considered more user friendly.

Table 3:2: Stakeholder discussions to inform intervention development in step 8

	Methods	Results	Actions
Location: The Lincolnshire Institute for Health **Communication:** Face to Face **Date:** February 2018	sending daily messages to the group. This strategy enabled for the identification of any initial teething problems of the intervention strategies and intervention devices.		
Attendees: Chief Investigator, Academic Supervisor and group members of a Pulmonary Rehabilitation follow on group (n=6) **Location:** Lincoln **Communication:** Face to face **Date:** February 2018	The pedometer and mobile phones were pilot tested by a patient follow on group within Lincolnshire (n=4). Individuals' were provided with an early version of the study manual, and one person volunteered to act as a 'WhatsApp leader', which involved following an early version of the WhatsApp guidelines, and sending daily messages to the group. This strategy enabled for the identification of any initial teething problems of the intervention strategies and intervention devices.	Patients from the follow-on group were disappointed by the slow functioning of the phone, the short battery life (<1 day), the small screen and keypad and the number of updates it requires. Communication was limited by these barriers and the nominated WhatsApp leader volunteer did not adhere to the WhatsApp guidelines; however, this was attributed to the mobile device rather than the WhatsApp guidelines.	To identify and source other mobile phones which are considered more user friendly.
Attendees: Chief Investigator, Academic Supervisor and group members of a Pulmonary Rehabilitation follow on group (n=6) **Location:** Lincoln **Communication:** Face to face **Date:** April 2018	The Chief Investigator sourced Nokia 1 mobile phones (Appendix F). Individuals from the follow-on group agreed to trial these devices and report their experiences.	Individuals from the follow-on group considered the Nokia 1 more user-friendly and an acceptable device to provide to potential participants.	It was agreed that the device would be used in the feasibility study.

3.4 Results

3.4.1 Stage 1

PA was identified as the behaviour to target within this intervention. PA is important for the health and well-being of people with COPD following PR, and research suggests that individuals do not maintain PA after PR.[109] Daily steps was chosen as the specific target behaviour.

The behavioural diagnosis concluded that psychological capability, reflective motivation, automatic motivation, physical and social opportunity need to change for the target behaviour (PA maintenance) to occur (**Table 3:3**). The only behavioural source that was not deemed to require change was physical capability. Both previous literature and stakeholder discussions suggested that patients upon completion of PR would be in a position of increased physical capacity and hence physically capable to maintain PA after PR.

Table 3:3: Barriers and facilitators of PA following PR in COPD, mapped onto COM-B components

COM-B component	Barriers and facilitators to PA following PR in patients with COPD
Psychological capability	Information during PR is considered as important. Information can positively influence individuals' intentions towards maintaining PA (+) Family understanding of the importance of PA affects the family's attitudes to PA (+)
Reflective motivation	PA is associated with breathlessness, which leads to avoidance of PA (-) (due to the belief that they are not able to cope with breathlessness) Self-efficacy: exacerbations lead to distress and avoidance of PA (-) (due to the belief that they are not able to cope with PA However, recognition of improvements through self-monitoring and feedback leads individuals to recognise their capabilities and increase motivation for PA (+) Belief that PA is enjoyable and leads to health benefits (+) Information during PR influence intentions towards maintaining PA (+)
Automatic motivation	PA is associated with breathlessness, which leads to avoidance of PA (-) (due to negative emotions associated with breathlessness) Exacerbations lead to distress and avoidance of PA (-) (due to negative emotions associated with breathlessness) Establishing a routine after PR (+) and maintaining habits after PR (+) are important in the maintenance of PA
Physical opportunity	PA venue is important, e.g. access to a variety of structured maintenance sessions after PR (+) Limited venues can be a barrier due to travel practicalities e.g. cost of public transport (-)
Social opportunity	Hospital based programmes regarded as safe/supportive as they are associated with the health care system (+) Support and understanding from HCPs is important e.g. HCPs provide a sense of security/comfort (+) Maintenance of support from peers is important, e.g. peers provide a sense of solidarity/support following PR (+) Seeing other people with COPD can be reminder of the disease progression which is uncomfortable and can lead to avoidance of others in social situations (-) Social isolation is barrier to managing negative emotions (-) Home responsibilities; caring for partner limits PA opportunities (-) Negative pressure from family leads to avoidance of PA (-)

(+) facilitators; (-) barriers

3.4.2 Stage 2

Based on the COM-B components that required targeting, all nine intervention functions were available for selection. However, only four intervention functions were considered acceptable and likely to serve the intervention, including education, environmental restructuring, enablement, and persuasion. Incentivisation, coercion and restriction were excluded as they were not considered suitable functions (i.e. did not meet APEASE criteria) for this intervention, e.g. there was uncertainty about the equity of incentivisation and its effectiveness for modifying PA in a COPD population.

Based on the intervention functions selected, all seven policy categories were available for selection. However, only four policy categories were selected to implement these intervention functions and considered acceptable, including guidelines, service provision, communication, and environmental/social planning. The other four policy categories were excluded as they were not considered to meet the APEASE criteria, e.g. fiscal measures and legislation would not be possible, or appropriate, to use in this context.

3.4.3 Stage 3

Based on the four chosen intervention functions in step 5 (education, environment restructuring, enablement and persuasion), there were a total of 25 listed BCTs which were reported as frequently used, and a total of 63 BCTs reported as less frequently used BCTs. Of these BCTs, 13 were considered appropriate to stakeholders and selected to be included in the intervention (**Table 3:4**). These included social support (unspecified 3.1, practical 3.2, emotional 3.3), instruction on how to perform a behaviour 4.1, behavioural practice/rehearsal 8.1, self-monitoring of behaviour 2.3, credible source 9.1, written persuasion about capabilities 15.1, focus on past successes 15.3, prompts and cues 7.1, restructuring the social environment 12.2, social reward 10.4 and feedback on behaviour 2.2. All other BCTs were

excluded as they were not considered to meet the APEASE criteria. For example, goal setting: behaviour (1.1) and graded tasks (8.7) were not considered acceptable to stakeholders due to health and safety concerns i.e. the chance of patients over-exerting themselves and not having a HCP nearby.

Based on the existing literature, stakeholder discussions and APEASE criteria, potential intervention components to utilise the selected BCTs included adding patients to a WhatsApp group populated by fellow PR graduates and a 'WhatsApp leader' (a volunteer from a patient support group), providing patients with a pedometer and, finally, providing patients with a step diary for 52 weeks following PR. Stakeholders considered 52 weeks as an appropriate intervention duration, as it was able to target long-term behaviour change and provide support to a population who suffer exacerbations and whose symptoms are likely to vary.[1,31,52]

Stakeholders agreed that the intervention should be introduced to groups of patients, face to face, during PR. Stakeholders agreed that patients would benefit from the support of the research team and HCPs within in a familiar setting. This would also enable patients to meet the WhatsApp leader and to practice communicating with their peers (other COPD patients) via WhatsApp.

Following PR, the WhatsApp leader would deliver WhatsApp messages via the internet to groups of individuals. The WhatsApp leader was considered a suitable person to deliver messages to the WhatsApp group, as they have experiences living with, or with someone, with COPD and therefore understand both the facilitators and barriers to PA.

Social networking was considered an appropriate intervention strategy, as patients valued social support but were restricted by barriers such as transport and cost that limited face to face contact with others.[241] Social networking was chosen as a method to overcome

these barriers. An outline of the final intervention, including the implementation of each BCT and mode of delivery is provided in **Table 3:5**.

Table 3:4: Selection of behavioural sources, intervention functions, policy categories, BCTs, intervention strategies and mode of delivery for the intervention developed to promote PA following PR in COPD

Behaviour source targeted in the intervention	Intervention functions	Policy category	BCTs	Intervention strategy	Mode of delivery
Psychological capability **(patients report they are not aware of PA opportunities)**	Education	Service provision Guidelines Communication	3.1 Social support (unspecified)/ 4.1 Instruction on how to perform a behaviour/ behavioural practice	WhatsApp messages provide information about local PA opportunities which provide support	Distance. Group/Individual level (messages sent to the group, but individuals have the option to reply and receive tailored messages). Digital media; Mobile Phone App.
Reflective motivation **(patients do not believe they are making progress after PR/do not believe they are capable)**	Education	Service provision Guidelines	2.3 Self-monitoring of behaviour.	Pedometer allows individuals to recognise potential progress in their PA following PR	Distance. Individuals' to be provided with the pedometer at the beginning of the intervention only
	Education	Service provision Guidelines	2.3 Self-monitoring of behaviour	Daily diary of PA (step count from the pedometer educates/inform individuals about their PA capabilities)	Distance. Individuals' to be provided with the step diary at the beginning of the intervention only

Table 3:4: Selection of behavioural sources, intervention functions, policy categories, BCTs, intervention strategies and mode of delivery for the intervention developed to promote PA following PR in COPD

Behaviour source targeted in the intervention	**Intervention functions**	**Policy category**	**BCTs**	**Intervention strategy**	**Mode of delivery**
	Persuasion	Service provision Communication Guidelines	2.3 Self-monitoring of behaviour 3.1. Credible source 15.1 Written persuasion about capabilities 15.3 Focus on past successes	WhatsApp messages encourage group members to reflect on their step counts/activities. WhatsApp leader represents credible sources as they have completed PR and successfully maintained their physical activities. WhatsApp messages ask to list the previous performances of the behaviour	Distance. See the first row for further detail.
Automatic motivation **(Patients reported challenges of forming habits/a routine following PR)**	Education/ Environmental Restructuring/ Enablement	Service provision Guidelines Communication	7.1 Prompts and cues	WhatsApp messages encouraging group members to form habits	Distance. See the first row for further detail.
	Environmental Restructuring	Service provision Guidelines	7.1 Prompts/cues	Pedometer and step diary provide reminders for the participants to be active	Distance. Individuals' to be provided with the pedometer and step diary at the beginning of the intervention only.

Table 3:4: Selection of behavioural sources, intervention functions, policy categories, BCTs, intervention strategies and mode of delivery for the intervention developed to promote PA following PR in COPD

Behaviour source targeted in the intervention	Intervention functions	Policy category	BCTs	Intervention strategy	Mode of delivery
Social opportunity **(Individuals feel self-conscious being active by themselves. Some reported that they appreciate communicating with peers (as they can positively influence the way they think about PA))**	Environmental Restructuring/ Enablement	Service provision Guidelines Communication Environmental planning	3.1 Social support (unspecified)/3.2 practical 3.3 Social support (emotional) 12.2 Restructuring the social environment	WhatsApp messages advise group members to seek company for PA. WhatsApp messages advise group members to seek company if they are worried/struggling to motivate themselves to engage in PA. WhatsApp group enables individuals to contact each other. This facilitates group support and removes distance/travel/social isolation barrier.	Distance. See the first row for further detail.
	Persuasion	Service provision Guidelines Communication	10.4 Social reward/2.2 feedback on behaviour	WhatsApp messages to congratulate group members if PA effort/progress has been made.	Distance. See the first row for further detail.
Physical opportunity **Time and location influence PA choice, affecting behaviour.**	Education	Service provision Guidelines Communication	3.1 Social support (unspecified)/ 4.1 Instruction on how to perform a behaviour/ behavioural practice	WhatsApp messages provide information about local PA opportunities which provide support	Distance. See the first row for further detail.

Table 3:5: Implementation of each BCT adopted within the developed intervention

Intervention component	BCT	Further description of BCT implementation (with mode of delivery)
Addition of patients to a WhatsApp group	**Adding objects to the environment (12.5)**	Participants were provided with a mobile phone (Nokia 1) that had the Social Networking application 'WhatsApp'.
	Restructuring the social environment (12.2)	Participants were added to a WhatsApp chat, which was populated by other members of the PR they were enrolled on (only patients who enrolled onto the study) and a volunteer from a COPD patient support group (e.g. Breathe Easy). The WhatsApp group enabled individuals to contact each other, which facilitated group support and removed barriers caused by distance, travel and social isolation.
	Credible source (9.1)	The volunteer was labelled as a 'WhatsApp leader'. As the WhatsApp leader has successfully completed PR and maintained their physical activities, they may therefore be regarded as a credible source for participants.
	Feedback on behaviour (2.2)	WhatsApp message are sent to WhatsApp group members to congratulate them if PA effort or progress has been made, for example 'Congratulations on maintaining your step count (since… yesterday/last week/since you finished PR)'.
	Social Support, unspecified, practical and emotional (3.1; 3,2; 3.3) and Instruction on how to perform a behaviour (4.1)	Throughout the intervention, the WhatsApp leader followed a series of guidelines and checklists which outlined a minimum number of messages to send to the group every week, for example including information about: PA opportunities available to group members activities participants could complete at home; social support; health and relevant contacts; and also encouragement for participants to monitor their activity levels and to seek social support if needed (Appendix K, p333) for the guidelines and checklists). Throughout the 52-week period, WhatsApp leaders were asked to send a minimum of one weekly PA summary to the group, which included information about PA opportunities. Examples of these messages include: 'it might help to meet up with other people in this WhatsApp group so that you can support each other to be active. Please let other group members know if you would be interested in meeting up and being active together' (3.2) and 'Friends, family, neighbours, colleagues etc. may provide you with emotional support/support if you are struggling to be active. Share your plans to be active with them so that they can support you.' (3.3). The WhatsApp guidelines and Checklists provided information about the content and frequency of messages to send to the WhatsApp group (Appendix K, p333).
	Prompts/cues (7.1):	WhatsApp leaders regularly sent participants messages to remind them of the importance of PA and encouraged participants to form habits and routine, for example 'Some people find it easier to be active by sticking to a schedule. Try and do your daily activities every day at the same time (for example at 1pm).'
	Social reward (10.4)	WhatsApp messages were sent to congratulate group members if they reported being active, for example 'Congratulations of achieving a higher step count (than… yesterday/last week/since you finished PR).'
	Written persuasion about capabilities (15.1)	WhatsApp messages were sent to ask participants to list their performances of previous PA, for example 'Has anyone noticed improvements in their step counts since PR?'

	and Focus on past successes (15.3)	
Providing patients with a pedometer	**Adding objects to the environment (12.5)**	Participants were provided with a pedometer (Yamax CW700/701). This was a small device that attached to participants' waist belts. It provided information/instant feedback regarding the number of steps that participants had done on that specific day. Daily step counts refreshed at midnight every day. Participants were asked to wear the pedometer every day, to put on when they wake up and to take off before bed.
	Prompts/cue (7.1):	The pedometer provided reminders for participants to be active.
Providing patients with a step diary	**Adding objects to the environment (12.5)**	Participants were provided with a paper step diary. This was a paper diary which had three columns (day of the week/number of steps/comments (optional)).
	Self-monitoring of behaviour (2.3)	Using the step diary, participants were asked to monitor and record their steps each day and to write any comments to explain their step count (e.g. 'feeling motivated', 'tired', 'bad weather' etc).
	Prompts/cues (7.1)	The step diary provided reminders for participants to be active.

3.5 Discussion

3.5.1 Main findings

This chapter described the development of an intervention to promote PA following PR in COPD. This included provision of a pedometer and step diary, and the addition of patients to a WhatsApp group populated by fellow PR graduates and a 'WhatsApp leader' for a duration of 52 weeks following PR.

3.5.2 Comparison to previous literature

Previous interventions to promote PA for people with COPD have utilised some of the intervention components adopted within this study and thus reflect the BCTs within this intervention. For example, pedometers and/or step diaries (adding objects to the environment 12.5; Self-monitoring of behaviour 2.3) have been provided to COPD patients to increase their steps[82,244,225] and patients have also been encouraged to use social media for social support (social support: unspecified 3.1; practical 3.2; emotional 3.3).[246] However, many of those interventions were not specifically targeting long-term PA following PR (limited to three months post-PR).[86,246] Therefore those interventions did not target the long-term facilitators and barriers of PA after PR, such as long-term social support and patient self-efficacy[241], which the developed intervention aims to address.

Stakeholders considered WhatsApp as more appropriate than COPD web-based applications utilised in other interventions[244,236] due to it being more accessible and familiar to patients and/or their friends and relatives, and it is an application which has been implemented in other interventions with a similar aim to help support health behaviour change.[187,248] Use of WhatsApp as an intervention component addresses calls of previous research to explore the use of instant messaging as a strategy to facilitate long-term PA behaviour change for patients with COPD.[249,238]

3.5.3 Strengths and limitations

A clear strength of this study is the systematic development of an intervention which was based on a theoretical framework, a systematic review of the literature[241] and stakeholder engagement. Intervention development was based on stakeholders within Lincolnshire and therefore it could be argued that the intervention may be context-specific, and not be as applicable to other areas. However, the prioritisation of patient and public involvement (PPI) enabled the research team to focus on the priorities of various COPD patient groups across Lincolnshire, thus considering the views of many individuals across different settings. Various meetings with stakeholders enabled further exploration of key issues such as the selection of acceptable pedometers, mobile handsets, WhatsApp, and WhatsApp guidelines. As reported in previous research[242], application of the BCW was time consuming. However, it resulted in the selection of intervention components that were informed by usability tests as well as previous literature.[252,91]

Whilst the BCW has been applied to the development and evaluation of interventions including modifying PA behaviour in COPD[165,175], it has limited application in the development of interventions to promote PA following PR.[176] Relatively few interventions have referred to theory[92,90] and explicitly referred to the development of the intervention based on a behaviour change framework.[253] There was therefore a need to utilise the BCW in the systematic development of this intervention.

Understanding that it is not possible to design a 'one-size fits all' intervention [254], the intervention was multi-component, and thus incorporated many BCTs. The decision to implement the intervention for 52 weeks (long-term) enabled the research team to target long-term behaviour change for a population that may see a seasonal change in risk of exacerbations and whose symptoms are likely to vary.[1,31,52]

3.5.4 Conclusion

The BCW enabled a systematic and comprehensive development of a novel, multicomponent intervention to promote PA following PR in patients with COPD in an NHS PR service, facilitated by stakeholder involvement. The next steps are to conduct a feasibility study to assess acceptability and experiences of the intervention to a larger group of COPD patients and the potential impact of the intervention on clinical outcomes, such as PA and QoL.

4 Chapter 4: Methodology and general methods

The development of the intervention adheres to the stages outlined in the Medical Research Council (MRC) framework: development, feasibility and piloting, evaluation and implementation.[159] Chapter 3 reported the theoretically guided process of the development of this intervention. However, there are still unanswered questions regarding the intervention which need to be addressed prior to a full-scale definitive trial. The following steps in the MRC framework, the feasibility and piloting and evaluation, are the mechanisms in which to answer these questions, and these are reported in this chapter. Assessing the feasibility is a vital step in the development of a complex intervention and enables researchers to test the acceptability of an intervention, research procedures and the estimation of recruitment and attrition rates within a study.[255] The outcome of this feasibility study informs the next step in the development of this complex intervention, and whether there is the need for further studies to refine this intervention design prior to its implementation.

Both qualitative and quantitative methods are considered appropriate methods to address the overarching aim of the study and to address the uncertainties surrounding the acceptability of the intervention and research procedures. This chapter addresses the rationale for the methods chosen to test this intervention, and describes the methods used in the remainder of this thesis.

4.1 Methodology

4.1.1 Research design

This intervention was tested in a mixed methods feasibility cluster randomised controlled trial (CRCT) with an embedded qualitative process evaluation, illustrated in **Figure 4:2**, **Figure 4:3** and **Figure 4:4**. The choice of the research design included a careful consideration of the

strengths and limitations of the available approaches, which are described in the following text.

4.1.2 Quantitative and Qualitative approaches

Qualitative and quantitative research methods have their unique strengths and limitations. Strengths of quantitative research include the ability to identify the relationships between variables, to control for confounding variables, the ability to replicate experimental trials and collect data that is generalisable.[256] Quantitative research only has limited capacity to provide insight into participants experiences, for example those relating to the quality of their health care.[257]

Qualitative research enables the researcher to gain insight into of how participants experience a phenomenon, as well as the meanings and interpretations participants attach to a phenomenon.[258] Procedures within qualitative research are generally more flexible and responsive to the research participants.[259] However, a limitation of qualitative research can be the time-consuming nature of data collection and analysis[260] and the inability to objectively measure the relationship between variables. In this case, a solely qualitative study would not enable this thesis to measure the likely impact of the intervention on clinical outcomes such as PA.

4.1.3 Mixed Method Research

Mixed method research involves using both quantitative and qualitative approaches in the collection, analysis and integration of data to answer a research question within a single or longitudinal study.[256]

4.1.3.1 Strengths and limitations of mixed methods research

In principle, mixed method research is able to draw on the strengths of both qualitative and quantitative research and has the flexibility to use both methods in a creative and complementary way.[261–263] Though mixed method research is a relatively recent method, its

growing popularity reflects the increasing recognition of its benefits.[264] Mixed methods is considered particularly powerful when addressing health service interventions and management of chronic conditions[265–252] and there has been a growing interest in mixed method research in health research settings.[265] Mixed method research has been used to gather insight into health care services and self-management for individuals with COPD[268,254] and to test the feasibility and acceptability of health interventions.[221–257] Mixed method research is supported by the MRC[159] and use of qualitative and quantitative methods are often applied within process evaluations of complex interventions within RCTs and field observations are increasingly recognised as methods to understand patients' experiences of trials, in attempt to understand health problems.[272]

Insight into the intervention

A mixed method design enables triangulation, complementarity, initiation, and expansion in this thesis. Objective quantitative measures enable an understanding of the likely effects of the intervention on PA and other health outcomes and qualitative measures can help gain an understanding into the reasons for PA patterns following PR but also participants experience following PR. In this thesis, it was important that the qualitative data could illustrate the quantitative findings and contribute to understanding the context and potential mechanisms of impact of the intervention. But it was also important that the qualitative methods could potentially challenge the quantitative results and offer possible explanations for any unexpected results. In this study, qualitative methods included interviews and focus groups, which aim to understand the views and experiences of various individuals (patients, HCPs and WhatsApp volunteers). As there were various components of the intervention, including provision of a pedometer, step diary and inclusion in a WhatsApp group (see Chapter 3 for a detailed description of these intervention components), it was particularly important to identify which aspects of the intervention the participants felt may or may not have been

acceptable. As this was a feasibility study, a key aim was for the qualitative data to provide insight into the acceptability of the intervention and research procedures (such as participant recruitment and timings of the follow ups). Qualitative methods have the potential to offer multiple perspectives on the acceptability of the intervention[273,274], thus potentially increasing the credibility and depth of the overarching study conclusions.

Theoretical viewpoint

Despite growing popularity, mixed method research has also been met with criticism. For example, it has been argued of there being theoretical hurdles to mixing paradigms associated with qualitative and quantitative research, due to the assumption that the two research methodologies are too separate in their underlying epistemology, meaning that they cannot be combined.[275] However, this claim is based on arguments rooted in ontology and epistemology, including individuals' perceptions of reality and their approach to understanding reality. This is traditionally an argument from a Constructivist and/or Positivist/Postpositivist viewpoint.

Positivists believe that there is a single reality and therefore believe that reality can be measured with reliable and valid tools. Postpositivism stems from the positivism paradigm, though Postpositivists recognise that outcomes are a result of a complex interaction between various factors.[276] Positivists and Postpositivists may likely adopt quantitative designs such as experimental designs and surveys to answer a research question. At the other end of the spectrum, Constructivist and Interpretivists believe that there is no single reality and that it is created by individuals in groups and therefore reality can only be interpreted by identifying individuals' underlying meaning of the situations in question.

The research contributing to this thesis was based on a pragmatic approach, with the assumption that reality is 'constantly renegotiated, debated, interpreted in light of its usefulness in new unpredictable situations'.[277] Therefore, reality can be known by using the

method and design suited to answering a research question, and therefore refutes the assumption that qualitative and quantitative methods should not be combined. Pragmatism is less concerned about the questions relating to reality and instead focused on the practicalities involved in answering a research question.[278,279]

Quality of Mixed Methods integration

A commonly reported weakness of mixed method research is poor understanding and limited evidence of integrating quantitative and qualitative data.[280] Integration of qualitative and quantitative data is an increasingly important criterion for mixed method research[281], yet there are claims of low-quality data integration[282] and lack of clarity in the rationale of collecting both qualitative and quantitative data. This may be attributed to mixed method research being a relatively new approach.[262] There has been a surge of research using a mixed methods approach, yet there has been limited instruction in the integration of data. The development of clear, credible guidelines of systematic methods for conducting mixed method research has only been a relatively recent occurrence.[272] To avoid low quality data integration, this mixed methods study was informed by recent mixed methods guidelines and recommendations.[272,283]

Competence in using Mixed Methods

Another reported pitfall in mixed method research is the lack of experience and expertise in conducting both quantitative and qualitative research methods. Mixed method designs can be a challenging and time-consuming approach, as it relies on conducting, analysing and integrating data from both qualitative and quantitative methods.[265] The integration of the qualitative and quantitative data are reported in Chapter 6.

4.1.3.2 Priority of qualitative and quantitative data

Both qualitative and quantitative data were collected during the trial, as illustrated in **Figure 4:2**, **Figure 4:3** and **Figure 4:4**. The process evaluation was embedded into the CRCT. This

may suggest that priority was given to the quantitative data. However, as the aim of this study was to test the feasibility of a CRCT, equal priority was given to the qualitative and quantitative data. The qualitative data collected during the trial aimed to provide rich and valuable insight into participants' perceived acceptability of the intervention and research procedures. Insight from patients, HCPs and WhatsApp leaders therefore contributed to understanding the feasibility of the trial. Equal priority to both quantitative and qualitative research is less common than prioritising either qualitative or quantitative research, but is justified when both methods are afforded equal status in answering the research question.[270–288]

4.1.3.3 Sequence of qualitative and quantitative data collection

Qualitative and quantitative data were collected concurrently during the trial. To an extent, quantitative feasibility data, including consent and attrition rates, informed the selection and timing of the qualitative data collection. Qualitative interviews at the beginning of the trial aimed to understand and explore patients' reasons for declining participation in the intervention. Interviews with participants who withdrew from the intervention were based on patient attrition rates and therefore were not planned. Interviews with those that adhered to the intervention were conducted after a minimum of 12 weeks of engagement in the intervention (inclusion in the first follow up). Other qualitative data, including focus groups with HCPs and WhatsApp leaders, occurred during the delivery of the intervention. Focus groups were conducted towards the end of the trial and enabled a reflection on the strengths and limitations of the intervention and research procedures. Qualitative research to address problems which potentially undermine the acceptability and delivery of an intervention and/or research procedures is a recognised strength of qualitative research within feasibility studies for randomised controlled trials.[289]

4.1.3.4 Integration of qualitative and quantitative data

Reporting of the quantitative data and qualitative data were initially reported and analysed separately, through a contiguous approach.[283] Chapter 5 first reports the quantitative outcomes (5.3, 5.5) of the feasibility study, followed by the qualitative outcomes. The results are then integrated to further explore patterns based on patients' engagement in the intervention. The integration of the data included writing both qualitative and quantitative findings together on a theme-by-theme basis (Chapter 6).[283]

4.1.4 Summary

The previous section (4.1) outlined the methodology of the feasibility RCT with a qualitative embedded process evaluation and reported the rationale for the adoption of mixed methods. In summary, a mixed methods approach was chosen as an appropriate method to address the overarching aim of the thesis and identify the acceptability and feasibility of an intervention to promote PA following PR in patients with COPD.

4.2 General methods

The following text reports the general methods adopted in this study, starting with ethical approval (4.2.1), study setting (4.2.2), and clusters (4.2.4.1). Following this text, this section describes the research procedures included in the feasibility CRCT, outlined in **Error! Reference source not found.**- **Figure 4:4**, including the recruitment (4.2.4), consent (4.2.5), and quantitative and qualitative outcome measures adopted in this study (including HCPs, patients and patient volunteers) (4.4, 4.5). **Error! Reference source not found.** also illustrates the study arms which patient clusters were allocated, including the intervention group (IG) and control group (CG), but also the study procedures and timings of the patient follow ups (4.5.4). Description of the methods employed in this mixed methods study is separated into various sections, including a description of the methods employed in the collection of quantitative data (4.4), followed by the methods employed to collect qualitative

data (4.5). **Figure 4:6** illustrates how outcomes collected during this study provided insight into the context, implementation, mechanisms of impact and clinical outcomes of the intervention tested within this CRCT.[160]

Reporting of the feasibility CRCT adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidance for cluster trials and the extension for pilot and feasibility trials.[290,291,292] Reporting of the qualitative research adhered to the Consolidated criteria for reporting qualitative research, a checklist guiding the explicit and comprehensive reporting of qualitative research.[201]

4.2.1 Ethical approval

Ethical approval for this study was obtained from South Central- Oxford B Research Ethics Committee and the Health Research Authority in May 2018. This study was also registered on ClinicalTrials.gov, NCT03660644.

4.2.2 Study setting

The setting for this study was LCHS NHS trust. The Countywide Respiratory service delivers PR for LCHS across the four regions of Lincolnshire including North West Lincolnshire (number 1), North East Lincolnshire (number 2), South West Lincolnshire (number 3) and South East Lincolnshire (number 4),

Figure 4:1.

All patients received PR. Within Lincolnshire, PR is delivered as a community programme across LCHS NHS Trust. The setting of PR varies across Lincolnshire, including

a mixture of community halls and community hospital settings dependent on the region. PR programmes across Lincolnshire lasted for 8 weeks, divided in 2 x 2-hour sessions per week, resulting in a total of 16 sessions. PR programmes included group education and exercise classes. Each course delivered fifteen education sessions, which lasted one hour and included topics: introduction to rehab; benefits of exercise; how the lungs work; breathlessness; inhalers and devices; medications; inhalers, devices and oxygen; managing exacerbation; chest clearance; coping strategies; energy conservation/relaxation; planning for the future; nutrition; and finally, the open forum to discuss self-management after PR. Each course delivered sixteen exercise sessions which also lasted one hour and included activities which required minimal equipment so that these could be performed at home during and following PR. These exercises included get up and go; wall press; steps up; bent arm lateral raises; cross and reach; bicep curls and walking. PR included pre and post assessments on health-related outcomes.

Figure 4:1: Map outlining the four regions in Lincolnshire

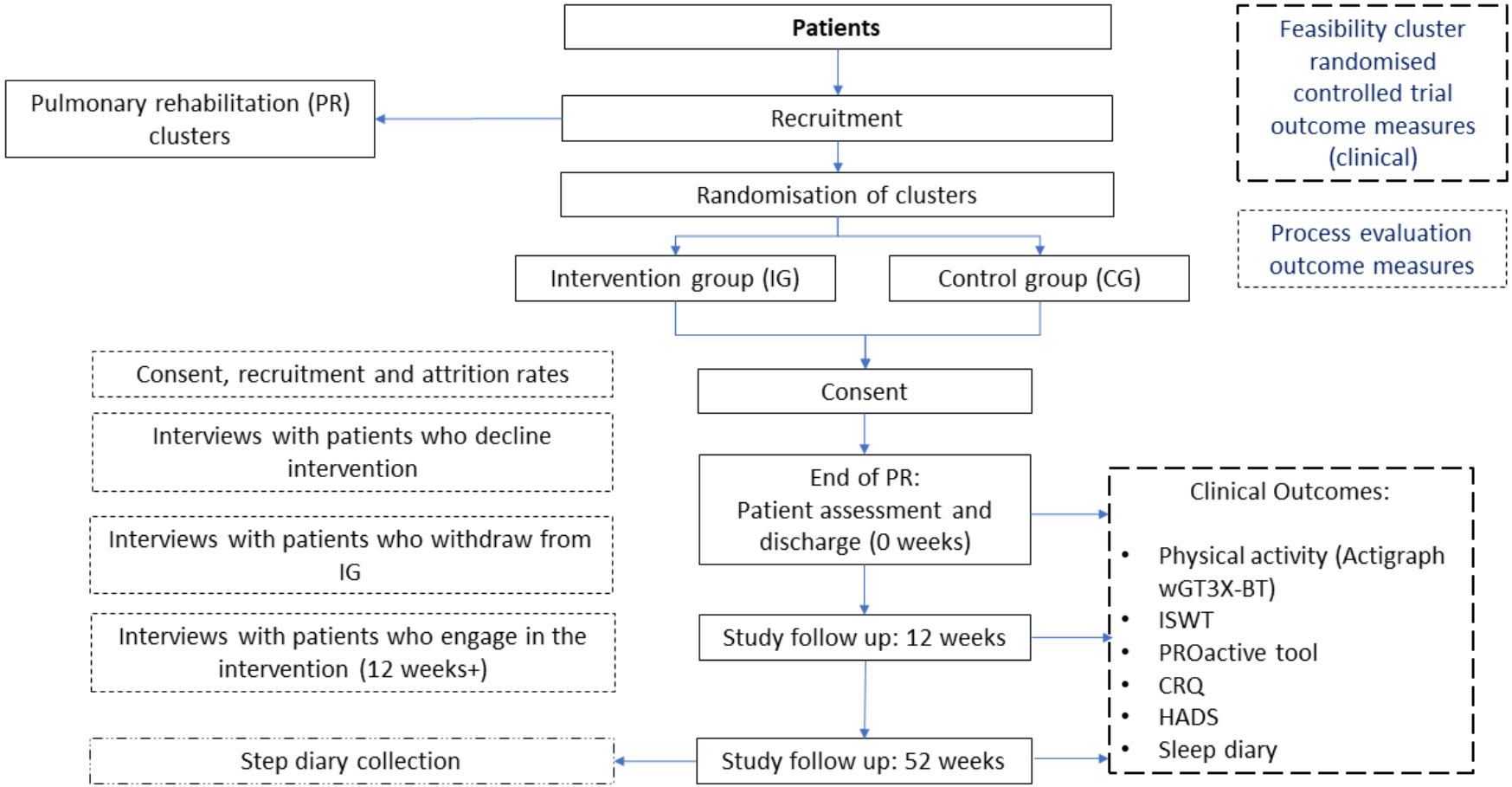

Figure 4:2: Illustration of the study procedures for Patients

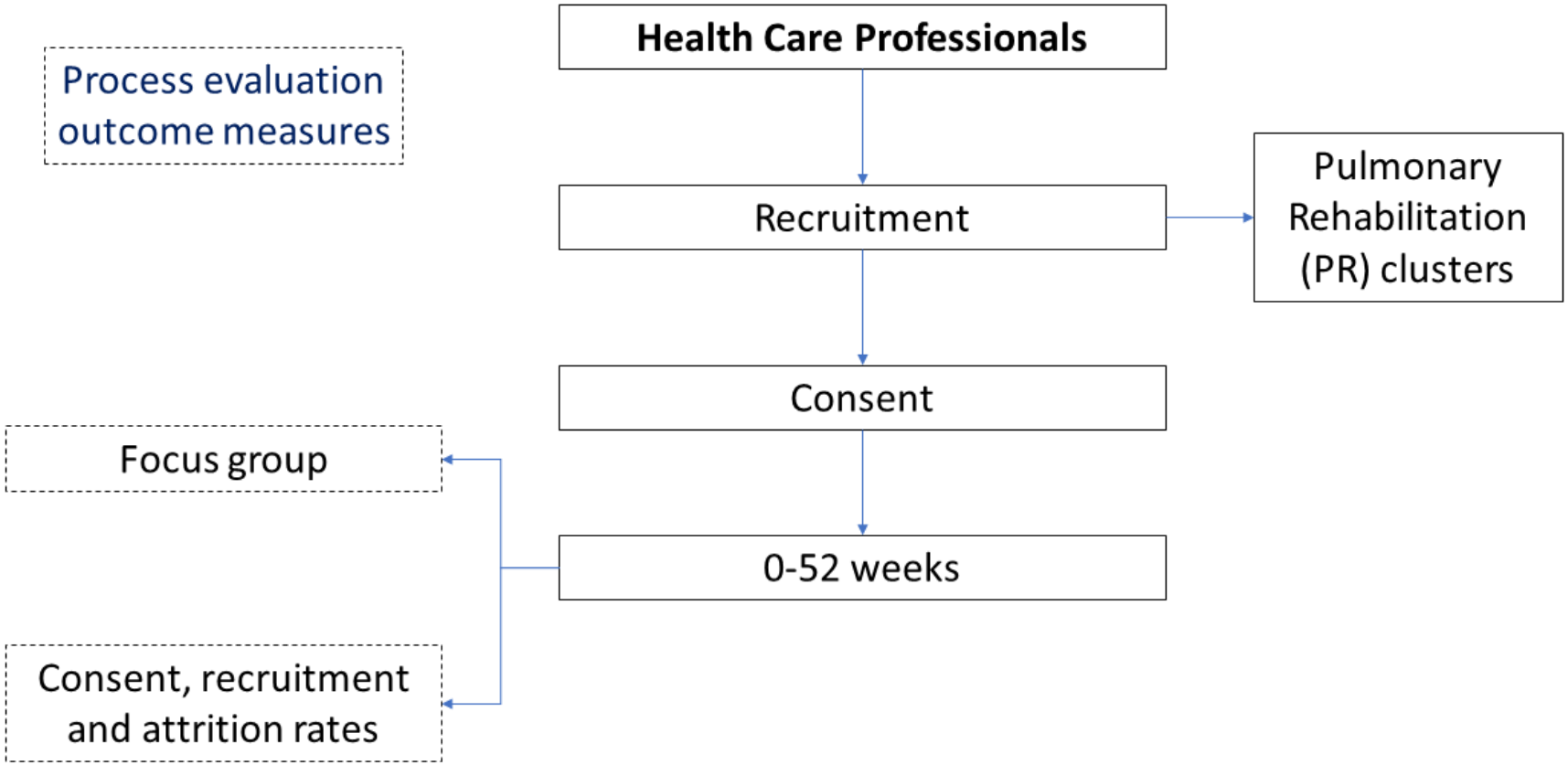

Figure 4:3: Illustration of the study procedures for Health Care Professionals

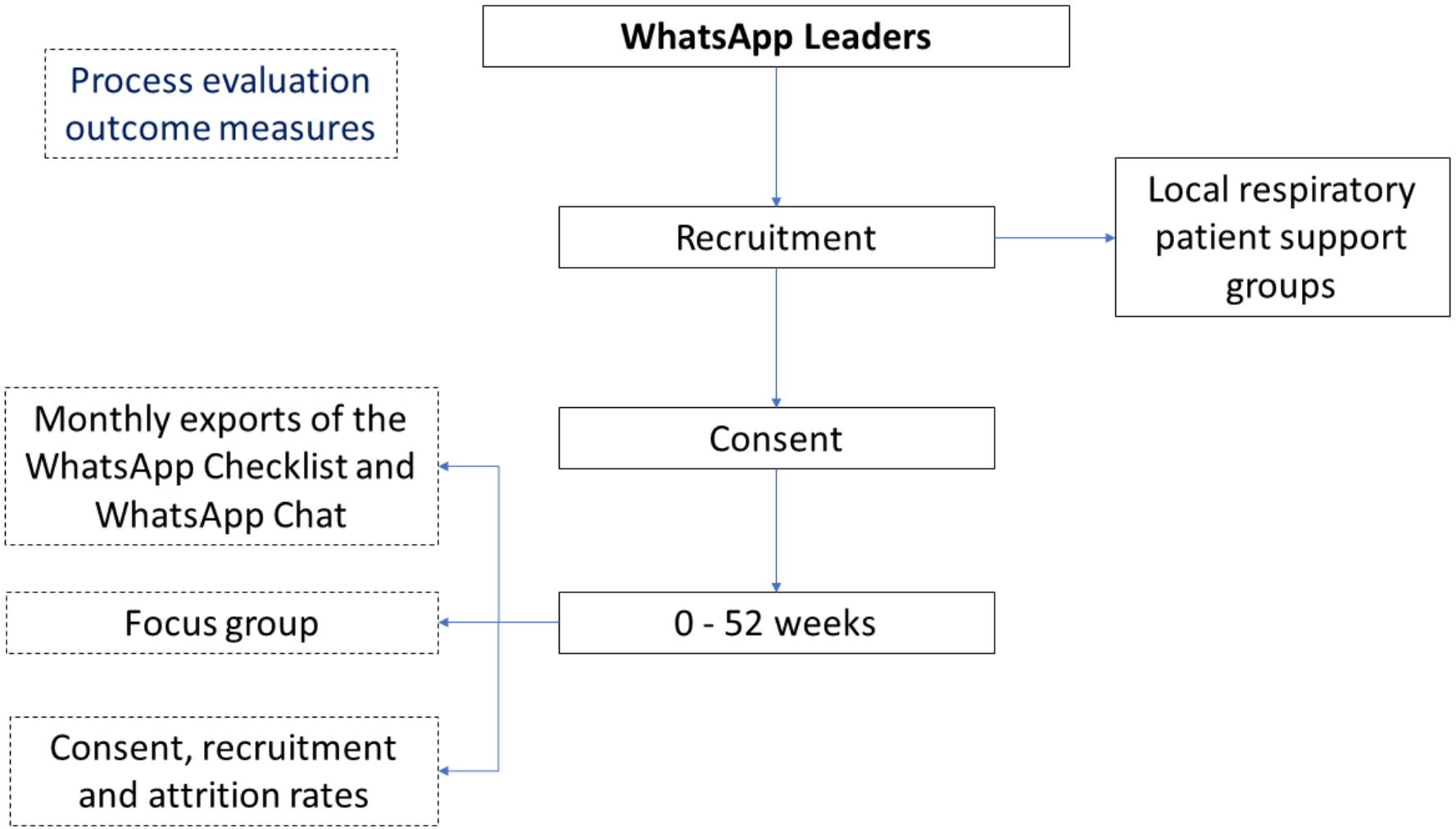

Figure 4:4: Illustration of the study procedures for WhatsApp Leaders

4.2.3 Clusters

PR programmes were the unit of randomisation, and thus, patients followed the care pathways to which the programme (cluster) was randomised, **Error! Reference source not found.**. PR programmes (clusters) were randomly allocated to the Intervention or Control Group. Cluster randomisation was considered an appropriate method due to the nature of the intervention. For example, one component of the intervention was based on group involvement with fellow PR graduates. It was therefore not logical to randomise patients individually. Cluster randomisation was also used because it minimises treatment "contamination" between intervention and control patients.[293] For example, groups of individuals were allocated to a specific programme, and they were in the same group for the duration of the programme. If individuals were aware of any differential treatment between each other within PR, contamination effects may have occurred. For example, individuals in the control condition might have adopted intervention strategies themselves or simply be affected by their awareness of the intervention.

PR programmes were considered as eligible clusters if they were based within LCHS (NHS trust) and permission was provided from the lead HCPs of the PR programme to be involved in the study. PR programmes were not considered as eligible clusters if they were not within LCHS (NHS trust) and if the lead HCPs of the PR programmes were unwilling for the programme to be involved in the study.

4.2.4 Recruitment

4.2.4.1 Clusters

Clusters (PR programmes) were screened by HCPs involved in PR to identify eligible participants. It was necessary to recruit from programmes with a minimum of two patients with COPD.

4.2.4.2 Patients

Prior to the start of the study, the research team contacted HCPs within LCHS who were involved in the delivery of PR, to provide patients information about the study. At least four weeks prior to discharge from PR (i.e. during the programme), HCPs provided eligible patients, within the allocated clusters, verbal and written information about the study, which included a brief script read by the HCPs prior to the research team attending PR, (Appendix E, p297) and a patient information sheet which outlined the aims and content of the study (including collection of data outcomes and telephone interviews). Patients then had at least one week to consider study involvement prior to being approached by the research team. The following week, the research team attended PR and individually asked eligible patients whether they had any questions about the study and/or whether they wanted to participate in the study.

4.2.4.3 Health care professionals

During the delivery of PR to patients in the intervention groups, at least three weeks prior to patients being discharged from PR, HCPs were invited to take part in a focus group (planned towards the final stages of intervention delivery). Verbal and written information about the study were provided, including an information sheet which outlined the aims and content of the study. HCPs then had at least one week to consider study involvement prior to providing their consent.

4.2.4.4 WhatsApp leaders (patient volunteers)

The Chief Investigator contacted COPD patient support groups to identify individuals who were interested in volunteering in this study. This included face to face visits and/or email contact with COPD patient groups based in Lincolnshire and surrounding areas (e.g. Sheffield, Nottingham, and Leicestershire). Email contact with some groups was facilitated by the British Lung Foundation (BLF). BLF advertised the aims of the study and provided the research team's contact details for interested individuals to inquire about getting involved as a 'WhatsApp leader' in the study. When attending COPD patient support groups, the recruiting investigator explained the details of the study and individuals who raised interest in volunteering within the study were provided with the participant information sheet, ensuring that the individuals had enough time to consider participating or not. Opportunity was given to individuals to ask any questions they may have had concerning study participation.

4.2.5 Consent

Verbal and written informed consent were sought from all participants at the point of recruitment into the feasibility CRCT (including patients, HCPs and WhatsApp volunteers) (**Error! Reference source not found.** - **Figure 4:4**). Verbal consent was also verified prior to interviews and focus groups with all participants. In all cases, the research team collected consent from all participants.

4.2.6 Population

4.2.6.1 Patients

Inclusion criteria: Patients within the clusters were considered as eligible if they were adults (age range: 30-100 years) with COPD[294]; were enrolled in PR within LCHS (NHS trust) and if they provided informed consent for their outcome data to be collected.

Exclusion criteria: Patients within the clusters were not considered eligible if they were: not diagnosed with COPD; not enrolled on a PR programme within LCHS (NHS trust); had

dropped out of PR following enrolment; were unable/unwilling to provide informed consent for their outcome data to be collected; and were involved in another study including the use of an intervention to promote PA.

4.2.6.2 Patients (interviews)

Inclusion criteria: Patients who participated or declined to participate in the feasibility CRCT; patients who provided informed consent to participate in a telephone or face to face interview.

Exclusion criteria: Patients who were not approached to participate in the feasibility CRCT patients who are unable/unwilling to provide informed consent to participate in telephone or face to face interview.

4.2.6.3 Health care professionals

Inclusion criteria: HCPs who were involved in delivering the PR programmes allocated to the Intervention Group within LCHS (NHS trust) and those who were willing/able to provide informed consent to participate in a focus group.

Exclusion criteria: HCPs who were not involved in delivering the PR programmes allocated to the Intervention Group within s (NHS trust) and/or those who were unable/unwilling to provide informed consent to participate in a focus group.

4.2.6.4 WhatsApp leaders

Inclusion criteria: Volunteers (who were members of local COPD support groups, whom held the position of Chair, Treasurer or Secretary, or were ordinary members, and in general, sufficiently stable to be a proactive and regular member of the group) and provided informed consent to lead the WhatsApp groups and participate in a focus group.

Exclusion criteria: Not volunteers (and have not been involved in local COPD support groups, have not held the position of Chair, Treasurer or Secretary, have not been ordinary members, and in general, are not sufficiently stable to be a proactive and regular member of

the group) and/or were unable/unwilling to provide informed consent to lead the WhatsApp groups and participate in a focus group.

4.2.7 Randomisation and blinding

PR programmes (clusters) were randomised (1:1) via a web based randomised system[295] according to a computer-generated random sequence, stratified by programme location (North West, North East, South East, and South West). Eligible programmes were informed by a researcher of their allocation verbally and in writing via email. The researcher was blinded to the randomisation sequence with allocations only made available one at a time. Patients were not directly informed that there was an alternative group (intervention or control) being studied.

4.2.8 Sample size

4.2.8.1 Clusters and patients

Prior to patient recruitment, based on patient flow through PR service (LCHS) and data from previous research studies by the research team, 12 clusters (n= 6 per arm) were believed to provide a minimum of 30 patients in each arm. 30 patients in each arm was considered a sufficient number to meet the study objectives.[296]

4.2.8.2 Patient interviews

Interviews were conducted with up to 30 patients and sought to understand (at the relevant intervals) the views of subsets of patients in the intervention group, and included those who: refused to participate in the study; agreed to participate but withdrew; and agreed to participate and completed the study. Interview participants were purposefully sampled to ensure variation in clusters and sociodemographic variables such as age, gender and ethnicity.[297]

4.2.8.3 Health care professionals

Focus groups were conducted with a maximum of 10 HCPs who were involved in delivering PR to patients enrolled in the research study. Efforts were taken to ensure variation by recruiting HCPs who were involved in the delivery of the intervention to different clusters, i.e. different regions of Lincolnshire.[297]

4.2.8.4 WhatsApp leaders

A minimum of six volunteers were required to act as WhatsApp leaders throughout the study (one volunteer for each cluster allocation to the intervention group). However, due to the long intervention period of 52 weeks, ten volunteers were recruited, controlling for any potential withdrawals during the study. All WhatsApp leaders involved in the delivery of the intervention to participants were invited to participate in a focus group, ensuring variation across clusters.

4.2.9 Interventions

4.2.9.1 Intervention

Clusters allocated to the intervention group received the intervention in addition to PR. The intervention was multi-component and aimed to increase individuals' motivation to engage in PA upon completion of PR, including 1) inclusion in a WhatsApp group; 2) provision of a pedometer and 3) provision of a daily step diary (Appendix I, p309, for pictures of each intervention component). The development and underlying theory for this intervention has been previously described (Chapter 3).

PR in the intervention clusters had an additional education session, 16 in total. **Figure 4:5** illustrates the study familiarity procedures for the intervention components. The research team and WhatsApp leader attended PR and introduced the intervention in the additional educational session on the 6th week (two weeks before the end of PR) (see Appendix F, p299, for the PowerPoint slides the research team delivered to patients in the educational talk). The

research team included the Chief Investigator (PhD student) and their Academic Supervisor from the University of Lincoln. The WhatsApp leader was a patient/lay volunteer who volunteered to take part in the study. The WhatsApp leader was allocated to 'lead' the WhatsApp group in their local region (or regions they were most familiar with) and to send regular messages to the WhatsApp group over the 52 week intervention period (see the WhatsApp guidelines and Checklists for further information on the messages sent by the WhatsApp leader, Appendix K). The education talk lasted approximately one-hour and participants were provided with the patient intervention manual (Appendix J, p312) and study mobile phones. Participants were encouraged to take the phones home with them, and to practice using the phones by communicating with peers and the 'WhatsApp leader'. The research team provided participants with pedometers on the 7th week of PR (1 week before the end of the programme). Researchers and WhatsApp group leader attended the open forum session to allow participants to ask any remaining questions about the intervention. The intervention officially started following the final PR session (open forum). Patients were then encouraged to begin recording their steps and to communicate via WhatsApp to a level that suits them. The WhatsApp leader then began to send regular weekly messages to the WhatsApp group. These messages aimed to support patients to maintain PA and included information about local activities, social support, encouragement to reflect on step counts; to ask about previous performances of PA; to encouragement habit formation and routine and to congratulate PA. The intervention lasted 52 weeks and participants were encouraged to engage in the intervention to a level that suited them. The development and underlying theory for this intervention has been previously described (Chapter 3).[145] **Figure 4:6** outlines how the intervention components related to the behavioural sources which were targeted (previously described in Chapter 3).

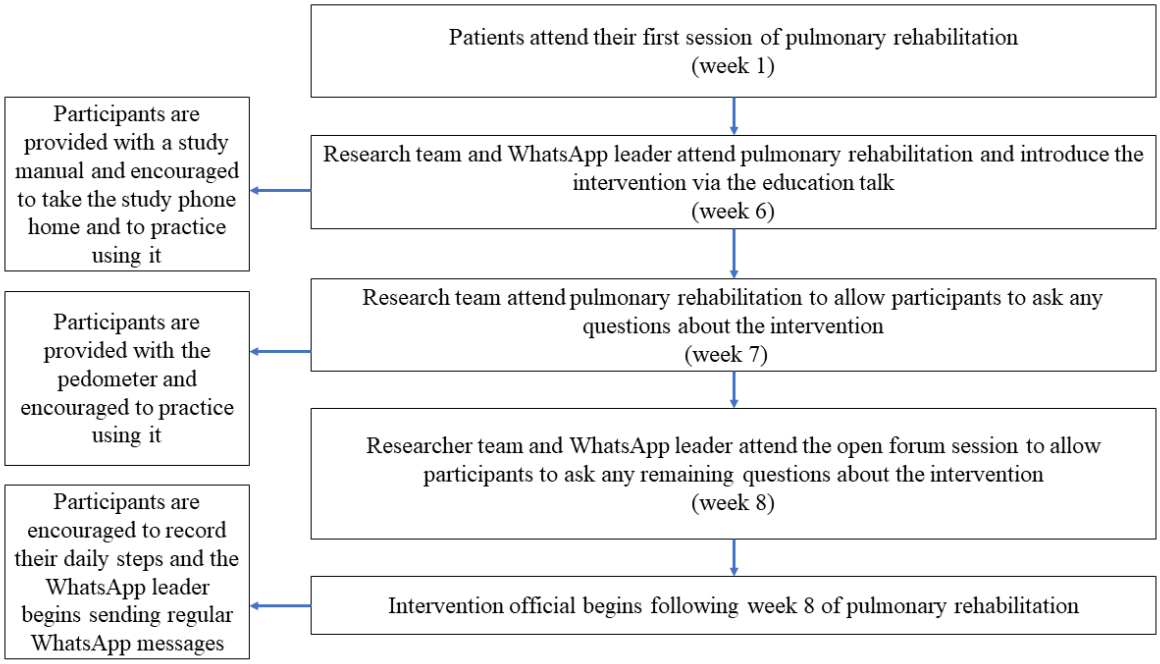

Figure 4:5: Illustration of the intervention familiarity procedures during pulmonary rehabilitation for the intervention group

4.2.9.2 Control (usual care)

Following completion of PR, all patients were discharged and referred to their primary care provider with no formal follow-up or support to maintain the benefits of PR.

4.2.10 WhatsApp leader training

Prior to starting the intervention, it was necessary to familiarise the patient volunteers with the aims and procedures of the intervention. The following text describes the steps taken to introduce the intervention and WhatsApp leaders' role throughout the study (4.2.10.1).

The Chief Investigator met with the WhatsApp leaders individually for approximately 1-2 hours to discuss the study procedures and their role in the intervention. However, timing was flexible as it was expected that there would be individual differences in the level of familiarity with the study materials.

During these meetings, the Chief Investigator provided volunteers with the study phone (Nokia 1) and were given the option of receiving the pedometer (Yamax CW700/701 model) and step diary that other members of the WhatsApp group were to be provided. The WhatsApp leader was also provided with WhatsApp guidelines and checklists (Appendix K, p333). The WhatsApp guidelines provided an overview of the research procedures and instructions for WhatsApp volunteers. These were informed by previous literature and stakeholder discussions[193] and were an attempt to provide structure to the delivery of the intervention i.e. facilitate the consistent delivery between WhatsApp volunteers.

4.2.10.1 WhatsApp leader guidelines

The guidelines included information and instructions to WhatsApp Leaders. For example, this included: suggestions that the WhatsApp leaders become familiar with the list of example messages; instructions about timings, for example to send a reply to the messages from individuals in two time slots; instructions about WhatsApp security, for example to not change the security setting on their phone; instructions on WhatsApp behaviour, for example to be the role model for the group and to not post offensive statements; information about the end of the study i.e. that the research team will collect the mobile phones used in the study, and finally, information about contacting the research team, for example to contact the research team if the WhatsApp leaders' encountered any problems during the study.

There were eight distinct categories of WhatsApp messages, including a total of 74 example messages, which were based on the BCTs outlined in the BCTTv1[145] (see Chapter 3 for more information). Categories included: Active Lincolnshire (n=13); vitality exercise classes (n=12); activities at home (n=6); social support (n=8); monitor activity levels (n=14); habits/routine (n=11); congratulatory messages (n=5) and finally, health (n=5) (Appendix K, p333).

WhatsApp leaders were also provided with a list of the current PA opportunities in the local area, (according to their WhatsApp groups location). For example, details about local health walks, COPD exercise classes etc.

4.2.10.2 WhatsApp Checklists

WhatsApp leaders were also provided with WhatsApp Checklists (Appendix K, p333), which provided instructions about specific messages to send to the WhatsApp group on a weekly or monthly basis. There were three checklists, including Checklist Week 1, Checklist 1, and Checklist 2.

Checklist Week 1 informed the WhatsApp leader what to send to the WhatsApp group on the first week of patient-participant enrolment. These messages included introductory statements to familiarise the group with the WhatsApp group and the types of messages to be sent to the group, for example 'Hello and welcome to the WhatsApp group. My name is XXX and I am your WhatsApp leader. My role is to motivate you to keep active now you have finished PR' and 'next week I will start sending you information about the local PA opportunities in your area. Make a note of any activities that you would be interested in attending'.

Checklist 1 informed the WhatsApp leader what type of messages to send to the WhatsApp group each week, for example to send a message from the category 'social support' on a Tuesday and to send a message from the category 'monitor activity levels' on a Wednesday, etc. The message categories listed on Checklist 1 represented different Behaviour Change Techniques (BCTs), as discussed in further detail in Chapter 3.
Checklist 2 was provided to WhatsApp leaders as a blank template, to be filled in when they send any additional messages to the WhatsApp group i.e. not outlined in Checklist 1.
See the WhatsApp guidelines, Appendix K, p333 for examples of the WhatsApp Checklists.

Further face to face meetings were arranged with WhatsApp leaders if they felt they required further information or guidance in their role as a WhatsApp leader. Furthermore, volunteers were encouraged to contact the research team if they had any questions about their role in the study.

4.3 Quantitative data (procedures)

The following text describes the quantitative procedures for all patients, which is illustrated in **Table 4:1**.

4.3.1 Baseline

As illustrated in **Table 4:1**, following written consent and at least 3 weeks before the intervention began (patient discharge), the Chief Investigator or other member of the research team attended PR to collect information about patient demographics. A detailed form was used to collect information including patient demographics (age, race, ethnicity, gender), body measurements (stature, body mass, Body Mass Index) other comorbid chronic diseases (e.g. hypertension, cardiac illness, hypercholesterolemia, and/or stroke), medication use, smoking history and number of exacerbations in the previous 12 months. Smoking status was validated by measuring exhaled carbon monoxide (MicroCO, CareFusion Ltd.UK) (Appendix L, p348).

Participants were then provided with an accelerometer (Actigraph wGT3X-BT). Patients wore the accelerometer on the dominant side of their waist (dependent on them being right or left hand sided). Participants were instructed to wear the USB port facing towards the ceiling (vertical side), on axis 1= -1G. Participants were instructed to wear the accelerometer on a continuous basis (i.e. over 24 hours) for 7 days. At PR, (at the end of the 7-day period), the Chief Investigator instructed patients to complete the weekly version of the PROactive tool[73]. As part of standard care, the patient assessment at the end of PR within LCHS involved the completion of the Chronic Respiratory Questionnaire (CRQ)[117], Hospital

Anxiety and Depression Scale (HADS)[118], the Incremental Shuttle Walk Test (ISWT)[115] and the Endurance Shuttle Walk Test (ESWT).[116] To collect the baseline measures for these outcome measures, the responses to these questionnaires and the results from the ISWT and ESWT were shared in a pseudonymised form between the LCHS and Lincoln Institute for Health.

4.3.2 Follow up visits (12 and 52 weeks)

There were a further two study follow ups. The Chief Investigator contacted patients (at approximately 10 and 50 weeks after patient discharge from PR) to arrange a convenient day/time/location to provide the accelerometer (Actigraph wGT3X-BT). A convenient day/time to attend a follow-up visit 7 days after this was also arranged. Patients were asked to undergo the same 7-day accelerometer and data collection periods as the baseline timepoint at both 12 and 52 weeks. After the 7-day periods at 12 and 52 weeks timepoints, the Chief Investigator instructed the patients to complete the CRQ, HADS and the weekly version of the PROactive tool. These measures were not collected as part of standard care. The Chief Investigator asked patients to return their step diary when attending the 52-week study follow up (**Table 4:1**).

Table 4:1: Schedule of procedures for all participants (quantitative measures)

Procedure	Description	Baseline (-3 weeks to 0 weeks)	First follow up (12 weeks)	52 weeks
Assessment patient demographics/medical history	Age; race; ethnicity; gender; body measurements; other comorbid chronic diseases; medication use, smoking history; number of exacerbations in the previous 12 months; and smoking status (exhaled carbon monoxide)	X		
Objective PA	Activity measures (Actigraph wGT3X-BT) Activity: daily steps, time spent in different activity intensities; daily vector magnitude units; self-reported activity (via pedometer)	X	X	X
Subjective PA	Patient reported outcome tool for PA (PROactive)	X	X	X
Disease specific quality of life	Chronic Respiratory Disease Questionnaire (CRQ-SR)	X*	X	X
Anxiety and depression	The Hospital Anxiety and Depression Scale (HADS)	X*	X	X
Intervention adherence	Step diary			X
Intervention fidelity	WhatsApp checklists		X	X
Intervention fidelity/participant engagement	WhatsApp chat exports[†]			

*Outcomes collected as part of standard care; [†]WhatsApp leaders were asked to send monthly WhatsApp chat exports throughout the intervention period

4.4 Quantitative data (outcome measures)

4.4.1 Feasibility outcomes

4.4.1.1 Consent, recruitment, and attrition rates

The primary outcome of this trial was the number of patients who consented and complied with the intervention for 52 weeks. Secondary feasibility outcomes included consent, recruitment, and attrition rates.

Consent rates referred to the number of eligible individuals who received a participant information sheet that were willing to consent and participate in the study. Recruitment rates referred to the time taken to achieve planned sample size of participants. Withdrawal rates referred to the number of individuals who enrolled (signed a consent form) and subsequently dropped out of the study prior to the end. These measures enabled the research team to measure individuals' acceptability of study, help inform the time taken for recruitment for a definitive trial and provide a measure of compliance in the study.

Consent, recruitment, and attrition rates were collected for all participants in the study, including patients, HCPs, and WhatsApp leaders.

4.4.1.2 Step diary

Though the initial aim of the step diary was to promote PA (intervention component), the step diary also provided a measure of subjective PA and enabled a verification of the primary outcome measure (Actigraph wGT3X-BT). They were also another measure of adherence to the intervention.

4.4.1.3 WhatsApp checklists

WhatsApp leaders were asked to send copies of WhatsApp checklists to the research team every 4 weeks. The WhatsApp checklists enabled the research team to measure the consistency of the intervention delivery across the research study.

4.4.1.4 WhatsApp chat exports

WhatsApp chat exports provided a copy of the conversation on WhatsApp between group members. These exports were beneficial as they enabled a verification of the WhatsApp checklists. They were also another measure of fidelity when the WhatsApp checklists were not completed. For example, the research team could measure the frequency and content of the message types sent to the WhatsApp group. WhatsApp leaders were also instructed to export a copy of the conversation on WhatsApp between group members every 4 weeks.

4.4.2 Clinical outcomes

4.4.2.1 Physical activity (Actigraph wGT3X-BT)

The proposed primary outcome for a future definite trial was daily steps. Hence, the primary clinical outcome in the feasibility study was average daily steps at 12 months. Daily steps was connected to the intervention component (pedometer) and supported by previous research which states that steps are a common outcome measure which is readily interpretable.[53] Daily steps provided an indication of how physically active individuals are. Average daily steps at 12 months reflect whether PA has been maintained long-term upon completion of PR. Daily steps have been collected in various recent studies which have aimed to determine COPD patients' PA levels.[84,252,285]

A wGT3X-BT triaxial accelerometer was used to measure daily steps. This Accelerometer has access to raw data and can capture and record continuous, high resolution PA information. This wGT3X-BT triaxial accelerometer was chosen as it is the preferred and recommended activity monitor model as reported in recent guidelines[53] and it has been used in previous studies.[299,300] The Accelerometer wGT3X-BT has also been validated for use in COPD populations.[301] Data was sampled in 10 second epochs as research suggests that shorter epoch lengths are suited for estimation of sedentary behaviour (SB). Data were sampled at the standard 30 hertz frequency. Non-wear episodes were defined as 60 min of

zero counts, up to two 1-minute epochs of up to 100cpm. The data was considered valid if the patients had worn the accelerometer for a minimum of 600 minutes (10 hours) in one day, which is supported by recommendations.[53] Patients were asked to wear the accelerometer for a minimum of seven days which meant that patients had a high chance of accumulating valid data. Half days were excluded from the analysis, as the data did not necessarily reflect true activity levels of patients. For example, the accelerometer may have recorded data before participants started wearing the accelerometer and after the participants returned the accelerometer. Guidelines suggest that a minimum of five days of data is a valid interval of data.[53] However, researchers included all valid days of data from patients, irrelevant of how many valid days they achieved throughout the wear time interval. This decision was made based on the conclusion that previous literature does not report a weekday/weekend effect in this population who are older and less active.[53] Placement of the activity monitor on the waist enabled accurate assessment of sedentary and postural transitions.[53]

Data collected from PR and non-PR days were analysed separately, as it has previously been suggested that days where patients completed PR were often higher in PA than non-PR days[128], and therefore not representative of their usual daily PA.

4.4.3 Secondary outcomes (clinical)

4.4.3.1 Activity (Accelerometer wGT3X-BT)

In addition to average daily steps, the accelerometer was used to record a range of secondary outcomes, which included: daily and weekly vector magnitude units; and time spent: sedentary behaviour (SB); in light physical activity (LPA); moderate to vigorous physical activity (MVPA). PA data (time spent in different PA intensities) was based on METS (metabolic equivalent of task). Thresholds were informed by MET thresholds used in previous literature[302] set as the following: SB (<1.5 metabolic equivalents of task), LPA (between 1.5 and 3.0), and MVPA (>3.0).

4.4.3.2 PROactive tool (weekly tool)

This tool was used in conjunction with the accelerometer. A working group of international experts developed this patient reported outcome (PRO) tool to measure patients' experience of PA in terms of 'amount' and 'difficulty'. PROactive is a hybrid tool which combines a short patient-reported outcome questionnaire with activity monitor variables (daily and weekly steps, daily and weekly vector magnitude units) which provides valid and reliable measures of PA in COPD patients.[73] This tool is useful as it is possible that the accelerometer will not completely capture activities of low intensity. Additionally, questionnaires do not always accurately measure PA as patients can have errors in recall. The weekly PROactive instrument includes 14 items, including the domains 'amount of physical activity' and 'difficulty with physical activity', and is quick to administer. Each question is rated on a numerical, 5-point modified Likert Scale.

4.4.3.3 Chronic Respiratory Disease Questionnaire (CRQ-SR)

This is a self-reported measure of disease specific QoL for people with chronic lung disease.[117] It is made up of four dimensions relating to dyspnoea (breathlessness), emotional function, fatigue, and mastery, with 20 questions in total. Each question is rated on a numerical, 7-point modified Likert Scale and a higher score indicates better disease specific QoL. This questionnaire has been found to be a reliable measure of health status (reproducibility and internal consistency), and valid (content and concurrent validity)[117,303] and is currently used in pre and post PR across LCHS.

4.4.3.4 Hospital Anxiety and Depression Scale (HADS)

HADS[118] is a widely used instrument to assess symptoms of depression and anxiety in patients with COPD, with evidence to suggest that it is sensitive to detect symptoms in COPD patients.[306,307] The questionnaire asks how patients have felt in the previous week and encourages patients to respond quickly. It is a short (estimated time of 2-5 minutes), self-

reported questionnaire which comprises of 14 items. Each question is rated on a numerical, 4-point modified Likert Scale and a higher score indicates higher levels of anxiety/depression. This questionnaire is currently used pre- and post- PR across LCHS.

4.5 Qualitative data (outcome measures)

4.5.1 Semi-structured Interviews with patients

Qualitative interviews were chosen as a method of data collection. Interviews facilitate the exploration of patients' perceptions and meaning of a specific phenomenon, thus increasing understanding of the research in question.[308,309] There are a variety of interview techniques which vary in their level of rigidness, for example structured, semi-structured and open ended, each associated with their own strengths and limitations.[310] Semi-structured interviews are among the most popular in qualitive research[310] and they generally centre around a set of predetermined open-ended questions and potentially generate other questions based on the interaction between the interviewer and interviewee.[311] A strength of semi-structured interviews involves the flexibility of the process, for example the researcher has the freedom to deviate from the topic guide and probe on a line of questioning.[312] This method prioritises understanding the perceptions and meaning of the patients' and provide opportunities for the researcher to ask probing questions to explore topics that patients' find particularly important. An element of structure was required for this research, as it was necessary to explore specific processes of the study e.g. participant recruitment and experiences of the intervention components. However, it was also important to identify and understand the processes that influenced patient acceptability and experience of the research procedures and intervention, hence semi-structured interviews were the chosen method of data collection. To enable the interview data to reflect patient acceptability throughout different stages of the study, the interviews were organised to span across the 52-week period.

4.5.2 Focus groups with Health Care Professionals and WhatsApp leaders

A focus group was chosen as the method to gain insight into HCPs' and WhatsApp leaders' experience of the intervention and research procedures. A focus group is a semi-structured discussion with a small group of people (for example ranging from 4-12 people), which aims to explore and understand a topic of interest, and use open questions to gather rich and meaningful data.[313] Focus groups enable the identification of potential issues within research and generate impressions/insight of the service and the direct interaction with HCPs and WhatsApp leaders, and therefore the possibility to observe non-verbal cues.[314] The main benefit of Focus Groups over semi-structured interviews is that data collection is both situated in and facilitated by a group setting and the complex and dynamic social context influences the results. Social interactions within focus groups enable discussion around the topics of interest and enables individuals to offer their opinions regarding the research. The group format enabled individuals to react and build upon each other's opinions.[315]

The Focus Groups were planned towards the end of the research study, meaning the preliminary findings of the wider study (both short and long term feasibility and clinical results, Chapter 5) could be discussed and interpreted by the HCPs and WhatsApp leaders.

As the validity of focus groups were reliant on individuals' level of comfort when sharing their views about the research, which is potentially affected by group dynamics, careful consideration of intrapersonal factors, interpersonal factors and environmental factors was considered important prior to the start of qualitative research.[314] For example, there were different roles within the PR team, including: the lead Clinical Specialist Physiotherapist, Physiotherapists and Physiotherapist Assistant's, and therefore there was a clear hierarchical structure within the team. However, HCPs within LCHS regularly work together, have regular monthly meetings, and the Chief Investigator judged their interactions as comfortable and therefore the decision to use focus groups was considered acceptable. Additionally, the

Chief Investigator had met all HCPs prior to conducting the focus groups and obtained informed consent for their potential participation in the focus group. Arguably, all HCPs were motivated to take part in the focus groups, implicating their co-operation within a focus group. The research team did not consider there to be any hierarchical structure between the WhatsApp leaders.

4.5.3 Topic guide development and structure

All topic guides (Appendix M - Y, p349- 358) were informed by previous literature and stakeholder discussions. To increase the validity of the topic guides, they were initially reviewed by the Chief Investigator's academic supervisors and patient volunteers (individuals within COPD patient groups). Final versions were then pilot tested with colleagues.

As all topic guides were semi-structured, the questions within the interview/focus groups remained the same, but the order of the questions were flexible. These questions enabled Chief Investigator to identify participants' views on how the intervention and research procedures could be improved during the feasibility study (e.g. early interviews could have enabled the research team to improve upon their recruitment technique) and for the development of a future trial.

The topic guides included open questions to invite participants to describe and explain their experiences and prompts were used to further explore participants' responses, and verbal and non-verbal prompts included statements to remind participants of the phenomena included in the question, in addition to open questions to further explore participants' experience. For example, when patients were asked 'can you tell me how did you first hear about this research?' the prompt for patients included the reminder 'information sheet from the lead health care professional, spoke to the research team.' When HCPs were asked 'could you tell us about your relationship with other WhatsApp group members?' the prompt included the question 'Did you feel comfortable sending messages to the group?'.

Non-verbal prompts such as head nodding and silences were also used to encourage participants, in addition to techniques such as reflective listening and summary reflections to check that interviewer/moderator had understood what the participants meant to convey.[316] The prompts were important during the interviews, as they lead the participants to further consider factors they may have forgotten or not explored during the interviews/focus groups.

4.5.3.1 Topic guides for patient interviews

Topic guides for all patient interviews (intervention and control group) (Appendix M, p349) were tailored due to patients' level of inclusion in the study, meaning there were several variations of the topic guide. The number of questions varied for each subset of patients. For example, patients who refused to participate were asked for their reason/s for deciding not to take part, and patients who withdrew from the study were asked for their reason/s for deciding to withdraw from the research. However, topic guides for all subsets of patients included the following groups of questions: recruitment: how patients first heard about the research, their initial reaction to receiving the invitation to take part, their thoughts on the invitation technique and the written information about the research (n=4); Capability, Opportunity and Motivation (COM-B) (n=3); Data collection (including accelerometer) and measurement time points: follow-up visits; patients thoughts on the activity monitor; PROactive; CRQ and HADS questionnaires; the ISWT (n=6); Plans to keep active (n=1); End of interview (n=1). The Topic Guide included additional questions for the Intervention group: Experiences of using the devices: their thoughts on the pedometer, step diary, mobile phone and WhatsApp group (=4); Patient training (n=2); Familiarisation period (n=2); Impact of the Intervention on PA (n=11); Plan to keep active (use of intervention components) (n=1). Overall, the topic guide for the IG included 35 questions, and usual care included 15 questions. Questions about patients' capability, opportunity and motivation enabled the Chief Investigator to identify the behavioural sources that influenced patients' PA following PR.

4.5.3.2 Topic guides for focus groups with health care professionals

Topic guides with HCPs (Appendix N, p355) included the following components: PR programme recruitment (n=3); Patient recruitment (n=2); patient training (n=2); phone and pedometer familiarisation period (n=2); impact of the study on the programme (n=1); impact of the study on HCPs (n=1); Impact of the intervention of PA (n=1); feasibility questions (n=3); end of the interview (n=1). Overall, there were 16 questions included in the topic guide. The topic guide included open questions to invite HCPs to describe and explain their experiences.

4.5.3.3 Topic guides for focus groups with WhatsApp leaders

The topic guide (Appendix O, p358) included 8 groups of questions, including the following: introductions (n=2); recruitment (n=2); training (n=2); experience of using the intervention components (n=5); experience of messaging the WhatsApp group (n=2); messages (n=5); support (n=3) and future involvement (n=1). Overall, there were 22 questions included in the topic guide.

4.5.4 Procedures

4.5.4.1 Patient interviews

The Chief Investigator contacted subsets of patients during the study and asked them to reconfirm their decision to participate in an interview (face to face or telephone). The time and day were based on patients' convenience. Patients who opted for a face to face interview were given the opportunity for it to be conducted at their homes, the University of Lincoln, or the local PR community centre, subject to the setting being free of distractions. Patients were informed that they could be joined by a relative or friend if this made them feel more comfortable and that the interview was predicted to last approximately 60 minutes.

The interviewer (Chief Investigator) had previously met all patients on numerous occasions. However, it was still considered important to develop a rapport with patients

before the interview and therefore every effort was made to construct an environment which made the participant feel at ease. This enabled an effortless conversation style approach to the interview and allowing the interviewer the possibility of clarification when making sense of patients' answers.[311] Prior to starting the interview, the interviewer summarised the purpose of the interview and asked patients to reconfirm their agreement for the interview to be recorded. If patients did not feel comfortable answering specific questions during the interview, the interviewer moved the interview onto the next component.

A Dictaphone (Btopllc digital voice recorder) was used to record the interview, meaning that the Chief Investigator did not need to make notes during the interview, as this would have interrupted the flow of the interviews. However, field notes were recorded after the interviews to capture contextual factors such as setting, time of day and interruptions during the interview. The duration of the interview was also recorded.

At the end of the interview, patients were reminded that they could contact the research team with any questions about the study. Participants were asked to take part in a maximum of one interview. However, in the unlikely event of technical failure (for example, inadequate Dictaphone recordings), repeat interviews were re-scheduled.

4.5.4.2 Focus groups with Health Care Professionals and WhatsApp leaders

Two separate focus groups were organised. One with HCPs and the other with WhatsApp leaders. Prior to the focus groups, HCPs and WhatsApp leaders involved in the study were contacted by the Chief Investigator and asked for their permission to participate in a Focus Group. Participants were informed that the focus groups were predicted to last approximately 90 minutes, and they were organised at a time and place of convenience for participants, dependent on the room being comfortable and free of distractions. Prior to conducting the focus group, the Chief Investigator summarised the purpose of the focus group and asked participants to reconfirm their agreement for the focus group to be recorded.

The Chief Investigator moderated the focus group and was facilitated by their Academic Supervisor to assist with practicalities such as note taking and summarising the main discussion points to the group. The participants were familiar with the research team as they had met the Chief Investigator and their Academic Supervisor during recruitment and data collection procedures.

Notes were taken to record participants' non-verbal aspects of the focus groups[314], such as emotional cues such as smiles, body position and raising of voice. These cues may have been in response to topic guide questions and comments from other group members and therefore important data. In addition, the moderator recorded contextual factors such as setting, time of day and the flow of discussion e.g. duration and frequency of silences within the group, individuals talking at the same time, potential interruptions or leadership tendencies and conflicts between group members. A Dictaphone was used to record the focus group, meaning that the research team were not reliant on field notes.

At the end of the focus groups, participants were reminded that they could contact the research team with any questions about the study. The moderator summarised the main discussion points to the groups at the end of the focus group, which enabled participants to offer any further information that they considered relevant. Participants were asked to take part in a maximum of one focus group. However, in the unlikely event of technical failure (for example, inadequate Dictaphone recordings), repeat focus groups were re-scheduled.

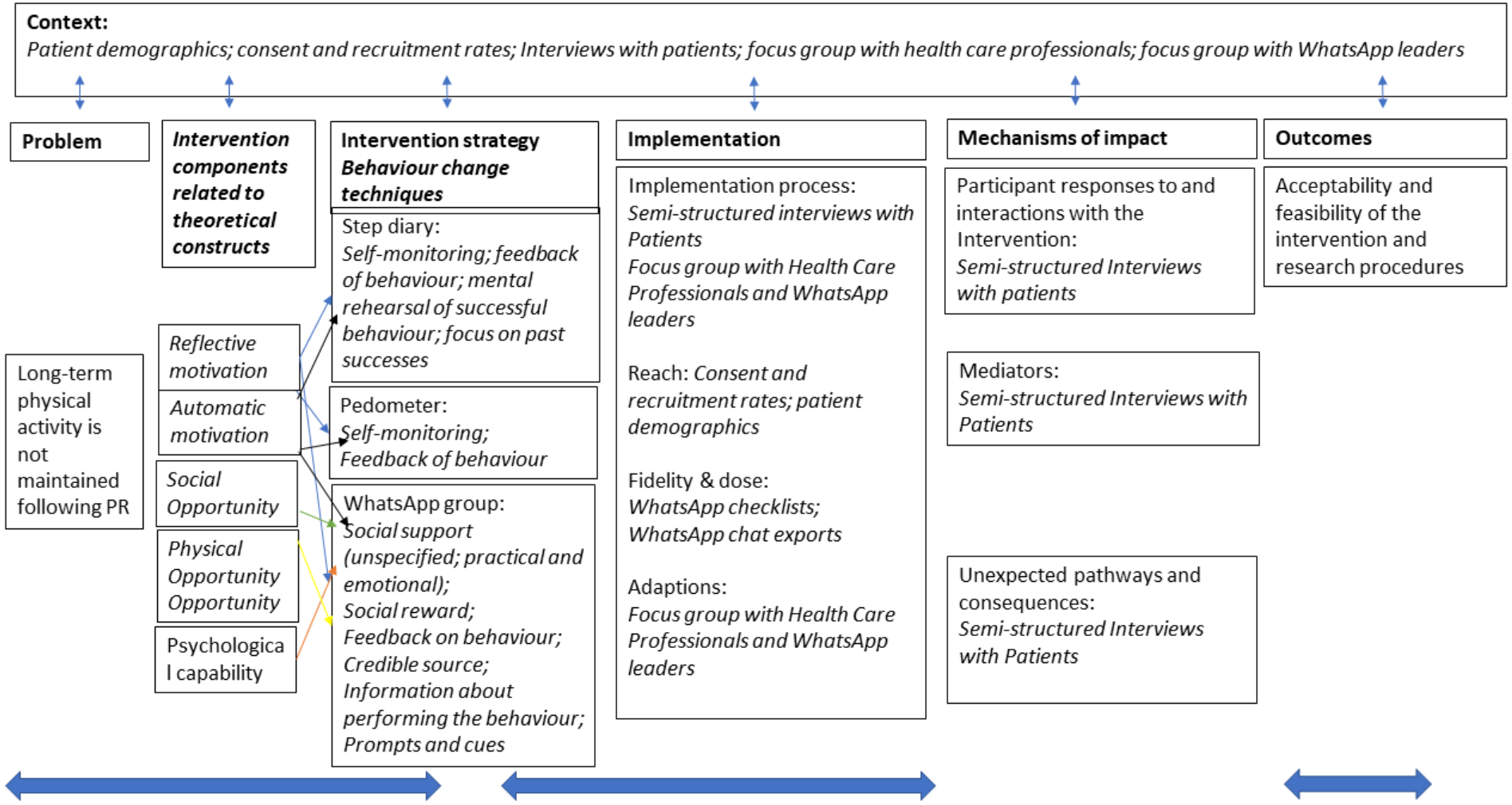

Figure 4:6: An edited MRC illustration, outlining the intervention components which relate to behavioural sources, and the key components of the process evaluation

4.5.5 Analysis

The analysis of all data was performed by the Chief Investigator. As this was a feasibility study, analyses of quantitative data were treated as exploratory and mainly reported descriptively. Quantitative data was presented using numbers and proportions for categorical data, and means and standard deviations (SDs), medians and effect sizes for continuous data. Estimates of effect size and their 95% confidence intervals were also reported. The data provided information on the potential efficacy of the intervention and hence suitable parameters to inform a sample size calculation for a future, definitive CRCT.

The WhatsApp exports were exported onto NVivo 12 Pro.[203] A deductive approach was then used to analyse the data referring to type of messages sent to the WhatsApp groups (based on the categories of messages which reflect the BCTs used in the intervention). There are 93 codes, referring to the Behaviour Change Techniques (BCTs) outlined in the Behaviour Change Technique Taxonomy 1 (BCTTv1) that were applied to the data, enabling an identification of the types of messages that the WhatsApp leader sent, to the intervention framework applied in the development the intervention.[145]

All interviews and focus groups were audio recorded and data was transcribed verbatim. In some cases, automatic transcription software 'Transcribe' (audio to text)[317] was used to facilitate transcription. Personal identifiers were removed, and participants were pseudonymised where necessary.

NVivo Pro 12[203] was used to facilitate the analysis of the anonymised transcripts. A thematic analysis of the patient interviews and focus groups was conducted. Thematic analysis was informed by stages outlined by Braun and Clarke.[205] An inductive approach was used to analyse the data referring the patients', HCPs' and WhatsApp leaders' acceptability and experience of the intervention and research procedures. This approach was therefore

data-driven and not driven by the researcher's analytic preconceptions.[205] This approach enabled the identification of patterns or themes within the data.[205]

The Chief Investigator also adopted a deductive approach to thematic analysis to identify the behavioural sources that related to PA following PR for participants. The intervention was informed by the steps outlined in the Behaviour Change Wheel (BCW)[145], which outlines that behaviour is driven by Capability, Opportunity and Motivation (COM-B) (Chapter 3). A deductive approach to thematic analysis enabled the Chief Investigator to map the factors referring to individuals' COM-B components.[145] Six deductive codes referring to the behavioural sources outlined in the Behavioural Change Wheel[145] were applied to the data. These included physical and psychological capability; social and physical opportunity and automatic and reflective motivation (discussed in Chapter 3).

Interviews were transcribed and coded throughout the study, an iterative process, meaning that emerging themes were apparent to the Chief Investigator. Data saturation signalled the end of data collection and no more interviews were arranged with subsets of patients.

Identified themes were discussed between the research team and presented to key stakeholders, including individuals in Breathe Easy[138] groups across Lincolnshire and physiotherapists involved in PR across Lincolnshire, with the aim to enhance credibility and transparency of the analytical process.

5 Chapter 5: Results of the Feasibility Cluster Randomised Controlled trial

5.1 Abstract

Background: Despite PR's beneficial impact on exercise capacity and quality of life in COPD, these improvements do not translate to an increase in long-term PA. Previous interventions to promote PA following PR have had limited efficacy. Chapter 3 outlined the development of a complex, multicomponent intervention to support patients' maintenance of long-term PA following PR, which included provision of a pedometer and step diary, and addition of patients to a WhatsApp group populated by fellow PR graduates and a 'WhatsApp leader' for 52 weeks.

Aim: This chapter reports the quantitative and qualitative results from the cluster randomised controlled trial (CRCT) and process evaluation.

Methods: This was a mixed-methods study including a feasibility CRCT and a qualitative process evaluation. Clusters were PR programmes across LCHS, NHS Trust (n=12), randomly allocated to the Intervention Group (IG) or Control Group (CG). The primary outcome was the acceptability of the intervention. Secondary outcomes included: recruitment, consent and attrition rates, intervention fidelity, and the proposed clinical measures for a definitive trial, including: daily steps and PA intensity (Actigraph wGT3X-BT), PA Amount and Difficulty (PROactive), Anxiety and Depression (HADS), and disease specific quality of life (CRDQ). Semi-structured interviews with participants and focus groups with HCPs and WhatsApp leaders assessed individuals' experiences and perceived acceptability of the intervention and research procedures.

Results: The study was successful in recruiting the target number of patients, and the consent rate was 55%. Most patients in the IG engaged in the intervention components. By 52 weeks, 49% had engaged in the step diary, and 58% of participants who had consented to use WhatsApp had sent at least one WhatsApp message to the group. Participants who engaged in the step diary had a smaller decline in their daily steps at 52 weeks compared to those who did not engage in the step diary, MD, 45.5 (-1796, 1889), although this did not exceed d = 0.2. Participants who engaged in WhatsApp had a smaller decline in daily steps at 52 weeks compared to those who did not engage in WhatsApp, MD, 730 (-992, 2454), d = 0.52.

However, results also suggest there was a larger detrimental decline in breathlessness, emotion (CRQ) and depression (HADS) in the IG than the CG. WhatsApp leaders adhered to sending a minimum of weekly PA messages throughout the 52 weeks period. Common themes from interviews and focus groups were that patients would benefit from more familiarity with the intervention components, and that the convenience of the intervention components and research procedures could be improved. Rapport between the patients and WhatsApp leaders was considered important and face to face support should complement social networking following PR.

Conclusion: The results highlighted that the intervention is feasible for a definitive trial. The clinical results outlined a beneficial impact of the intervention on patients' PA. All groups considered the intervention and research procedures to be acceptable and feasible, based on specific modifications, which require further testing prior to a definite trial.

5.2 Introduction

Chapter 1 and 2 reported the evidence base surrounding PA following PR in patients with COPD. This informed the development of the complex, multicomponent intervention to support patients' maintenance of long-term PA following PR, which included provision of a pedometer and step diary, and addition of patients to a WhatsApp group populated by fellow PR graduates and a 'WhatsApp leader' for 52 weeks, (Chapter 3). This intervention was tested in a mixed-methods study including a feasibility CRCT and a qualitative process evaluation (Chapter 4). The feasibility testing of the intervention and research procedures adheres to the stages outlined in the MRC framework.[159]

This Chapter reports both the quantitative and qualitative results from this study. The following text reports the quantitative results, starting with the feasibility outcomes (5.3.1), followed by the clinical outcomes (5.3.5), the qualitative results (5.5), including the results from the interviews with patients (5.5.1) and focus groups with WhatsApp leaders (5.5.2) and HCPs (5.5.3). As previously reported in Chapter 4, the outcomes from the feasibility study are important for informing the next step in the development of this complex intervention,

and determines whether there is the need for further studies to refine this intervention design prior to its implementation. However, the main aim of this chapter is to report the acceptability and feasibility of the intervention and research procedures.

5.3 Quantitative results

5.3.1 Feasibility outcomes

5.3.1.1 Consent, recruitment, and attrition rates

5.3.1.1.1 Patients

Participants flow through the study is illustrated in **Figure 5:1**. Twelve PR programmes (clusters) were invited to the study and were randomised to the intervention group (IG) or control group (CG). Overall, there were a total of 134 patients eligible for the study, with an overall consent rate of 55%, between June 2018 and January 2019. There was an overall attrition rate of 35% over the 52-week period, which was higher in the IG (41%) compared to the CG (30%), **Figure 5:1**.

5.3.1.1.2 WhatsApp leaders

Eight volunteers from COPD patient groups consented to become a WhatsApp leader, but only seven proceeded to deliver the intervention by sending messages to the WhatsApp groups (one individual volunteered to be the WhatsApp Leader for two WhatsApp groups). Two WhatsApp leaders withdrew from the Intervention. Five WhatsApp Leaders sent messages to the six WhatsApp groups. There was therefore an attrition rate of 29%.

5.3.1.2 Completeness of follow-ups

Of those participants who consented to the study, fewer participants provided data at all three study visits (baseline, 12 and 52 weeks), including; valid wGT3X-BT triaxial accelerometer (wGT3X-BT) data (IG = 14; CG = 13); HADS data (IG = 14; CG = 21), CRQ data (IG = 18; CG = 23), and finally, PROactive data (IG = 10; CG = 15). Reasons for missing Accelerometer data included invalid Accelerometer data (n=5) and refusal to wear the

Accelerometer due to discomfort and inconvenience (e.g. away on holiday) (n=5), **Figure 5:2**.

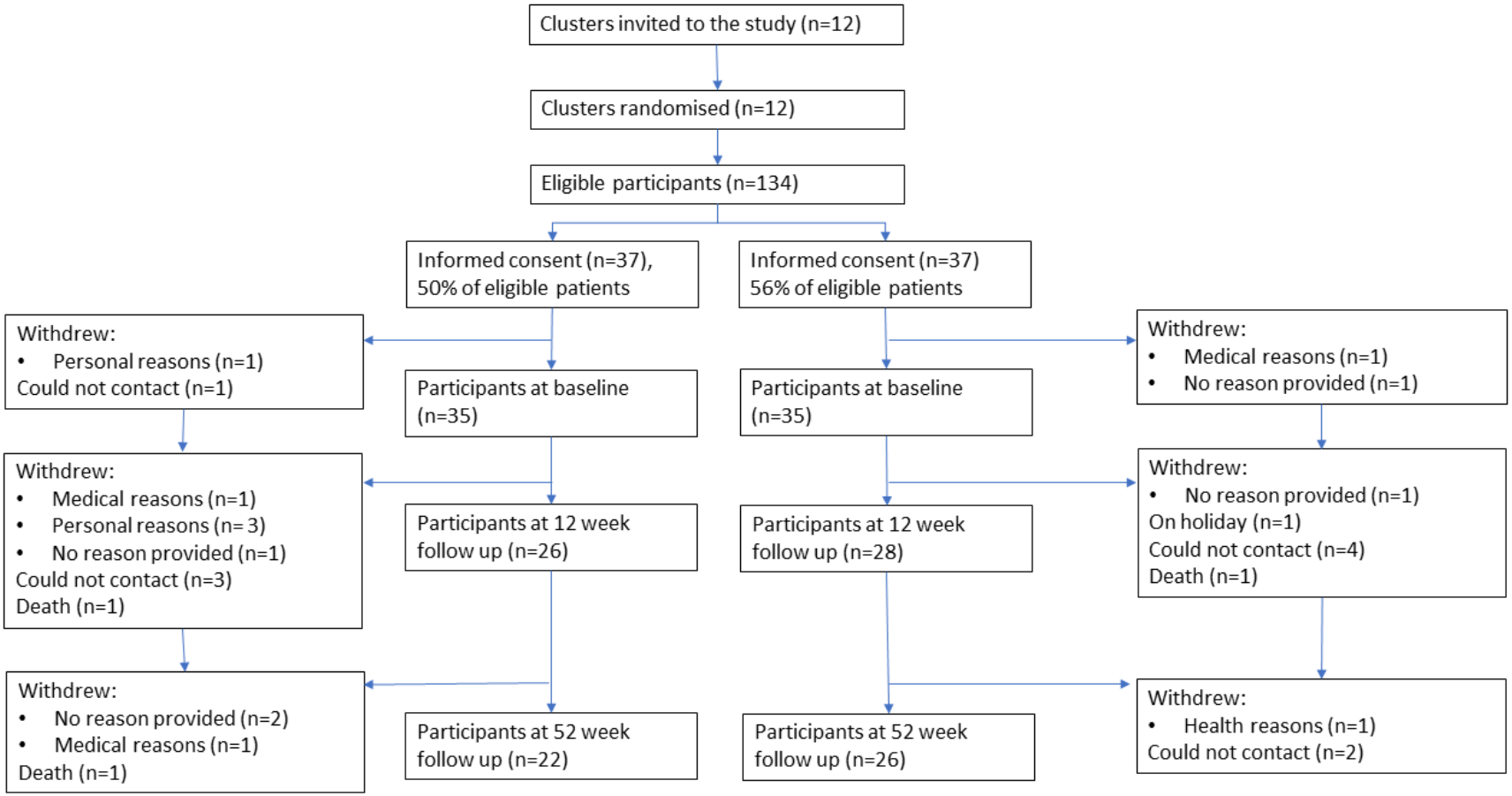

Figure 5:1: Participant flow chart

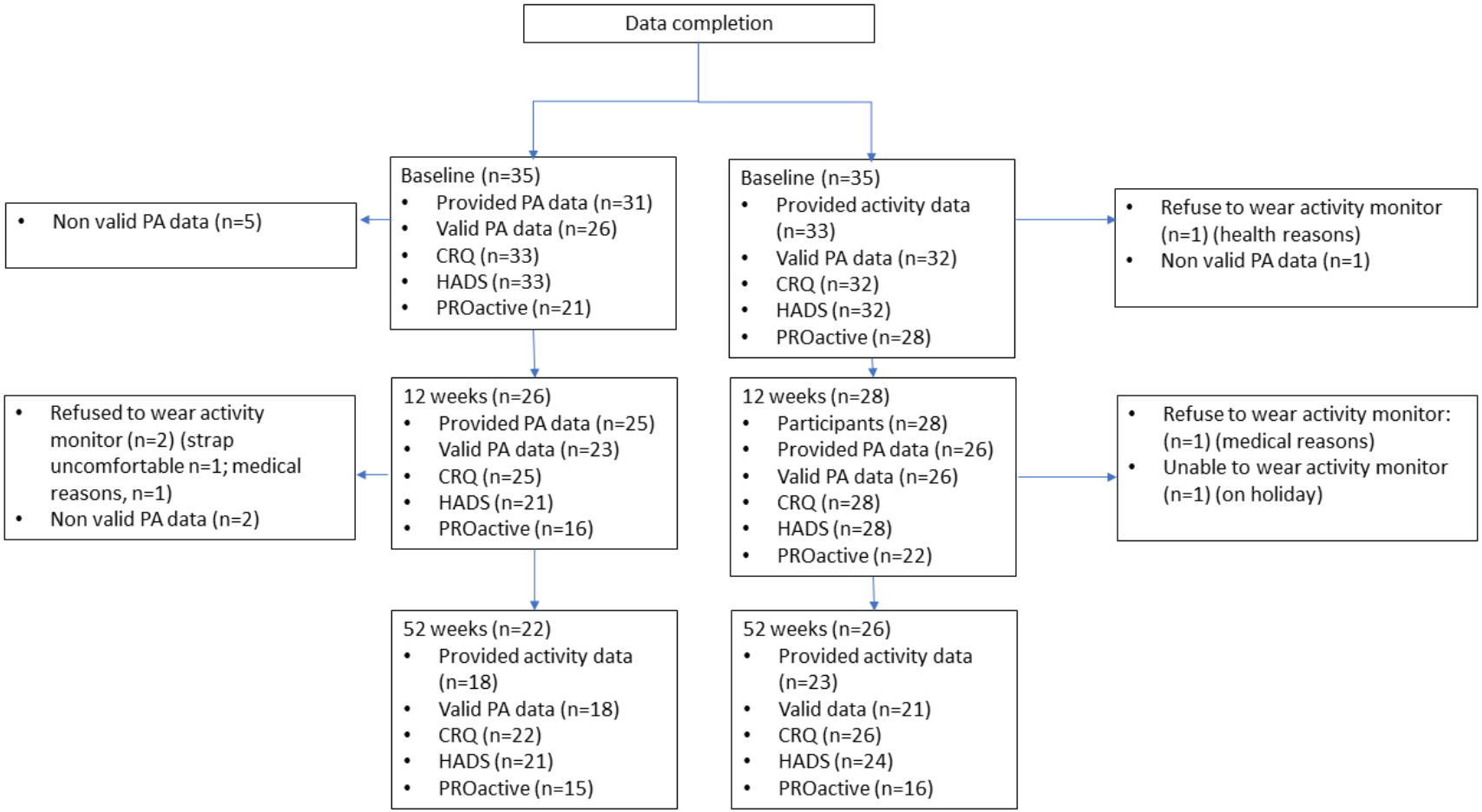

Figure 5:2: Data collection at baseline, 12 weeks and 52 weeks across the IG and CG.

5.3.2 Clinical Characteristics

5.3.2.1 Baseline characteristics of the Intervention and Control group

Of the 74 participants enrolled onto the study, there were an equal number of participants in both groups (IG, n=37; CG, n=37). Overall, 58% of participants were male and 97% were White British. The mean (± SD) age was 70.2 years, (8.19), BMI 28.2 (7.13) (kg/m^2) and the FEV_1% predicted was 55.3 (19.2). Overall, 17% were current smokers, 77% were former smokers and 6% of participants had never smoked. All participants who were current or former smokers had a mean (± SD) pack history of 39.6 (34.3). The median MRC score was 3 and there was a median number of 2 comorbidities and 1 exacerbation per year. The CG had a larger mean age, with a mean difference (MD) of 4.11 years, (95% Confidence Interval (CI), -7.81, -0.41). The CG had a larger reported: BMI (kg/m^2), MD, 1.65, (-4.93, 1.63); FEV_1 % pred, MD, 3.83, (-13.7, 6.02); ISWT, MD, 37.3m, (-110, 35.5); and ESWT, MD, 181m, (-468, 106). However, the CG had a lower reported score in: CRQ Emotion, MD, -0.25 (-0.24, 0.75); Depression (HADS-D), MD, -0.81, (-2.66, 1.04); and fewer exacerbations per year, MD, -1.14, (-0.66, 2.93), **Table 5:2**

5.3.2.2 Baseline post-PR outcomes of patients who declined vs. patients who consented to the study

The intervention aimed to promote PA for patients following PR. To understand if there were differences in the groups which consented and those who declined the study, their PR outcomes were collected and examined. Overall, 74 patients consented to the study and 60 patients declined the study (55% of eligible patients).There were few differences detected between the clinical characteristics (post PR outcome data) of patients who consented to the study compared to those who declined the study (**Table 5:1**), suggesting that those who consented had lower disease specific quality of life (CRDQ) and psychological wellbeing

(HADS). Those who consented had smaller mean scores in: CRQ Emotion, MD, -0.56, (-0.96, -0.16), and CRQ Mastery, MD, 0.27 (-0.72, 0.18). Those who consented also had a larger mean score in Anxiety (HADS-A), MD, 1.16 (-0.36, 2.69); and Depression (HADS-D), MD, 1.12, (-0.07, 2.4).

Table 5:1: Baseline characteristics of patients who consented vs those who declined the study

		N		M (SD)				MD (consent-decline)	95% CI		Effect size (d)
		Consent	Decline	Consent		Decline			(Lower, Upper)		
Functional capacity	ISWT (m)	67	48	274	(281)	234	(142)	39.4	-39.9	119	0.17
	ESWT (m)	55	46	586	(524)	575	(495)	10.4	-192	213	0.02
CRQ	Dyspnoea	65	58	3.46	(1.15)	3.69	(1.21)	-0.22	-0.65	0.2	0.19
	Emotion	65	57	4.7	(1)	5.26	(1.25)	-0.56	-0.96	-0.16	0.49*
	Fatigue	65	58	4.04	(1.15)	3.95	(1.28)	0.09	-0.35	0.52	0.07
	Mastery	65	57	5.01	(1.24)	5.28	(1.26)	-0.27	-0.72	0.18	0.22*
HADS	Anxiety	65	58	7.09	(3.78)	5.93	(4.61)	1.16	-0.36	2.69	0.28*
	Depression	65	58	6.4	(3.73)	5.19	(3.39)	1.21	-0.07	2.4	0.34*

*Effect size is >0.2 (exceeded Cohen's d convention for a small, medium or large effect size), M: Mean, SD: standard deviation, SE: standard error, CI: confidence interval, d: Cohen's d, ISWT: Incremental Shuttle Walk Test, ESWT: Endurance Shuttle Walk Test, CRQ: Chronic Respiratory Questionnaire, HADS: Hospital Anxiety and Depression Scale, SB: Sedentary Behaviour, LPA: Light Physical Activity, MVPA: Moderate Vigorous Physical Activity.

Table 5:2: Baseline characteristics of the Intervention and Control group

		N		M (SD)						
		IG	**CG**	**IG**		**CG**		**MD (IG- CG)**	**95% CI (Lower, Upper)**	**Effect size (d)**
Patient demographics	Age (years)	37	37	68.1	(8.71)	72.2	(7.18)	-4.11	(-7.81, -0.41)	0.51*
	Gender (m/%)	19 (51)	24 (65)							
	BMI (kg/m2)	36	37	27.4	(7.16)	29	(7.09)	-1.65	(-4.98, 1.68)	0.23*
	FEV_1 (% pred)	30	31	53.3	(19.5)	57.2	(19.4)	-3.83	(-13.7, 6.02)	0.2*
	MRC Mean			3.47	(0.72)	3.08	(1.02)	-.39		
	Pack history	30	30	42.2	(37.8)	37.1	(30.9)	5.16	(-12.7, 23)	0.15
Functional capacity	ISWT (m)	33	27	233	(134)	271	(148)	-37.3	(-110, 35.5)	0.26*
	ESWT (m)	26	28	496	(498)	677	(549)	-181	(-468, 106)	0.35*
CRQ	Dyspnoea	33	32	3.39	(1.06)	3.5	(1.24)	-0.11	(-0.68, 0.46)	0.1
	Emotion	33	32	4.82	(1.04)	4.57	(0.96)	0.25	(-0.24, 0.75)	0.25*
	Fatigue	33	32	4.02	(1.1)	4.05	(1.22)	-0.03	(-0.61, 0.54)	0.03
	Mastery	33	32	5.1	(1.32)	4.93	(1.17)	0.17	(-0.45, 0.79)	0.14
HADS	Anxiety	33	32	7.09	(3.81)	6.97	(3.8)	0.12	(-1.76, 2.01)	0.03
	Depression	33	32	5.97	(3.43)	6.78	(4.01)	-0.81	(-2.66, 1.04)	0.22*
PROactive	Amount	22	32	7.67	(2.94)	7.73	(3.37)	-.06	(-1.84, 1.72)	0.02
	Difficulty	22	32	23.1	(7.69)	23.5	(5.66)	-.44	(-4.08, 3.2)	0.07
	Sum	22	32	30.8	(9.61)	31.3	(7.45)	-.5	(-5.16, 4.16)	0.06
Physical activity	Daily steps	26	32	3397	2217	3220	(2181)	176	(-986, 1339)	0.08
METS (minutes)	SB	26	32	1076	(206)	1039	(201)	36.3	(-71.1, 144)	0.18
	LPA	26	32	11.7	(13.1)	12.4	(13)	-.729	(-7.63, 6.17)	.05
	MVPA	26	32	5.47	(14.7)	6.23	(8.03)	-77	(-6.84, 5.3)	.06
Adverse events	Hospitalisations (per year)	37	37	0.27	(0.73)	0.16	(0.69)	0.11	(-0.22, 0.44)	0.15
	Exacerbations (per year)	37	37	3.14	(3.67)	2	(4.07)	1.14	(-0.66, 2.93)	0.29*

Effect size is >0.2 (exceeded Cohen's d convention for a small, medium or large effect size), IG: Intervention Group, CG: Control Group, M: Mean, SD: standard deviation, SE: standard error, CI: confidence interval, d: Cohen's d, ISWT: Incremental Shuttle Walk Test, ESWT: Endurance Shuttle Walk Test, CRQ: Chronic Respiratory Questionnaire, HADS: Hospital Anxiety and Depression Scale, SB: Sedentary Behaviour, LPA: Light Physical Activity, MVPA: Moderate Vigorous Physical Activity.

5.3.3 Level of intervention engagement

Overall, 31 participants consented to the full intervention (WhatsApp, Pedometer and Step Diary), and 6 participants partially consented to the intervention (Pedometer and Step Diary only).

5.3.3.1 WhatsApp

Participant engagement in WhatsApp varied between individuals and across the WhatsApp groups (clusters). The number of participants involved in each WhatsApp group ranged from 2-6. However, only 18 (58%) of the 31 participants who originally consented to use WhatsApp were engaged in WhatsApp (sent at least one WhatsApp message to the group). In one WhatsApp group, no participants sent any WhatsApp messages. In another, only 1 participant sent a WhatsApp message. Participants sent a mean (± SD) of 18.3 (35.6) WhatsApp messages to the group over the 52-week period (365 days). The mean (± SD) duration that participants stayed in the WhatsApp group was 222 (141) days out of 365 (61% duration of the study).

5.3.3.2 Step diary

Overall, 19 participants (51% of those who originally consented) in the IG engaged with the step diary and returned this to the Chief Investigator at the end of the intervention. The remaining 49% of participants did not return the step diary and it was therefore not possible to calculate their engagement in the step diary.

5.3.3.3 Step diary engagement at 12 weeks

At 12 weeks, 17 participants had engaged in the step diary (49% of the total participants) and the median number of people in each cluster who engaged with the step diary was 3. The mean (± SD) number of days that participants engaged with the step diary (recorded their steps from the Yamax CW700/701 pedometer and/or commented about their steps) was 65.8 (22.7). The mean (± SD) number of daily steps for participants was 4297 (2070).

5.3.3.4 Step diary engagement at 52 weeks

At 52 weeks, the mean (± SD) number of days that participants engaged with the step diary was 177 (132) and the mean engagement for participants was 25% (percentage that participants recorded their mean daily steps). The mean (± SD) number of daily steps for participants was 3803 (1671).

At 52 weeks, 14 participants engaged with the step diary beyond 12 weeks (43% of the total participants who had engaged at 12 weeks) and the median number of people in each cluster was engaged was 3. Of these participants, their mean engagement in the step diary was 61% and their mean daily step counts were 3962 (1675). Two participants started recording their step counts after 12 weeks, and their mean engagement was 19%, and their mean daily step counts were 2054 (56.4).

5.3.4 Intervention fidelity

5.3.4.1 WhatsApp checklists

WhatsApp leaders did not complete the WhatsApp checklists during the intervention as they considered it too time consuming. However, WhatsApp leaders did base most (57%) of their messages on those outlined in the WhatsApp guidelines (Appendix K, p333) to select the type of messages they sent to the WhatsApp groups. The WhatsApp guidelines provided examples of messages that the WhatsApp leader could send to the WhatsApp group. These messages were divided into nine categories which included messages to introduce participants to the WhatsApp groups; messages to summarise PA opportunities (including information from Active Lincolnshire and about Vitality exercise classes); information and encouragement for completing activities at home; encouragement for group members to seek social support; encouragement for group members to record their PA and share this in the group; encouragement for group members to form habits and routines; messages to congratulate groups members' PA achievements and finally, messages to remind group

members to seek support if they notice a decline in their health. The type of messages the WhatsApp leader sent to the WhatsApp groups were identified in the WhatsApp chat exports (see WhatsApp chat exports below).

5.3.4.2 WhatsApp chat exports

All WhatsApp leaders (n=5) sent the Chief Investigator WhatsApp exports at the end of the intervention (after 52 weeks). The WhatsApp leaders sent a mean (± SD) of 92.5 (68.5) messages to the WhatsApp groups over the 52-week period. Of these messages, 36% were weekly PA summaries, which included messages about activities offered by local organisations (e.g. Active Lincolnshire and Vitality). The other 67% of these messages were messages based on: Introduction messages to WhatsApp (3%); Activities at home (<1%); Social support (3%); Monitor activity levels; (8%); Habits and routines (1%); Congratulatory messages (4%); and Health (<1%); and other (43%). 'Other' included a broad range of messages, such as responses to participants' questions and general reflections about their day, **Table 5:3**.

Table 5:3: Type of WhatsApp Leader messages to participants

	Total (%)	**M (SD) (per WhatsApp group)**
Total messages	569 (100)	92.5 (68.5)
Physical activity summaries	177 (36)	33 (13)
Introduction to WhatsApp	17 (3)	2.83 (2.71)
Activities at home	3(<1)	.5 (.84)
Social Support	14 (3)	2.33 (2.73)
Monitor activity levels	45 (8)	7.5 (5.75)
Habits and routines	7 (1)	1.17 (.98)
Congratulatory messages	21 (4)	3.5 (4.04)
Health	3 (<1)	.5 (.55)
Other	282 (43)	47 (49.8)

M: Mean, SD: Standard Deviation

5.3.5 Clinical outcomes

5.3.5.1 Primary clinical outcome: daily steps at 52 weeks (Accelerometer wGT3X-BT)

The proposed clinical outcome for a definite trial was mean daily steps at 52 weeks. A total of 35 participants (IG, n=18, CG, n=17) had valid Accelerometer data at 52 weeks. However, only, 34 participants (IG, n=14; CG, n=20) had valid Accelerometer data at both baseline (non-PR days) and 52 weeks, where it was possible to calculate the mean difference (MD) between the two time points. Of the participants who had both data sets, the duration of the data sets at 52 weeks ranged from 1-6 days, with a mean of 5.6 (1.76) days. Both groups declined in mean daily steps at 52 weeks, with a larger decrease in the CG than the IG (**Error! Reference source not found.**), MD, 180, (-765, 1126), **Table 5:4**.

Secondary clinical outcomes

5.3.5.2 Daily steps at 12 weeks (Accelerometer wGT3X-BT)

There were a total of 49 participants (IG, n=23, CG, n=26) who had valid Accelerometer data at 12 weeks, however, only 43 participants (IG, n=18; CG, n=25) had valid data at both baseline and 12 weeks. Of these participants, the duration of the data sets at 12 weeks ranged from 1-6 days, with a mean (± SD) of 5.09 (1.39) days. Both groups declined in mean daily steps from baseline to 12 weeks, with a larger decrease in the IG, however there were no effects of the groups which exceeded d = 0.2, **Table 5:4**.

5.3.5.3 Physical activity intensity (METS) (Accelerometer wGT3X-BT)

There was a decline in daily Sedentary Behaviour (SB) from baseline to 12 weeks in both the IG and CG. This decline was larger in the IG (MD, -86.6, (183, 9.93). SB in both groups declined from baseline to 52 weeks, but the effect size did not exceed d = 0.2. Both groups decreased in LPA at 12 weeks, but the decrease was higher in the CG (MD, 5.17, (-1.12, 11.5). At 52 weeks, the both groups had an increase in LPA, but this increase was higher in

the CG, (MD, 19.18, (-49.3, 6.97). Both groups decreased in mean daily MVPA from baseline to 12 weeks and 52 weeks. There were no effects of the groups at 12 weeks, and 52 weeks which exceeded d = 0.2, but the line chart (**Error! Reference source not found.**) illustrates that the CG had a larger decrease in MVPA than the IG at 52 weeks a, MD, 2.14 (-3.95, 8.24), **Table 5:4**. See **Error! Reference source not found.** which illustrates the comparison of PA intensities between groups from baseline to 12 and 52 weeks

Table 5:4: Between groups differences in physical activity outcomes from baseline to 12 and 52 weeks

		Allocation	N	M (SD)	MD (from baseline)	MD (IG-CG)	95% CI (Lower, Upper)	Effect size (d)
Physical activity								
Mean daily steps	12 weeks	IG	18	3122 (1836)	-689	-159	(-854, 536)	0.13
		CG	25	2887 (1777)	-529			
	52 weeks	IG	14	3198 (2210)	-794	180	(-765, 1126)	0.11
		CG	20	2980 (1581)	-974			
METS (minutes)								
SB	12 weeks	IG	18	942 (180)	-148	-87	(-183, 9.93)	0.11
		CG	25	960 (139)	-61.12			
	52 weeks	IG	14	872 (130)	-202	-2.57	(-112, 107)	0.05
		CG	20	879 (134)	-200			
LPA	12 weeks	IG	18	13.5 (15.3)	-0.47	5.17	(-1.12, 11.5)	0.51*
		CG	25	8.38 (7.81)	-5.63			
	52 weeks	IG	14	14.9 (18.4)	-.276	-19.18	(-49.3, 6.97)	0.53*
		CG	20	36.81 (55.5)	19.5			
MVPA	12 weeks	IG	18	5.15 (9.03)	-6.72	-0.19	(-7.67, 7.3)	0.01
		CG	25	4.78 (7.35)	-6.54			
	52 weeks	IG	14	8.5 (15.7)	-.066	2.14	(-3.95, 8.24)	0.16
		CG	20	6.65 (5.3)	-2.21			
PROactive								
Amount	12 weeks	IG	15	7.8 (3.23)	-.21 (1.7)	0.39	(-1.09, 1.86)	0.08
		CG	24	7.53 (3.5)	-.6 (2.48)			
	52 weeks	IG	13	7.24 (2.41)	-.57 (2.54)	0.25	(-2.09, 1.59)	0.27*
		CG	20	7.99 (3.19)	-.32 (2.52)			
Difficulty	12 weeks	IG	15	21.2 (9.01)	-4.07 (4.61)	2.28	(-5.81, 1.26)	0.04
		CG	24	21.5 (6.93)	-1.79 (5.69)			
	52 weeks	IG	13	20.6 (7.21)	-.57 (2.54)	2.48	(-6.85, 1.9)	0.13
		CG	20	21.6 (7.05)	-.32 (2.52)			
Sum	12 weeks	IG	15	29 (11.5)	-4.28 (5.4)	1.89	(-6.02, 2.24)	0.01
		CG	24	29.1 (8.6)	-2.39 (6.64)			
	52 weeks	IG	13	27.8 (8.32)	-4.64 (6.71)	2.73	(-7.87, 2.42)	0.19

*Effect size is >0.2 (exceeded Cohen's d convention for a small, medium or large effect size), METS: metabolic equivalent of task; IG: Intervention Group, CG: Control Group, M: Mean, SD: standard deviation, MD: Mean Difference, SE: standard error, CI: confidence interval, d: Cohen's d, SB: sedentary behaviour, LPA: light physical activity, MVPA: moderate vigorous physical activity; PROactive: patient reported Outcome (hybrid outcome tool), x: not applicable

Table 5:5: Between groups differences in Clinical Outcomes from baseline to 12 and 52 weeks

		Allocation	N	M (SD)	MD (from baseline)	MD (IG-CG)	95% CI (Lower, Upper)	Effect size (d)
CRQ domains								
Dyspnoea	12 weeks	IG	21	2.49 (0.88)	-1.01	-0.23	(-0.92, 0.45)	0.20*
		CG	26	2.75 (0.80)	-0.78			
	52 weeks	IG	18	2.89 (1)	-1.12	-0.47	(-1.40, 0.47)	0.33*
		CG	23	2.9 (1.23)	-0.65			
Emotion	12 weeks	IG	21	4.04 (1.24)	-0.84	-0.67	(-1.34, 0.01)	0.58*
		CG	26	4.43 (1.19)	-0.17			
	52 weeks	IG	19	4.23 (1.26)	-0.58	-0.26	(-0.89, 0.36)	0.27*
		CG	23	4.2 (1.26)	-0.31			
Fatigue	12 weeks	IG	22	3.52 (1.39)	-0.5	-0.09	(-0.79, 0.6)	0.08
		CG	26	3.65 (1.27)	-0.41			
	52 weeks	IG	19	2.96 (1.31)	-0.91	-0.09	(-0.81, 0.63)	0.08
		CG	23	3.32 (1.11)	-0.82			
Mastery	12 weeks	IG	22	4.67 (1.64)	-0.44	0.05	(-0.79, 0.88)	0.03
		CG	26	4.54 (1.4)	-0.48			
	52 weeks	IG	19	4.55 (1.59)	-0.54	-0.11	(-0.83, 0.61)	0.1
		CG	24	4.61 (1.21)	-0.43			
HADS								
Anxiety	12 weeks	IG	18	8 (4.89)	0.44	0.21	(-1.87, 2.3)	0.13
		CG	26	7.12 (4.31)	0.23			
	52 weeks	IG	18	7.56 (5.24)	0.67	0.35	(-1.77, 2.47)	0.11
		CG	22	7.68 (4.6)	0.32			
Depression	12 weeks	IG	18	7.06 (4.37)	1.11	0.15	(-1.79, 2.08)	0.05
		CG	26	7.81 (4.08)	0.96			
	52 weeks	IG	18	8.33 (4.6)	2.33	1.11	(-1.24, 3.45)	0.30*
		CG	22	8.14 (4.04)	1.23			

*Effect size is >0.2 (exceeded Cohen's d convention for a small, medium or large effect size), IG: Intervention Group, CG: Control Group, M: Mean, SD: standard deviation, MD: Mean Difference, SE: standard error, CI: confidence interval, d: Cohen's d, CRQ: Chronic Respiratory Questionnaire, HADS: Hospital Anxiety and Depression Scale

Table 5:6: Between and within group differences in mean daily steps in Non-PR and PR days

		Between group differences					Within Group differences			
		N	**M (SD)**	**MD**	**95% CI (Lower, Upper)**	**Effect size (d)**	**N**	**MD**	**95% CI (Lower, Upper)**	**Effect size (d)**
Non- PR days	**IG**	26	3397 (2217)	176	(-986, 1339)	0.08	25	826	(-637, 2289)	1.13*
	CG	32	3221 (2181)							
PR days	**IG**	25	4223 (2944)	311	(-1387, 2008)	0.1	31	692	(-715, 2098)	0.98*
	CG	31	3912 (3305)							

*Effect size is >0.2 (exceeded Cohen's d convention for a small, medium or large effect size), IG: Intervention Group, CG: Control Group, M: Mean, SD: Standard Deviation, SE: Standard Error, CI: Confidence Interval

5.3.5.3.1 PR vs non-PR days (baseline)

Prior to a definitive trial, it was important to identify if the baseline PA should include both PR and non-PR days, and whether PR days impacted the mean daily steps. The duration of the baseline data sets ranged from 1-7 days, with a mean (± SD) of 5.48 (1.06) days (non-PR days: 4.5(1); PR days: 1(.23)). There was a difference between PR and non-PR days on mean daily steps in both groups, and there were more steps recorded in PR days (IG, MD, 826, (-637, 2289); CG (MD, 692, (-715, 2098), **Table 5:6**. In this study, baseline PA data during PR was based on non-PR days only, as the results from this study supported the suggestion that days where patients completed PR were often higher in PA than non-PR days, and therefore not representative of their usual daily PA.[128]

5.3.5.4 PROactive

There was a decrease in the mean scores in the Amount and Difficulty domains of the PROactive in both the IG and CG at 12 and 52 weeks, suggesting that both groups decreased spent time in PA, but also found PA more difficult throughout the study. However, there was a larger decline in the scores in the IG across 12 and 52 weeks in both domains. The only notable difference between the IG and CG (effect size > 0.2) was the mean change in the amount of PA at 52 weeks, MD, .25 (-2.09, 1.59), which was lower in the IG, **Table 5:4**.

5.3.5.5 Hospital Anxiety and Depression Scale (HADS)

There was an increase in the mean scores in the Anxiety and Depression domains (HADS) in both groups at both 12 and 52 weeks. Though the mean increase in scores appeared higher in the IG, there was only a notable difference between the groups in the mean increase in Depression from baseline to 52 weeks, which was higher in the IG (MD, 1.11, (-1.24, 3.45) **Table 5:5**.

5.3.5.6 Chronic Respiratory Questionnaire (CRQ)

There was a mean decrease in all CRQ domains from baseline to 12 and 52 weeks in the IG and CG. The decrease appeared to be larger in the IG than the CG for all but one measure (mean change in Mastery at 12 weeks). However, the only difference that exceeded d = 0.2 was the mean change in Dyspnoea, with a larger decrease in the IG at 12 weeks (MD, -0.23, (-0.92, 0.45) and 52 weeks (MD, -0.47, (-1.40, 0.47), Emotion at 12 weeks (MD, -0.67, (-1.34, 0.01), and finally, Emotion at 52 weeks (MD, -0.26, (-0.89, 0.36), **Table 5:5**.

5.3.6 Comparison of the Feasibility and Clinical outcomes

5.3.6.1 Intervention engagement (Step diary) and daily steps (Accelerometer wGT3X-BT)

For IG participants who provided valid Accelerometer data at baseline and 52 weeks (n=14), daily step counts (from the Accelerometer) was compared between those who engaged in the step diary (n=9), with those who did not (n=5). Participants who engaged in the step diary had a smaller decline in their daily steps at 52 weeks compared to those who did not engage in the step diary, MD, 45.5 (-1796, 1889), although this did not exceed d = 0.2. Nevertheless, this result requires further exploration to identify if the intervention had any impact on patients' PA.

5.3.6.2 WhatsApp engagement and daily steps (Accelerometer wGT3X-BT)

For IG participants who provided valid Accelerometer data at baseline and 52 weeks, and engaged in WhatsApp (n=18), daily step counts (from the Accelerometer) was compared between those who engaged in WhatsApp (n=11), with those who did not (n=6). Participants who engaged in WhatsApp had a smaller decline in daily steps at 52 weeks compared to those who did not engage in WhatsApp, MD, 730 (-992, 2454).

5.3.6.3 Comparison of the Accelerometer wGT3X-BT and step diary (Yamax Digi-walker CW-700) data

Daily steps from the Accelerometer were compared with daily steps from the pedometer to validate the accuracy of the devices. PA data from 14 datasets, across 68 days was compared. The mean (± SD) daily steps the Accelerometer recorded was 3648 (1966), which were similar to the pedometer, 3663 (1865), MD, 15.6, (-1504, 1473).

5.4 Discussion (quantitative results)

5.4.1 Summary

The aim of this study was to report the feasibility of intervention and to identify the likely effects of the developed intervention on PA and other health outcomes following PR. The study was successful in recruiting the target number of patients and WhatsApp leaders.[148] Over half of the participants engaged in the intervention components, and the majority continued to record their daily steps past the first follow up (12 weeks). The mean (± SD) duration that participants stayed in the WhatsApp group was 222 (141) days out of 365 (61% duration of the study). The mean (± SD) number of days that participants engaged with the step diary was 177 (132). WhatsApp leaders adhered to sending weekly messages to the WhatsApp groups, and based most of the messages on those outlined in the WhatsApp guidelines. Although there were no improvements in daily steps and secondary health outcomes for the IG and CG, there was a larger decline in mean daily steps and MVPA in the CG at 52 weeks, suggesting that there was a beneficial impact of the Intervention on the rate of decline in PA. Unexpectedly, there was a larger increase in the LPA at 52 weeks in the CG compared to the IG. Within the IG, daily steps of those who engaged in WhatsApp and the Step Diary was higher than those who did not engage with the intervention components. However, results also suggest there was a larger detrimental decline in dyspnoea, emotion (CRQ) and depression (HADS) in the IG than the CG.

5.4.2 Comparison to previous literature

The consent rates were lower compared to previous trials which have aimed to promote PA following PR.[3–8] However, these studies were full scale trials, and may have undergone feasibility studies or pilot trials to optimise patient engagement, therefore it is expected that recruitment rates in this trial would be higher in a definitive trial. All cluster sites in this study consented to take part in the feasibility study. The recruitment was perceived as positive

compared to a previous cluster RCT which aimed to promote PA via mobile and web-based monitoring and feedback, where only 10% of practices agreed to participate in the trial.[318] There are only a limited number of studies with similar intervention components delivered over 52 weeks, and attrition rates in this study are similar to a previous study.[148] Similarly, attrition rates at 12 weeks in this study were similar to attrition rates in previous studies[85,88,319], and these rates reflect the various factors that this population encounter, such as illness, appointments with HCPs and family and social responsibilties.[241,136,320]

Of the studies reporting COPD patients' engagement with the pedometer, figures are higher in previous studies than those reported in this study.[246,319] However, these studies were conducted over a much smaller time frame, and were therefore less demanding of patients, hence it is not surprising that engagement is lower in this study. In this study, it is possible that participants lost their step diary and/or did not return their step diary, or engaged in WhatsApp without recording their engagement, hence the engagement rates may be underestimated. However, one of the previous studies involved asking participants to upload their weekly step counts online, which added a level of accountability to participants' intervention adherence.[246] The other study involved participants wearing their pedometer during PR, meaning that participants were likely supported and reminded by HCPs to adhere to the intervention.[319] These factors may explain the differences in intervention engagement. Although step diary engagement was higher at 12 weeks compared to 52 weeks, it should also be noted that the majority of participants who did engage in the step diary recorded their steps beyond the 12 week mark, and the adherence of those who started recording their steps reflects a much higher intervention engagement figure.

There are a limited number of studies which reported participants engagement in social networking applications as part of a behaviour change intervention.[193,321] One study reported that almost all participants posted to a WhatsApp group at least once, suggesting that

their study had higher participant engagement rates.[193] However, the average number of messages sent in this study was higher than this previous study[193], suggesting that those who were engaged in WhatsApp were likely to send more messages. The other study recorded participant engagement by reporting the number of participants who read the weekly feedback, rather than the number of posts from participants.[321] In this study, it was not possible to count the number of messages that WhatsApp members read, and therefore it was possible that WhatsApp engagement was underestimated in this study. Also, many studies have not reported participants' level of intervention engagement[83,91,92,90,84,137,178,306] so it is difficult to discern the relative acceptability of the intervention to other studies.

Recruitment and retention of WhatsApp leader volunteers in this intervention was challenging. There are few studies which have recruited lay volunteers to deliver a social networking intervention in people with COPD[185]. The results from this feasibility study were similar to a peer support intervention which had 40% withdrawal of volunteers prior to the intervention, and volunteers who provided inconsistent support to patients.[185] This highlights the need to identify how researchers can provide extended support to lay volunteers in research.

More than half of the messages were based on categories outlined in the WhatsApp guidelines (Appendix K, p333) and WhatsApp leaders were consistent in sending a weekly PA message to the WhatsApp group members, despite many participants not replying to their messages. This suggests that WhatsApp guidelines were considered acceptable to the WhatsApp leaders. However, the other messages sent by WhatsApp leaders were not related to the WhatsApp guidelines, which is similar to the results of another study in which trained counsellors sent messages to encourage participants to encourage smoking cessation. For example, most of the posts via social networking applications were not based on the protocol, but were related to general discussion with participants.[193] This could suggest that volunteers

are most comfortable in sending conversational messages, rather than structured posts, however this requires exploring in further research.

WhatsApp leaders did not adhere to the WhatsApp checklists, as they were considered too time consuming. This did not adversely impact the analysis of the results, as messages were coded based on the export of the WhatsApp chat. As the WhatsApp checklist was not considered a necessary or helpful resource in the trial, this should not be provided to lay volunteers in a future definitive trial, and researchers should ensure that all study procedures for lay volunteers are as simple as possible.

This intervention did not result in an increase in mean daily steps in the IG. These results contradict findings from various studies with similar intervention components, which reported an increase in PA[91,90,137] though few studies have reported that there were no difference between the IG and CG.[91,84,] However, the IG had a smaller mean reduction in daily steps than the CG at 52 weeks, and the rate of decline in MVPA was lower in the IG compared to the CG, which suggests a potential beneficial impact of the intervention. These results reflect previous studies which show a beneficial impact of the intervention on MVPA[85,244], yet contradict another.[91]

The time spent in SB decreased at a similar amount and rate between both groups. There are a limited number of interventions which have previously reported the impact of PA interventions on patients' SB in COPD.[89] However, a study which did report a reduction in SB was also accompanied with improvements in daily steps.[89] Nevertheless, previous literature has outlined the need to understand PA patterns in COPD across the whole day, which include SB and LPA[82,78,127,310,311], particularly as the government guidelines for older adults focus on the reduction of SB.[77] As the result highlights interesting long-term patterns in SB and LPA in participants in both groups, this requires further investigation in the definitive trial.

Participants in the IG who engaged in the intervention components (WhatsApp and Step Diary) had higher mean daily steps at 52 weeks than those who did not engage in the intervention. Furthermore, the mean difference in daily steps between the IG and CG increased from 12 weeks to 52 weeks, further supporting the suggestion that intervention engagement was associated with a lower decline in mean daily steps. This is a novel finding as previous research had not reported any positive associations in intervention engagement and PA.[321] This result points towards a positive impact of the intervention on PA, though the difference did not exceed the most recent reported MCID in daily steps in COPD of 300-1100.[99] These results require further exploration to understand if, how and why the intervention was beneficial, or whether low adherence to the intervention was related to barriers of PA such as poor health and competing demands, hence impacting PA levels.

The PROactive results are novel as there is limited research combining objective and subjective outcome measures for PA.[155] Interestingly, the results from the PROactive measure outlined that the IG reported a larger decline in the amount of PA at both 12 and 52 weeks compared to the CG. Similarly, the IG reported more difficulty in performing PA across the 52-week period compared to the CG. These results were surprising, as the results from the Accelerometer (Actigraph wGT3X-BT) reported that the IG had a smaller decline in daily steps compared to the CG. The questions about the amount of PA in the PROactive refer to how much walking outside and daily chores patients did. These questions may not capture other daily activities that patients complete, for example walking around the house and/or gardening, which may explain the discrepancies between the trend in daily steps and the 'amount' domain in PROactive.

Literature has outlined that PA is associated with beneficial health outcomes.[1,77] It was therefore unexpected that the IG had a larger decline in their disease specific quality of life and psychological well-being, which also contrasts results of previous studies.[82,85,91,312]

Based on the results from the CRQ, HADS and PROactive, it could be suggested that the IGs' well-being was associated with the difficulty they had in being active and maintaining their daily routine.[326] It could also be suggested that LPA is more important to patients than the number of daily steps they complete. However, this requires further investigation, possible by gaining insight from patients involved in the intervention.

The mixed results in PA and other health outcomes in previous literature may reflect heterogeneity between the studies, including sample sizes, type of intervention components and BCTs and the length of follow ups, and therefore it is challenging to understand the reasons for the different outcomes between studies.[130]

The Actigraph (wGT3X-BT) was the accelerometer used due to recommendations in recent literature.[53] However, there were various occasions when the accelerometer data was invalid, and some patients refused to wear the activity monitor during the study due to discomfort, which has been previously reported.[91] The accelerometer provided similar step count readings to the pedometer, which contradicts previous findings[91], therefore raising the possibility of these pedometers as a suitable outcome measure in further studies. Use of a pedometer as an outcome measure in future trials could resolve issues faced in this study, extend the datasets of PA, and potentially reduce the costs for researchers. However, more research is required to identify the consistency of these results, as well as the adherence of patients to wearing the pedometer and reporting their steps.

5.4.3 Strengths and limitations

A limitation in this study was the method by which intervention engagement was assessed. In this study, WhatsApp engagement was measured by the number of messages that patients sent to the WhatsApp group. This meant that patients who viewed the messages, but did not send replies, were not accounted for. Measurement of Step Diary engagement was only possible for those patients who returned their step diary after 52 weeks, therefore did not

account for patients who lost or forgot to return their step diary. Furthermore, a limitation of this study was that the number of participants reading the messages sent to the WhatsApp groups were not identified during the study. However, engagement in the step diary and use of the pedometer and WhatsApp are explored in the next chapter via patient interviews, which can help to understand the reasons for limited engagement from patients. As these factors contribute to understanding the acceptability of the intervention, it is important to consider how these could be measured in a further trial.

A potential limitation of the study is the small sample size of patients involved in the feasibility CRCT, as it the study was not powered for statistical data analyses. However, this was a feasibility study, with a primary aim in understanding the acceptability of the intervention and research procedures.[159,296] The feasibility study was valuable in outlining the likely impact of the intervention on patients' PA and other health outcomes and successful in recruiting the target number of patients. This feasibility study is therefore valuable in informing the definitive trial.

The decision to conduct a feasibility study prior to a larger scale trial is a clear strength, as it has enabled researchers to assess the feasibility and overarching acceptability of this intervention prior to a future larger scale trial. Though the impact of the intervention on clinical outcomes appear limited compared to previous studies, this feasibility study has outlined potential benefits of the intervention.

It could be argued that the sample is not representative of the ethnic profile of the wider population and therefore acceptability of the intervention cannot be generalised to other areas with different ethnicity profiles. However, the study sample was relative to the population in Lincolnshire.[327] Another limitation was that the mean age in the IG was higher than the CG as older age is generally associated with reduced PA[328], anxiety and depression[329] and comorbid conditions[330], which could potentially have impacted the results

of the study. However, this was not considered likely, as both groups were over 65 and therefore both categorised as 'older adults' who receive the same PA recommendations.[77] Differences in age such as these should be statistically controlled for in further research.

There were incomplete data sets from those participants who withdrew from the IG, meaning that results do not include data from those who found the intervention the least acceptable. However, as most patients, from both study arms, withdrew for similar reasons, such as health issues, it is unlikely that the results are impacted by bias.

A strength of this study was the decision to compare the clinical characteristics of those who declined the study with those who consented, as previous studies have not reported this.[331,84,91,90,137] This enabled researchers to explore the characteristics of people who found the study acceptable. In this study, the results for those who declined the study suggested that they had better psychological well-being and disease specific QoL, but little is understood whether worse anxiety and depression and disease specific QoL predicts involvement in the intervention. Furthermore, patients who declined the interviews also had lower functional capacity, possibly suggesting that those with lower functional capacity may be more interested in structured PA interventions following PR. Interviews with patients who declined the study may provide insight into the factors that prevent participants from engaging in the intervention, therefore discussing how the intervention could be improved to be acceptable for the wider population.

The cluster design of the intervention was successful in proving balanced groups, and participants did not report being aware of separate groups. This was considered a strength of the study. Though there were small differences in the baseline characteristics of the IG and CG, for example, age and functional capacity, cluster randomisation was deemed successful as the groups were mostly similar.

Factors which impacted the fidelity of the intervention included withdrawals and replacements of WhatsApp leader volunteers in the early stages of the intervention, meaning that some WhatsApp groups had limited engagement with the WhatsApp leaders throughout the intervention. This could have impacted patients' acceptability of the intervention. This is a limitation, as social support has been identified as an important factor that impacts PA following PR.[241] Prior to the delivery of the intervention, more than six WhatsApp leaders were recruited for the study. This was in recognition that COPD is a complex condition, which is associated with health concerns, and that many individuals with COPD have competing demands such as family and volunteering responsibilities (Chapter 2). Recruitment of a 'bank' of WhatsApp leaders enabled a smooth transition when replacing WhatsApp leaders who withdrew. This was considered a strength of the study.

Some of the WhatsApp messages that WhatsApp leaders sent were not based on those provided in the WhatsApp guidelines, meaning that the content of the messages was not controlled for across the WhatsApp groups. This is important, as the WhatsApp guidelines were initially categorised according to the Behaviour Change Techniques[145] to focus on the facilitators to PA following PR in COPD, which were identified in the systematic review reported in Chapter 2.[241] However, all WhatsApp leaders sent a minimum of one weekly PA message to the WhatsApp groups, which suggests that some aspects of the guidelines were acceptable.

Another limitation of this study was the missing data among the three study visits, which may have therefore impacted the conclusions drawn from this study. However, most who refused to wear the accelerometer agreed to provide questionnaire data, and some participants who were 'lost to follow up' during the 12-week follow up were later contacted for the 52-week follow up, hence many participants contributed at least two sets of accelerometer data, therefore it was possible to identify the patterns in PA across both groups.

A strength of this study was the collection of patient-reported outcomes in measuring PA (PROactive) which provided further insight than the traditional one-dimensional objective measurement.[73] The results indicated that patients in the IG found PA more difficult and were participating in less PA at 52 weeks compared to the CG. These results contradicted the results from the Accelerometer, which indicated that the IG had a lower rate of decline in daily steps and MVPA. These unexpected results support the importance of further research to identify the reasons for these differences, and for a conclusive outcome on the potential impact of the intervention on patients' PA.

5.4.4 Conclusion

This study addressed the feasibility of a complex intervention, the second stage outlined in the MRC guidance in the development and evaluation of a complex intervention.[159] The results of this study addressed the acceptability, feasibility, and likely impact of this intervention on patients' PA and other health outcomes. Recruitment of participants was considered successful. As WhatsApp leaders based most of their messages on the WhatsApp guidelines, the results suggest there was high intervention fidelity. There was a decline in PA and other health outcomes in both groups, which could suggest that there was limited acceptability of the intervention. However, participation in the IG was associated with a smaller decline in daily steps and MVPA compared to the CG. Also, engagement in the intervention components was associated with a smaller decline in daily steps than those who did not engage. Stakeholders' acceptability of the intervention and research procedures should therefore be explored to consider if and how the intervention should and could be improved for a future definitive trial. This was explored in the next section which reports the qualitative findings from the interviews with patients (5.5.1) and focus groups with WhatsApp leaders (5.5.2) and HCPs (5.5.3).

5.5 Qualitative results

An objective of this thesis was to conduct a process evaluation to assess the acceptability of the intervention and research procedures for patients, patient volunteers, and HCPs. An inductive thematic analysis was conducted to explore the acceptability and feasibility of the intervention and research procedures, in line with the guidance from the Medical Research Council (MRC) for process evaluations of complex interventions.[160] The following section describes the results from the interviews with patients and focus groups with WhatsApp leaders and HCPs. The results will help identify any changes to be made prior to a definitive trial, for example whether the intervention requires further refinement and/or whether the research procedures are acceptable and feasible.

5.5.1 Patients

Sixteen patients from the feasibility CRCT engaged in a semi-structured interview to discuss the acceptability and feasibility of the intervention and the research procedures. These included patients who: declined to take part in the intervention; enrolled in the intervention and subsequently withdrew; initially opted for some intervention components but declined others, and patients who opted for all intervention components. Full demographic information and clinical characteristics are presented for patients in **Table 5:7**, except for patients who declined the intervention (demographic information was not recorded for these patients).

The overarching themes included the ‘facilitators’ and ‘barriers’ of the acceptability and feasibility of the intervention and research procedures.

Table 5:7: Interviewee demographics of patients

Person ID	Intervention engagement	Months involved†	Age	Gender	Ethnicity	BMI	MRC score	Exacerbations* (n=)	Comorbid conditions (n=)	Smoking status	Pack history
P1	full	7	51	male	WB	29.5	4	0	1	ex-smoker	22.5
P2	full	10	69	female	WB	43.6	MD	1	2	ex-smoker	48
P3	full	7	70	male	WB	24.3	3	7; 0	3	ex-smoker	60
P4	full	6	58	female	WB	17.8	4	0	2	ex-smoker	46
P5	full	8	63	female	WB	35.5	3	10; 10	2	smoker	141
P6	full	7	73	male	WB	28.7	3	8; 1	0	ex-smoker	MD
P7	full	8	63	female	WB	19.5	3	0	2	ex-smoker	4.5
P8	full	3	67	female	WB	21.6	3	1; 0	1	ex-smoker	60
P9	full	11	65	female	WB	31.7	3	1; 1	4	ex-smoker	30
P10	full (withdrawn)	11	80	male	BI	20.45	4	1; 1	3	ex-smoker	MD
P11	partial	4	69	male	WB	23.3	3	1; 0	0	ex-smoker	30
P12	partial	4	75	female	WB	21.2	4	1; 0	3	never smoked	0
P13	decline	x		male	WB	x	x	x	x	x	x
P14	decline	x	x	female	WB	x	x	x	x	x	x
P15	decline	x	x	female	WB	x	x	x	x	x	x
P16	decline	x	x	male	WB	x	x	x	x	x	x

full = received all study components (WhatsApp, pedometer, step diary) ; partial = received pedometer and step diary only; decline = decline to be involved in the intervention but provided permission to be interviewed; withdraw = enrolled in the intervention and subsequently withdrew; x = no data available:
P: Person; WB: White British; BI: British Indian; MD: Missing Data; MRC: Medical Research Council Dyspnoea Scale
*Previous 12 months number of courses of antibiotics/oral steroids; hospitalisations; †the number of months that patients had been involved in the study, from the time that they provided informed consent

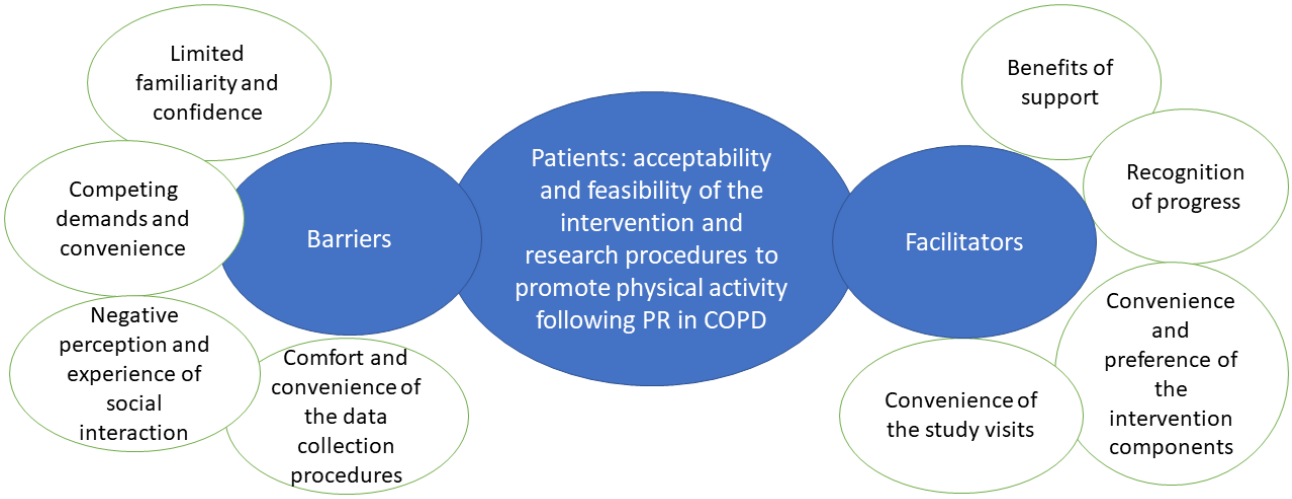

Figure 5:3: A concept map illustrating patients' acceptability and feasibility of an intervention, and associated research procedures, to promote PA following PR in COPD

5.5.1.1 Barriers to the acceptability and feasibility of the intervention and research procedures

The most common barriers to the acceptability and feasibility of the intervention and research procedures were limited familiarity and confidence in using technology, competing demands and convenience, negative perception and experience of social interaction and, finally, the comfort and convenience of the data collection procedures.

Limited familiarity and confidence

Limited familiarity and understanding of the intervention components impacted patients' experience of the intervention. Patients who had limited support from family and friends were less able to reach out to others for support in dealing with potential issues with the intervention components. For example, a patient who struggled to engage in WhatsApp said:

> *P7 (full): And it's not as if I could go to my partner and say, 'do you know what the devil this is all about?' I mean he knew about WhatsApp, he put it on my phone, but I never had that sort of thing on my own personal one, you know.*

Experience in using the WhatsApp was often associated with patients' confidence in using the smartphones. One patient declined to participate in the research because they did not believe they were good at using a smartphone and suggested that their age was a reason for this:

> *P15 (decline): well I'm just not very good at. Well, I don't know really. The phone and what have you….*
>
> *I'm getting a bit too old for it duck.*

Those enrolled in the study, who did not engage in WhatsApp, reflected on their limited experience with technology and often suggested that they were not skilled in using technology. Patients' reported how they have previously struggled to navigate their own mobile device and phones at their previous places of work:

> *P5 (full): So, it was like they introduced the phones and they started introducing the phones when I was at work…*
>
> *And what I did I had no idea, I used to do all sorts to it…*
>
> *Before going off it was 'not again what have you been doing to it this time?'*

Lack of interest in using technology was the reason one patient had never tried learning how to navigate a smartphone:

> *P3 (full): well I can't speak for other people but for myself, no well it can't have done any…I don't know if you have a mental block with these things, you know if you're not interested then you don't have to pick things up as quickly.*

Technical difficulties impacted on the ability to use WhatsApp, and sometimes left patients feeling like they were left out of the group:

I: so, there was some technical difficulties there.

P7 (full): Yes. I hadn't got a clue what to do about it so. I did see somebody, and they said 'ohh it doesn't matter, it doesn't matter' but then after a little while I thought it does because you feel something is going on that you don't know about...

Outstanding questions about the intervention devices suggested that not all information was covered in the study resources, hence impacting their familiarity and confidence with the intervention components:

P1 (full): Does it go back on its own, to where it was? (the time on the pedometer)

One patient, who reported having limited engagement in the intervention, struggled to recall receiving study resources. For example, when they were asked if they had received an intervention manual, they replied:

P2 (full): don't think so.

This could be a result of the patient either forgetting that they received an intervention manual, or that they did not receive one during PR. It also possible that patients did not receive the information as there was a high number of people who missed PR sessions for various reasons, such as illness and family responsibilities.

Competing demands and convenience

Most patients led busy lives and reported that they had to manage their schedule to accommodate responsibilities such as work, family support and volunteering roles. For some patients, their existing schedule impacted on their decision to be involved in the intervention, and their engagement in WhatsApp. Busy lives, particularly in combination with other factors such as personal issues and health concerns, impacted patients' engagement in the intervention and/or their motivation to maintain PA following PR. For example, one patient

who declined the study reported that they already had a busy schedule, which included family responsibilities and days spent driving. Though they reported having intentions to keep active following PR, their ability to engage in PA had been affected by a family bereavement and their responsibilities involved with the funeral. Other patients' who enrolled in the study report being busy with volunteering roles and hobbies:

> *P6 (full): I do the auctioneering for them. Then I get roped into doing other jobs. Saturday its bingo, I run that. But it's like, not for profit.*

Due to patients leading busy lives, some report forgetting to record their steps or have stopped using the step diary:

> *P7 (full): So, I'd quite often forget over this short period (to record steps).*

WhatsApp could feel restrictive, as it required more maintenance than the other intervention components. For example, patients needed to charge the smartphone and connect the smartphone to a Wi-Fi connection. Patients would particularly struggle to engage in WhatsApp when also dealing with work or health concerns:

> *P1 (full): I've only used it [WhatsApp] for the first, I sort of work in the day, long hours, and I'm not really a texty…I don't do a lot…*
>
> *It got to a point where I didn't have the time of the energy to use it. So, I mean I haven't used it in months.*

One patient reported that their PA since PR had been limited by their health concerns and caring responsibilities for their family. This meant that they had limited time to engage in the intervention, despite believing that WhatsApp was easy for them to use:

> *P2 (full): So, I don't walk very far at all.*
>
> *I: yeah. And how's this been since you finished rehab?*

P2 (full): It's hard to say really because I feel like I have been stuck indoors more. But that's basically because of this thyroid thing and because of keeping a watch on my X (family member) …

So, but yeah. It is really hard to say, because I've been stuck at home for months.

Health concerns, alone, were enough to prevent participant's engagement in PA:

P6 (full): and after a couple of weeks it goes back down again but I'm gonna have to start the steroids again…

So, it's like up and down, up and down. So physically and mentally, it's like driving me mad...

So, I've got to go back to the exercise sessions but it's just trying to fit in when.

The pedometer (Digi-walker CW-700) was not convenient for all patients, and many patients could not use the pedometer in their daily activities due to issues clipping the pedometer onto their clothing, particularly on certain items of clothing, such as smart clothing or elasticated waist belts. One suggestion was to wear the pedometer on a belt, rather than clipping directly onto clothing:

P12 (partial): I notice that if I left it off for a day or two that the time on it was totally different to what it should be...

And the steps sometimes it only showed six steps and I'd been all around time and that. I mean it seemed to catch up eventually, but I wonder if that was because it had been left off.'…

The only thing is, it's a pity you can't, use a belt or something. Well I suppose you can with a pedometer can't you. I suppose you can clip it on, can't you. On the belt yeah...

Patients also reported difficulties using the pedometer, such as faulty step count displays and often worried about losing their pedometer. For example, though another patient reported not having any problems with the pedometer falling off, they continued to worry about the pedometer falling off:

> *P8 (full): But I get, when I'm out, I keep going (moves hand to hip to check the pedometer is there), keep going like that to make sure…*
>
> *But it doesn't even work my way up my trousers or nothing...*
>
> *It's really good.*

With regards to a future trial, training to familiarise patients with the smartphone and WhatsApp may boost their confidence to integrate the intervention components into their busy lives. As the pedometer was difficult for many patients to wear on certain clothing, other step counter devices could be integrated in a future trial, potentially enabling patients to wear their personal device or a wrist worn device.

Negative perception and experience of social interaction

An element of face to face contact and support was considered important, as this enabled patients to become familiar with each other. At times, talking to others on the telephone felt impersonal for participants:

> *P10 (full, withdrawn): I wasn't particularly keen on using that. I was never kind of keen on using any sort of telephone cos I always felt like I was talking to a machine rather than a human being...*
>
> *And would have been my…(inaudible)…when I talk with other people. Even if I could talk to them, a lot of time I would prefer to see them face to face.*

Information from the WhatsApp leader was considered beneficial; however, most patients had not met the WhatsApp leader. They suggested that this may have been off-putting for group members:

> *P9 (full): But obviously…And I think it is hard for people to sort of talk to a phone, when they, you know when they're talking to somebody, they know it's different isn't it...*
>
> *But when they're just talking to…and I thought that the information thing was good. The bloke from X, it was good to tell everybody what was going on and that…*

Though patients had completed PR with other group members, they often did not feel comfortable when messaging them on WhatsApp:

> *P7 (full): Yeah. It's another means of support, but I found it hard to(long pause) to talk to anyone really. Cos, I didn't really know them.*

Another patient reported limited engagement with WhatsApp, and they were not confident that it was beneficial, unless they had some element of face to face support with the other WhatsApp group members:

> *P6 (full)…I've only used it once or twice when you gave it back to me. But I don't think, in my opinion, it's going to serve us a lot of good…to me, unless I was going back to the group, on a Monday (PA follow on group), it would be ok.*

Some patients were opposed to staying in touch with others via WhatsApp. Those who declined the intervention suggested that it felt intrusive and were not interested in the social aspect of the PA groups. There were individual differences in the amount of social interaction that people wanted.

P14 (decline): I'm not a sort of crowd person. So, like, if I go to it, I'd go to the exercise part and probably stay for 5 or 10 minutes but I won't stay there, sort of tea and caking it.

Another patient who enrolled in the intervention but declined the WhatsApp component because they did not want to join a group discussion, suggested that others' experiences after PR was not their concern:

P11 (partial): Well basically I mean that was all I was really interested in, the fact that how I got on with that, I wasn't really interested in joining a group discussion and things like that about it, I mean how everyone else manages, that was totally up to them.

Complex and interacting factors influenced patients' experience of WhatsApp, for example group members' levels of WhatsApp engagement, the number of group members, leadership qualities, feelings of belonging, and gender were factors that impacted participants' experiences of WhatsApp. The number of patients involved in the WhatsApp groups ranged from two to six. Such small numbers reduced the likelihood of WhatsApp engagement between group members.

Patients were discouraged from using the smartphone and engaging in WhatsApp because there was limited communication from those involved in the group:

P8 (full): No, I don't use the phone…

I had one message from XXX (another WhatsApp member) and I replied back and then I haven't heard any more from him.

No, I don't think it's about people needed. I think what you've done you've been a great benefit to all the people in the group. Maybe if there were more people in the group then that might have helped. (WhatsApp group)

Though one participant's daughter believed WhatsApp was a positive idea, they believed that it would be beneficial if more people were included and engaged in the group:

P8 (full)_Daughter: Yeah but the WhatsApp. If I don't go (to the house) then Mum can WhatsApp somebody. If there's more people in the group then she could WhatsApp more people to say, 'having a bad day', and then hopefully somebody can reply back and pick her up, if that make sense? …

It's brilliant, I just wish more people would do it.

Another patient believed that there were gender differences in the way that WhatsApp group members communicated with each other and believed that women may communicate with each other more than men:

P6 (full): So, I think it might be the ladies that do a lot more of the communicating between each other. So, this is number 4 talking to number 2 blah blah blah. With the guys it's hardly anything at all.

A lack of communication from the WhatsApp leader also discouraged WhatsApp use. One patient recalls a time they attended a PR exercise follow on group, which was led by the WhatsApp leader. They felt that it was important that the leader should take responsibility for the whole group. However, they believed that the leader only communicated with their friends who they were already close with, which impacted their feeling of belonging.

P7 (full): And with the groups in the halls, if the "leader" is not, is only taking notice of the friend she chats to on an everyday basis or is going shopping with then that isn't helpful for, or isn't a motivation for you to do anything, you know...

When discussing PA abilities and accomplishments, patients often compared themselves to others, for example, patients on the PR programme, 'normal people' (people without lung conditions) and to their family. One patient who declined the intervention felt that they were at earlier stages of COPD to others on the course and felt that the intervention was more appropriate for people at later stages of COPD:

P13 (decline): So to be absolutely honest, I think on the course I was on that I was one of the fittest ones there and I felt it wasn't really necessary for me at the early stages of the COPD that I have. So I thought it would of benefitted someone more that…I know you didn't sign up as many people as you wishes but I don't think I was a great candidate for that period of time, and I certainly didn't want to do it for nearly a year.

Those who compared themselves to 'normal people' reported that they could not do as much PA, nor keep up, with others:

P9 (full): And you just you know, think, you know I don't do loads of steps, like normal people. But if you just look at it, sometimes you think 'oh my god', you know and 'all these steps' and it just keeps you thinking about doing exercise and things like that.

P8 (full): Yeah. See I'd never do that in one go, would I?

Step counters are popular devices, and many of the patients' family members owned one. Some patients compared themselves to family members, who reported doing more steps than patients could achieve, which was demotivating for patients:

P3 (full): my Granddaughter has got, what do you call it, a Fitbit? …

Well it is cos, her mum you see, she takes the dogs out and she'll do. I said to her 'how many you doing?' and she said 'like a very, very quiet day is 10,000 plus'…

And I thought 'oh my god'.

Overall, social interaction had different meaning for different patients. Some patients felt they would benefit from more face to face contact with the fellow patients and WhatsApp leaders, and would perhaps benefit from having more people in the WhatsApp groups. However, for some patients, social interaction was perceived as negative and they didn't want to communicate with others following PR. Negative comparison to family members or feeling 'left out' of the WhatsApp group negatively impacted patients' experiences of the intervention.

When considering a future definitive trial, patients may benefit from face to face support interaction from the WhatsApp leader and other group members. This could be improved by inviting the WhatsApp leader to PR sessions and encouraging the WhatsApp group to meet outside of PR. As some of the WhatsApp groups were low in numbers, researchers should ensure that WhatsApp groups have more group members, potentially joining multiple PR WhatsApp groups together.

Though the education talk during PR (delivered by the research team) emphasised that all patients have different capabilities, some patients compared their PA capabilities to other people, such as their family, and reported feeling demotivated. This barrier could be addressed in a future trial by incorporating further education surrounding individuals' PA capabilities, and for potential 'WhatsApp leaders' (or someone with an equivalent role) to continue to remind patients, following PR, not to negatively compare themselves to others.

For example, HCPs could emphasise that they should only compared their achievements to their personal goals.

Discomfort and inconvenience surrounding the data collection procedures

All patients were contacted a minimum of two weeks before each study visit, to provide them with enough time to arrange a meeting with the research team. Patients had the option of meeting with the researcher at a place of convenience, for example at a community centre venue or at home. Although most patients believed that the study visits were convenient for them, one patient did not think they had enough time to prepare:

> *P10 (full, withdrawn): Er a bit of more notice would be useful because there are various other things.*

Patients were asked to complete three questionnaires and a diary at three intervals during the study. The only negative associated with the questionnaires was that they sometimes felt slightly repetitive:

> *P11 (partial): you know, no example like, I would sit there and think 'I've just answered that', maybe in a different format but it's the same answer. If you're with me.*

One patient did report struggling to remember details of the study when they were being interviewed about their experiences of the intervention and research procedures. They believed that they may have benefitted from receiving information prior to the interview which lists the type of questions that would be asked. They believe that this would have provided them time to reflect on the intervention and research procedures:

> *P3 (full): if say you had a sheet and said 'these are the sorts of things that I'll be asking'…*

Then I could have a think.

Overall, patients would benefit from more time to prepare for the study visits and more information about the sleep diary and the content of the interviews. The questionnaires sometimes felt repetitive, and patients may benefit from having less paperwork to complete.

Patients were asked to wear an accelerometer (Actigraph 3GTX) around their waist for seven days, at three intervals during the intervention. For some patients, the accelerometer was uncomfortable for a number of reasons, for example it was itchy, or dug into patients' abdomen or back when they slept. One patient had difficulty undoing the activity monitor strap because of their arthritis and needed assistance from their partner. Others were worried that the activity monitor slipped, meaning that their data would become invalid.

P2 (full): I didn't have to do anything with it, I just wore it. So that's ok, except it made me feel a bit itchy but the material. I may have been slightly sensitive to the material it was made of.

Although most patients did not believe the activity monitor was inconvenient, they did note that it sometimes it felt unnatural to wear it, simply because they were not used to wearing the activity monitor around their waist.

P10 (full, withdrawn): but it was not particularly inconvenient. Again, it is something that we are not normally used to, so that makes you feel uneasy when it's happening.

As various patients felt uncomfortable when wearing the activity monitor on their waist, they felt they may benefit from having the choice of wearing the monitor on their wrist. As the activity monitor strap and buckle was uncomfortable for some patients, they also suggested that they would benefit from using a different strap material, or even to remove the buckle and use Velcro.

5.5.1.2 Facilitators to the acceptability and feasibility of the intervention and research procedures

The most common facilitators to the acceptability and feasibility of the intervention and research procedures were benefits of support, recognition of progress, convenience, and preference of the intervention components, and finally, convenience of the study visits.

Benefits of support

Although patients identified various barriers associated with WhatsApp and the social support element of the intervention, some patients considered WhatsApp an important element of the intervention. For example, WhatsApp enabled another means of support, and patients and their families recognised that WhatsApp had the potential for patients get out and meet people.

> *P8 (full): I think it's brilliant. It gets you out. You meet people because if not, I know my daughter is brilliant. She comes every day and takes me. But a lot of them just sit their own.*

Family and friends took interest in the study and often supported them with the intervention components. Some patients' family or partners supported them by being present during the interview and often expressed interest in the study.

Patients made references to their family members also owning a pedometer, and suggested that their family were interested in their progress:

> *P3 (full): my Granddaughter has got, what do you call it, a Fitbit?*
>
> *Right and she came the other day because she knows I've got, I've got one and she says 'how many have you done?*

Progress using the pedometer led one patient to buy their daughter one. Recording steps from

the pedometer was a way to engage with their family and to compete to gain more steps. Their daughter was enthusiastic about the positive impact of the pedometer on their PA levels and suggested that their Mother had significantly increased their steps:

P8 (full): I've even brought my daughter one.

I: Yeah, so I remember you saying that. Did you buy the same make in the end or was it a different one?

P8 (Daughter): A different one. Yeah, but the kids have got the same one as what my mum's got.

P8 (full): They've all got them now. It's competition…

Daughter: So you was like only doing 300 and now...

P8 (full): 3 thou (thousand)

Daughter: To start off with and now she's doing 3,000…

And sometimes I'm over 4, way over 4.

Recognition of progress

The intervention components, particularly the pedometer and step diary, impacted patients' motivation to be physically active. Patients felt positive when they had completed many steps, as they could attribute it to their own PA achievement. Recognition of progress encouraged patients to do more steps, hence highlighting a virtuous circle:

P6 (full); I'm happier when I know there's a lot on there…Cos, I think 'great, I've been doing a lot of walking that day'.

Patients found it important to track their progress and identify if they had a low step count. Recognition of lower steps helped motivate patients to increase their PA:

P9 (full): yeah that was a good idea because you're keeping track aren't you…

So, some days I was only doing a thousand and was thinking that I must improve (laughs) you know I've had a lazy day today and yeah…

So, it does give you an incentive, definitely.

P8 (full)_(Daughter): it causes you to walk more, doesn't it?

P8 (full): Yes, it does. Cos I'll sit here and think I haven't done many steps, I better get going.

Convenience and preference of the intervention components

Patients considered it easier to engage with the intervention components if they were able to develop a habit in wearing the pedometer and recording their daily steps. Some patients reported problems in wearing the pedometer and preferred the option of using an alternative device, such as a Fitbit.

P12 (partial): No, I just thought it might restrict me a bit. With the pedometer I can just go out and about and do what I usually do, so I prefer that.

One patient who struggled to wear the pedometer due to skin sensitivities decided to improvise by using their Fitbit and recording their steps from this device instead of the study pedometer:

P2 (full): I mean I've got a Fitbit. I could always take the daily steps off that.

Once patients got used to the pedometer, wearing the pedometer became habitual:

P6 (full): But that's the activity I've been doing. Most of the time I forget it's there...

And then I go to bed and that's it. You don't think about it in the daytime, it's been that long now that it's there don't you forget it's any part of me.

Patients appreciated the simplicity of the step diary and reported being in a habit of recording their steps:

> *P4 (full); Yeah so, the paperwork is on the bedside cabinet With a pen, Just unclip it at night time, write it down and that's it…*
>
> *The automatic, you forget after a while, but you still do it automatically (step diary).*

When patients were asked about their preferences of how to report their steps, they suggested that the paper step diary suited them:

> *P9 (full): I quite like the paper diary, cos yeah. I mean, I probably could record it on my phone but that's alright for me really, a paper diary cos it's something to write everyday (laughs).*

Overall, the convenience of the intervention components was important to patients, as most patients reported leading busy lives. If patients perceived the intervention components as simple and easy to use, the more likely they were to integrate them into their daily lives.

Convenience of the study visits

Most patients were satisfied with the study visits from the research team. For example, most patients believed that two weeks to prepare for the study visits provided them with plenty of notice. For those that could not travel to a local community venue to meet the researcher, they were happy to receive a home visit from a member of the research team:

> *P12 (partial): Yeah, they're fine (research visits).*

Although it took many patients a few days to adjust to wearing the accelerometer around their waist during the three intervals throughout the study, most patients did not consider the activity monitor as disruptive in their daily activities:

> *P10 (full, withdrawn): But after two, three days, I got used to it.*

P12 (partial): Oh yes it was, yeah. Even wearing it at night it was quite alright. Mm yeah.

Patients also accepted that completing questionnaires and the sleep diary at three intervals throughout 12 months was part of the study, and that these were not too time consuming or tedious:

P6 (full): No trouble at all (completing the questionnaires and sleep diary).

P1 (full): It was easy enough, wasn't it? (completing the questionnaires and sleep diary).

Overall, most patients were satisfied with the study visits. If they had competing demands, for example hospital visits or health concerns, they were able to rearrange the study visit to suit them. As the research team had direct contact with all patients, they were able to help if patients had questions about the activity monitor or the questionnaires.

Prior to a future definitive trial, patients should have the necessary knowledge about the study and receive both oral and written information about the intervention during PR. Researchers should consider giving patients more time to prepare for the study visits. As some patients felt the questionnaires were slightly repetitive, the research team should consider methods to make these easier to complete. Patients should also be further prepared for the interviews and reminded about the intervention and research procedures prior the interview. The accelerometer should be comfortable for all patients and researchers should remind patients that they are able to wear it around their wrist.

5.5.2 WhatsApp Leaders

Five WhatsApp Leaders participated in a focus group to discuss their acceptability of the intervention and research procedures, in line with guidance from the MRC for process evaluations.[160] WhatsApp leaders were volunteers from COPD patient groups based in Lincolnshire and Sheffield who had received face to face training from the Chief Investigator (see the Methodology for more information, Chapter 4). Of these five WhatsApp leaders, three WhatsApp leaders had been involved in the WhatsApp groups since the beginning of the intervention. Two WhatsApp leaders had replaced previous volunteers who had withdrawn from the study.

As the WhatsApp leader's role was to communicate with patients via WhatsApp, the results are focused on the acceptability and feasibility of the WhatsApp component of the intervention, as well as the accompanying research procedures such as the recruitment of the WhatsApp leaders and exporting the WhatsApp chat to the Chief Investigator.

A thematic analysis was conducted to explore the acceptability and feasibility of the intervention and research procedures from the perspective of the WhatsApp leaders. The overarching themes were the 'facilitators' and 'barriers' of the acceptability and feasibility of the intervention and research procedures.

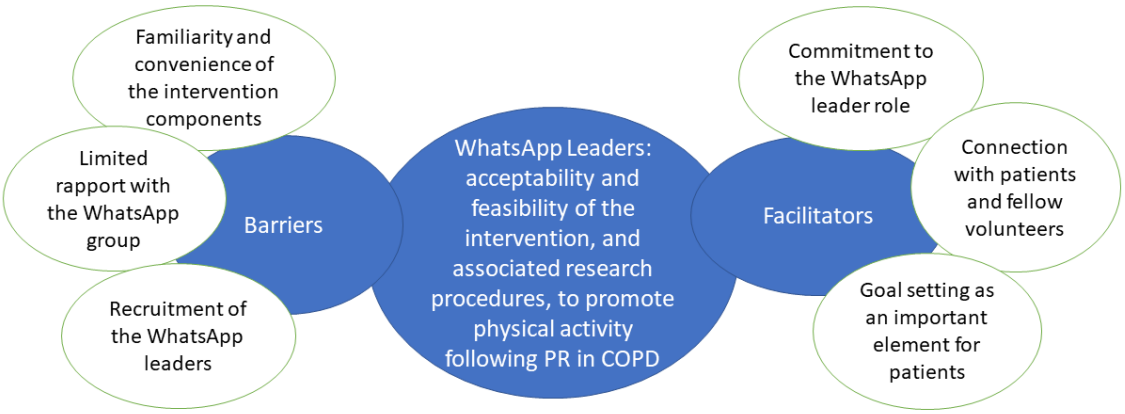

Figure 5:4: A concept map illustrating WhatsApp leaders' acceptability and feasibility of an intervention, and associated research procedures, to promote PA following PR in COPD

5.5.2.1 Barriers to the acceptability and feasibility of the intervention and research procedures

The most common barriers to the acceptability and feasibility of the intervention and research procedures were familiarity and convenience of the intervention components, limited rapport with the WhatsApp group and, finally, the recruitment of the WhatsApp leaders.

Familiarity and convenience of the intervention components

WhatsApp leaders suggested that patients were not familiar or confident with using technology. Age was given as a reason that some may not be as familiar with technology.

> *WL1: Are the people in the group given the phone as well? …*
>
> *I think. I don't know whether…I think you told me one was quite elderly….*
>
> *And I think if they're not…with tech (in audible)*
>
> *WL2: Familiar with technology.*

In this study, only one WhatsApp leader was able to attend two PR groups prior to becoming involved in the WhatsApp groups with patients. For a future definitive trial, WhatsApp leaders believed that patients would benefit from receiving more assistance in becoming

familiar with the smartphone during PR. For example, WhatsApp leaders, or other volunteers, should attend PR in a future study to help patients practice using the smartphone. Asking the WhatsApp group to practice using WhatsApp and enabling the group to ask questions at a later follow up session was a method that was suggested for the future definitive trial:

WL1: Get them to do the messages to each other just for a practice.

WL3: Yeah and when you…that's what I was thinking. And when you go back…the WhatsApp leader could go in maybe the last 6 sessions.

WhatsApp leaders were provided with a pedometer and a step diary prior to the intervention. Though WhatsApp leaders enjoyed reflecting on their daily steps and felt the pedometer and step diary were important to incentivise themselves and patients to do more activity, the pedometer was not always comfortable and convenient for WhatsApp leaders. For example, the pedometer was not comfortable for one WhatsApp leader, it did not stay attached to their clothing and was easily misplaced. Pedometers and step diaries were considered old fashioned, and devices such as Fitbits and activity trackers on people's mobile phones were considered more convenient. WhatsApp leaders considered themselves reliant on technology, and one individual preferred to record their daily steps on an excel spreadsheet:

WL1: I didn't mind using it, in fact I thought it was quite good to look and 'Oo'

WL5: it is.

WL1: Cos if you're near to. Or near to like 8000 steps, well you think 'oh ill just do…I'll just go over there…I'll just do that to get to 8000'

WL3: yeah

WL1: well I think that's pleased me but I was just so frightened of losing it and saying 'I've lost it, sorry'.

WL5: so was I.

WL1: I've not kept up with the step diary cos it was something to do…to write down and record it and I relied too much on technology and other things so if I'm honest…

Though WhatsApp leaders agreed that pedometer sometimes provided feedback which motivated them to be more active, they did report various issues when using these components. WhatsApp leaders did not explicitly state that the pedometer and step diary were necessary for their involvement in the intervention. As WhatsApp leaders were already motivated to remain active following PR, this raises the question of whether they should be provided with the step diary and pedometer in a future trial.

WhatsApp leaders considered the smartphone simple to use when sending messages to the WhatsApp groups. However, WhatsApp leaders reported practical issues such as low battery and problems maintaining a Wi-Fi connection:

WL5: It's fine, I'm quite happy with it.

WL1: it's fit for purpose.

WL2: it does "the job". It eats the battery.

WL5: Because I didn't have a problem with the phone. The only problem I had with the phone is that my Wi-Fi kept dropping out and I didn't realise that it wasn't going to automatically connect again when it came back in because I thought that's what it would do. But it didn't. I had to keep putting it back in so we had an awful lot of trouble with our Wi-Fi and we've changed it three times, the code. So it's alright now, so that wasn't a problem with the phone. That was just a connectivity problem.

WhatsApp leaders believed some patients may have had limited understanding of the smartphone and WhatsApp, hence their limited engagement in WhatsApp. Though the study

smartphone and pedometer were often fit for purpose, WhatsApp leaders often preferred using alternative devices, for example their personal smartphone and step counters such as 'Fitbit', which were considered more convenient for them.

Limited rapport with the WhatsApp group

The WhatsApp guidelines provided a set of example messages for WhatsApp leaders to send to the groups. The guidelines also outlined instructions for WhatsApp leaders to send, for example, they instructed the WhatsApp leaders to send a weekly PA reports to the WhatsApp groups. Despite trying to connect with the WhatsApp groups, WhatsApp leaders reported that they had received limited responses from the group. Though WhatsApp leaders understood the reasoning behind the structure of the WhatsApp messages, WhatsApp leaders avoided some of the messages outlined in the WhatsApp guidelines, as they did not feel appropriate and considered them as patronising.

> *WL3: Cos I felt. I must…I never put in 'if you like, you can use a fridge magnet and put the step diary on your fridge!'*
>
> *WL5: No*
>
> *WL3: Or 'if you put it next to you, where you can see it'…No I thought…*
>
> *WL5: It's a bit too much isn't it.*

In attempt to engage patients in conversation in the WhatsApp groups, one WhatsApp leader reported trying to be more social and another WhatsApp leader often sent messages about their experiences of PA:

> *WL5: Cos I think if they know how I find doing that, then that might encourage them to have a go. Because there's more than one Tai Chi class around the area around where I live, so I just wondered if that might encourage them to try and I've also said*

to them about their steps – 'have you done your steps?' and 'have you been recording them?' and 'how are you doing?' But nothing. And I've not stuck to the script in here, but I've tried to be more social with them to try and engage them, but that doesn't work either. (laughs)

WL3: yeah with my lot I've got photographs where I went to Blackpool illumination, so I send and say 'this is what I've been doing. I always connect it, saying I've walked up and down Blackpool prom which was 8000 steps, how you getting on? You know. I didn't do much this week because, you know, I was breathless or you know, I did something, cut my finger. So, I'm…so I've only done 3000 steps, how many have you done?

Low engagement of patients was also attributed to the group not knowing the WhatsApp leaders. Though patients in two PR groups met the WhatsApp in person leader during PR, the other patients had not met the WhatsApp leader prior to the intervention:

WL3: So, I'm XXX (name) and I'm from Lincoln and I'm WhatsApp leader for Gainsborough and Skegness. And I met the Skegness people briefly, but I didn't meet the Gainsborough people.

WL4: Haven't met any of them. I think at the moment it's dwindled down to two people. And I've not had any responses from anybody.

Despite WhatsApp leader's efforts to engage the WhatsApp group in conversation, there was limited communication between patients and the WhatsApp leaders. WhatsApp leaders suggested that patients would be more likely to engage in the conversation if they had met the WhatsApp leaders face to face and built a rapport. A social networking group would then feel more sociable:

WL1: That was, that was the plan. But I think it's. The opportunity is if in the beginning of that programme you've got phones that you can send messages to and people get used to it. And it's also then people are then motivated cos they like. I mean it becomes a little like…like the group I started in…people got on. We got on.

To move forward with a future definitive trial, face to face support was considered important in maintaining contact with the group and keeping patients connected. Regular meetings with group members could be a way to draw people 'out of their shells and help build a rapport with patients. Being familiar with the group enables them to follow up with patients who might be struggling, in a way that does not feel intrusive.

WL5: I think they do and then obviously the groups that we have are fairly local to each of us as individuals so once you've met face to face, once twice then you get everyone as an individual. Some people take two or three meetings before they sort of come out of themselves. But I think that…I think that would give them more, through this…

So, we would probably message more to them because we would have a communicate interaction...

Built on the grounds of the face to face contact.

WL3: But at the moment I can't phone round anybody because I think its intrusive, isn't it.

WL5: Yes exactly. Exactly. I don't know these people or anything about them. So, I wouldn't know what to say to them.

WL3: Mm

WL1: Or we've been pretty faceless.

WhatsApp leaders also felt that regular face to face meetings with patients in the WhatsApp groups could lead to the development of a larger network of patients who could meet. Face to face meetings were a way that group members could discuss their issues and motivate each other to stay active:

> *WL3: Or as the main thing. But is that part of the, is that what you want? To end up with this network of…cos of course once we get. Cos if it's us 5 in here for instance and we've all got our groups. Once we've got to know them really well, we could say 'do you want to meet up all together?' so you'd end up with 50 or 60 people all going across the 5 groups and countywide and then nationwide. We could all be talking and…*

Though face to face support was considered important, there were practicalities that needed to be overcome. For example, finding a date that suits everyone would be challenging, and it would be important for the WhatsApp leaders to live near other group members:

> *WL3: Yeah, I think yeah so, I think it would have to be quite local wouldn't it.*

Connection with other volunteers was also considered important for a further trial. This would enable volunteers to share their experiences and potentially alleviate any worry that group members have not responded to their messages. Contact with other volunteers would also enable volunteers to offer advice for engaging with the group:

> *I: So, there was a bit of interest in getting a WhatsApp group together for all the WhatsApp leaders. Would this be something that we could do in the future, just to get a sort of group together with all the volunteers to carry on? As WhatsApp leaders or the equivalent?*
>
> *WL5: Yeah, I think that's a good idea.*

WL1: I'd like to have known early, that you weren't getting a response (laughs).

WL2: It's exactly what I was going to say.

Further research should focus on the development of an intervention which enables WhatsApp leaders and patients to maintain face to face support following PR. Though there are challenges involved in the organisation of these meetings, face to face support was perceived as a necessary step which would benefit both WhatsApp leaders and patients.

Recruitment of WhatsApp leaders

The research team recruited WhatsApp leader volunteers by attending COPD patient support groups and introducing the study. All WhatsApp leaders who volunteered to take part in the study were provided more information about the research procedures from the Chief Investigator. WhatsApp leaders had no issues with the way that they were recruited to the study but reflected on how there was only a limited number of people who were interested in becoming a WhatsApp leader.

WL3: No, I felt recruiting us was fine but…X (WL1), how many of your PR group went on to do this social group? Was it all of them? Some of them?

WL1: Some guys are on a Thursday and a Tuesday, so you know, not all together but I'd say in my group there was 15.

WL3: So. But, out of the group when you went to see us, I think I was the only enthusiastic one about becoming a WhatsApp leader.

As there were only a limited number of WhatsApp leader volunteers for this study, this has implications on the feasibility of a further intervention. Changing the way that WhatsApp leaders are recruited for the study, for example by recruiting patients at PR, may improve the likelihood of recruiting enough motivated volunteers for the study.

Despite WhatsApp leaders' willingness to be involved in the intervention, some believed that a social support network led by patients from PR was the most feasible way to continue social support in the long-term. One WhatsApp leader sending messages to many PR group may not be possible. Volunteers suggested that they attend PR to discuss the benefits of maintaining PA and to suggest that PR members create their own social networking groups. This would also mean that the groups would already be familiar with all the group members and would not have an 'outsider' sending messages.

> *WL3: As WL1 said, say if I went along to a Lincoln group then the best outcome would be if someone else wanted to be a WhatsApp leader. Because if I went to this group and I get some from another group then…*
>
> *WL5: Yeah*
>
> *WL3: …You think well I'm sending messages to 15 groups now.*

5.5.2.2 Facilitators to the acceptability and feasibility of the intervention

Although there were various barriers to the acceptability and feasibility of the intervention and research procedures, there were several factors that facilitated WhatsApp leaders' acceptability of the intervention. The facilitators to the acceptability and feasibility of the intervention included the following subthemes: commitment to the WhatsApp leader role, connection with patients and fellow volunteers, and goal setting as an important element for patients.

Commitment to the WhatsApp leader role

WhatsApp leaders considered the intervention important. When asked if the WhatsApp leaders would like to have further involvement in shaping the intervention for the future, WhatsApp leaders outwardly expressed interest. They felt passionate and that there was a sense of purpose in being involved in the research:

WL3: No, I'd be very interested yeah. You know cos you get involved in something and you feel passionate. Well, not passionate…that sounds like it's coming off the telly doesn't it 'I'm so passionate…

WL5: There is a sense of purpose to it.

Two WhatsApp leaders based in Lincolnshire believed they could commit to becoming a WhatsApp leader in a further intervention. For example, one WhatsApp leader said they could attend all the PR sessions to meet with potential WhatsApp group members, whereas another felt they could attend at least a couple of the sessions. WhatsApp leaders were willing to help in a further study, but reported time restrictions due to prior responsibilities and limited ability to travel:

WL3: And we wouldn't have to go to 12 sessions would you, you know, but I would.

WL5: I could go to the odd one, you see.

Not all WhatsApp leaders were based in Lincolnshire and considered that a local WhatsApp leader could be more appropriate in a further study. WhatsApp leaders' passion for research and development was clear in their commitment to the research procedures. Despite limited engagement, and sometimes no response at all from the WhatsApp members, the WhatsApp leaders all reported that they regularly sent messages to the WhatsApp groups in line with the protocol for the study. WhatsApp leaders had therefore been sending out a minimum of one weekly message.

WL4: although I do find it. I don't have difficulty sending the messages out, that's fine, that's not been a problem at all. So, I'll keep going and hope that there's somebody out there.

WL1: I've sent the messages out. And that's about it really.

WhatsApp leaders did not find it difficult to send out the messages, and reported that they formed a routine of sending the messages out:

> *WL1: I just got a thing where I put it on Monday night and then that's it.*

> *WL5: I do mine on Monday or Tuesday. And I do Tai Chi and I tell them sometimes. There's only two but I tell them sometimes how I'm finding that.*

WhatsApp leaders rarely forgot to send out the WhatsApp messages, and when they did, it was only occasional:

> *WL3: …It's been quite good. But I did lapse last week. 7th of July, 7th of June was the last time. So, I missed one. So, it's been, been ok.*

Connection with patients and fellow volunteers

WhatsApp Leaders considered sending messages based on their personal experiences as more natural and they believed other group members would relate to their experiences and sense of humour. Relating the messages to their own experiences, by using anecdotes, was considered more acceptable. This was an approach that felt more natural and avoided them feeling as if they were patronising the group. Sending a joke to the group was a method to engage with the group, as one member hoped that humour would lighten the mood, and perhaps help the group start thinking about PA, or even trigger a response:

> *WL5: I haven't said that. I've said to them, ah what was it, when it was raining so much, I said 'has you got webbed feet yet? It's very difficult to get your steps on a day like this'. Things like that.*

> *Because that I think is…whilst there is a serious side to what we're doing, someone reading that message will say 'ahh that's really funny'….*

> *But even then, if they don't communicate back to you, if they're thinking…*

WhatsApp leaders shared their experiences and one individual commented how they liked the idea of sending more personal messages. They compared the messages to information that they would hand out to strangers.

> *WL3: Of when I went to Blackpool, of the illuminations, and you know, just all sort of quite friendly things.*
>
> *WL1: That's quite nice. I just send very small like 'hi, you know, I've not done this, or I've done this or I've been at home, had to give it a miss this week because…' but no response you know, you feel maybe they're not…you know why would they be interested in someone they've never met, and somewhere they haven't been (laughs).*

WhatsApp leaders reflected on the importance of social support in motivating themselves to maintain PA, and therefore believe it could help others. WhatsApp leaders recognise the value of social support and how this motivates them to stay active following PR:

> *WL5: And because there's two of us doing it, we make it continue (physical activity).*
>
> *WL2: It's very difficult to do anything on your own, even if you're surround by people that you don't know, it's very difficult to do anything on your own. Whereas the group that came from the NHS PR to continue at the gym has struck together.*

WhatsApp leaders suggested that an alternative social networking application to WhatsApp, such as Facebook, may be more beneficial in building a connection with patients and other WhatsApp leaders. For example, it would be possible to have a private group, yet more freedom to chat with other WhatsApp leaders. WhatsApp leaders considered Facebook as more personable, as it enables group members to upload their own profile picture and potentially share other pictures. Facebook was also considered less formal and a more user-friendly platform, as it would be easier for group members to scroll through:

WL1: Facebook. Mm, Facebook group…

You can have a private Facebook, can't you, where people can join.

WL4: Yeah cos ive wondered sometimes whether the actual format of the WhatsApp message, it's not really very easy to read, is it? It's a lot of scrolling down and…

Goal setting as an important element for patients

WhatsApp leaders considered goal setting as key in motivating patients to stay active. However, goal setting as part of an intervention was considered tricky due to variations in patients' exercise capabilities. The inclusion of physiotherapists could be a potential way to minimise the risk involved in setting goals, for example goals could be tailored to everyone.

WL5: I think setting goals is a good idea because it gives something to aim for. It's the same problem in school. If you don't give them something to aim for, they'll do whatever they want. But you're also, when you're doing that, you need to account for not everybody, it's not a level playing field. Some are far more ill than others. So, you'd have to give a personal goal...

WL3: But then the physio, when you do the PR, the physio takes your initial baseline results.

The current step diary was considered a way for patients to set their own goals, as patients could set their own targets based on their previous PA.

WL3: That's a good, that's a good idea. Cos also if we're getting the people as motivated as we are, then if you put down 3000, 3000, 3000, 1500, then you're going to be disappointed in yourself a bit aren't you, so you're gonna go for 4 and a half thousand or even keel. But you've got a reminder. I mean I don't know how many steps I did yesterday or the day before.

5.5.3 Health care professionals

Seven HCPs that supported delivery of the intervention in the feasibility cluster randomised controlled trial (CRCT) participated in a Focus group which took place in September 2019. These included three Specialist Physiotherapists (Resp) and four assistant physiotherapists of LCHS. At least one HCP (responsible for supporting delivery of PR) present from each region of Lincolnshire, (North East, North West, South East and South West Lincolnshire). HCPs had been involved in the delivery of the intervention for at least 10 months.

A thematic analysis was conducted to explore HCPs acceptability and feasibility of the intervention and research procedures. As HCPs only observed patients' experiences of the research procedures and intervention during PR, the themes are mostly based on the introduction of the intervention during PR. The overarching themes included the 'facilitators' and 'barriers' of the acceptability and feasibility of the intervention and research procedures.

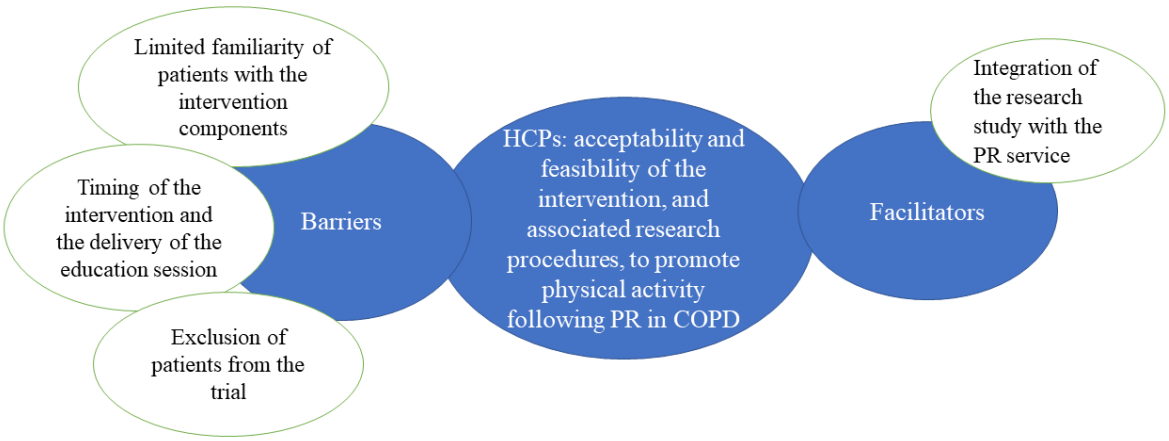

Figure 5:5: A concept map illustrating HCPs' acceptability and feasibility of an intervention, and associated research procedures, to promote PA following PR in COPD

5.5.3.1 Barriers to the acceptability and feasibility of the intervention and research procedures

There were various factors that impacted HCPs' acceptability and feasibility of the intervention and research procedures, such as limited familiarity of patients with the intervention components, timing of the intervention and the delivery of the education session and finally, exclusion of patients from the trial.

Limited familiarity of patients with the intervention components

Technology was often considered an obstacle due to patients' limited familiarity and confidence with the smartphone and pedometer.

Prior to the intervention there was scepticism about how patients would engage with technology. Information about the intervention was delivered during a PR education session, as it was considered important for all patients to receive this information:

> *HCP1: I was sceptical, and I think we had a lot of conversations around that anyway…*
>
> *I think I felt a bit sceptical about individuals actually using smartphones. But that's not me being ageist (laughs) that's just concern 'was it going to work'…*
>
> *In terms of technology and how that would in terms of people accessing your education, obviously on setting it all up. I think it was very pertinent to make sure that all those individuals that were interested were going to get that education on the smartphone and how was that being followed up. So, I was a little bit sceptical on that at first.*

The smartphone and pedometer were perceived as complicated, for example patients asked HCPs about the mechanisms of the devices, such as how to reset the pedometer every day.

This highlighted the importance of training and education for patients to become familiar with the intervention components.

HCP2: I really think that the technology is the bigger obstacle for them.

HCP3: And some people did feedback about the pedometer. Sort of, I can't remember it exactly because it was so long ago, but it was something to do with re-setting it each day and how it reset. If there was something they needed to do or if it was something automatically…

HCP2: …for some people was complicated. The phone was complicated. So, the phone was like 'no' for a lot of people because it's a phone. The pedometer was complicated as well.

Timing of the intervention and the delivery of the education session

HCPs did not have first-hand experience of the intervention components, and therefore offered limited insight into the acceptability of the content of the intervention for patients. HCPs mainly suggested various ways in which the research procedures and the introduction of the intervention within PR could be improved for future research.

Due to the complexity of the intervention, HCPs felt that the amount of information delivered to patients could have been overwhelming, which raised questions of the optimal method to deliver this information:

HCP2: I would say no. It was quite a lot of information in quite a short period of time. That was my feeling cos I was 'what? Talking on the phone and then the pedometer', so it was a lot to take.

HCP2: Yeah, so and then a new gadget at the same time, it's a bit overwhelming.

HCPs reflected on there being a rapid evolution of technology, meaning that it would be difficult to predict what social networking site could be appropriate for a future trial:

HCP1: and in terms of the apps and technology that's available to use…

We're looking at a completely different ball game probably.

However, HCPs believed that patients would be confident with any social networking application used in a future study, as long as they are confident in using a smartphone:HCP2: I think if they get on with their phone then they get on with the app.

HCP1: Mm

HCP2: That's my observation.

This highlights the importance of training patients to be comfortable in navigating the smartphone used in a further trial.

The optimal method and time to introduce the intervention to patients were based on various factors, such as the time available during PR, the workload of HCPs, time patients need to become familiar with the intervention components and whether intervention should be delivered as a group or individually. However, HCPs hoped to learn from the experiences of the intervention delivery during the study and were open to changing the method of delivering the information:

HCP1: Yeah, it was a dilemma if I remember rightly. When looking at the protocol, how long it would take to teach a patient how to use the phone and the pedometer, and the accelerometer and everything together. And I think hence why that's why we decided to do it in a group setting. I don't know, I didn't see one of those training sessions that you did. But it makes me wonder whether, I mean you guys probably had

more experience of them, but it's difficult but one to one, do you think that perhaps patients would have got on with that better?

Due to the complexity of the intervention, HCPs believed that the quality of the training and information provided to patients was important. However, due to their workload during PR, and particularly considering the change in the local PR programme since the study (now twelve classes instead of sixteen in the current study), HCPs were not sure how and when this information should be delivered:

HCP2: But it's another thing to do on pre assessment. And on pre assessment it's already busy enough and a lot of information so from my selfish perspective I'd prefer if the University introduced this study rather than if I'd got another thing to talk to them.

HCP2: Yeah or come into pulmonary rehab and just, I don't know, after or use the rehab. You can use the rehab to do it so you don't have to make another appointment or you don't have to make another appointment because I know some patients have quite few appointments in their week (laughs). It's also always a problem.

There were different opinions of when it would be appropriate to introduce the intervention during PR, for example during the 'introduction to PR' or the 'benefits of exercise' session. Some physiotherapists believed it would be possible during the introduction to PR, whereas others did not believe they would have the time.

HCP1: Yeah but you're doing all the explanation to the exercise and you'll have to say that I. Every session that I do, I fill that hour. With the explanations of what they're doing or all the exercises.

HCPs offered different methods of introducing the intervention to patients and discussed the appropriateness of introducing the intervention in person, when to introduce the intervention

and who the best person would be to deliver the information. HCPs often drew from their experiences during PR and with previous research studies:

> *HCP3: There's the open forum. And like we had the telehealth person. I know that's not the right word for that project but they came in and gave a quick ten minute thing so it was like, if you had the volunteers to support you all the time then maybe that talk that you do wouldn't have to be as long. And it could maybe be...*
>
> *HCP2: Yeah but then you're thinking about introducing it a little bit earlier during pulmonary rehab as well. And then the open forum is at the end. So, we sort of leave them until we finish the programme. They finish one but then they want to start another.*

Delivering information about the intervention in person was perceived as a better way to engage patients in the intervention. Reliance on leaflets and written information was not considered effective, and this had not worked in previous studies:

> *HCP2: In my opinion you won't get much intake if you give them a leaflet rather than come and introduce yourself.*
>
> *HCP3: Well it happened with that telehealth thing that she came and did…*
>
> *HCP2: Yeah (laughs)*
>
> *HCP3: ...10 minutes and then was like 'well I'll leave these leaflets and…*
>
> *HCP2: yeah*
>
> *HCP3: …not a single person picked…*

HCPs questioned who the best person would be to deliver the information, and wondered if patients would respond better to the research team or to HCPs:

HCP1: Yeah what I was saying. X (Researcher X), is there anything that you can think of in terms of. You know if one of your team is there and selling the research. That is there a….do patients potentially feel more pressured to say yes but then not necessarily sign up to it in the long term? As opposed to potentially us introducing it so slightly earlier. Even if it was with literature and then you coming in. Is there element of 'well I ought to say yes because they're here in front of me'. I don't know whether there's a…a behavioural aspect.

Delivering information about the intervention components individually, rather than in a group setting, could be more appropriate. Due to individual differences within the patient groups, HCPs suspect some patients struggled more than others. By identifying patients who struggled with the intervention components, information could be tailored for them:

HCP2: Laughs. The only idea I have for this is for people that do struggle, that you see struggle, arrange another appointment and to just do it one to one and just individualise it.

HCP1: So, a follow up after that individual follow up.

HCP2: Cos the group introduced, but maybe an introduction, just not as much information. And then let them know, if you are interested and then I can show you the gadget and then you can show them the phone and things like that.

The HCPs often provided the research team with assistance during the study. For example, sending GP letters for those involved in the study and following up with patients who were difficult to reach. Though HCPs were happy to help, they were concerned that this would not be feasible in the larger definitive trial. However, including other people in the delivery of the intervention is a way to ease HCPs workload.

HCP3: So even just with this smaller scale one, there's been a few people to follow up on. In terms of a few people that have dropped out and investigating their patient records and sending them a letter and that work has fallen on assistant type things. So, on a much larger scale…

Volunteers from COPD patient support groups were involved in the delivery of the intervention. Involvement from patient volunteers in the introduction of the intervention could be a method to ease HCPs workload, but also a method to improve patients understanding of the intervention and perception of peer support. HCPs suggest that patients were embarrassed to ask questions about the intervention components during the education session. However, patients may feel more comfortable asking patient volunteers for support:

HCP3: The volunteers that helped moderate the WhatsApp group. Could there be scope for those sorts of volunteers to support…

HCP1: That's a good idea…

HCP3:..getting patients to, even if they came to pulmonary rehab classes or. Because a lot of them are expected to be familiar with us and the things we do and things like that.

HCP2: yeah, well that's what it is, isn't it. Cos it's like maybe they feel like they should know that.

HCP1: Oh, ok so you maybe feel like they hadn't asked the questions.

HCP2: Yeah, I've seen people that were maybe a little bit embarrassed, especially men, and they're a little bit embarrassed that they don't know how to use the phone. It's hard for them and things like that. And you just don't want to embarrass even

more. And you know, maybe I can help, maybe this, maybe that. And if the peer doing it, it is different.

HCPs recalled other research studies which were conducted during PR, meaning that HCPs had knowledge of the practicalities to consider when conducting research alongside PR. A previous study included the assistance of another HCP, with expertise in technology, whose role was to provide additional support to help patients become familiar with technology:

HCP1: Ok. Just thinking about the work that they've been looking at with the COPD app, and that band 4…

HCP4: Yeah, I was thinking about that earlier.

HCP1: Ok, right. I was just thinking that if a similar thing happened, then potentially we could get an individual…

HCP4: Oh, ok yeah, an individual that they could go to.

HCP1: Yeah.

HCP4: For support…

HCPs considered that support from the research and development team is an option for a future larger scale trial:

HCP1: So, on a larger scale then maybe it would be the administrator from the research side that would perhaps need to be…

HCP2: Maybe the research team. If they could give us a hand, like they did with this telephone thingy. (separate research project). If they could give us a hand with that.

The research team should consider the workload of HCPs and identify other HCPs and/or patient volunteers to help with the delivery of the intervention during PR in a larger scale trial.

The research team should consider the workload of HCPs during PR when introducing the intervention to patients. As PR is now a shorter programme, the research team needs to consider how and when to introduce the intervention. HCPs were clear that patients respond to information delivered in person, rather than written information, and may benefit from further support when familiarising themselves with the intervention components.

Exclusion of patients from the trial

PR programmes recruit patients with a variety of lung conditions, hence patients form friendships with non-COPD patients. However, the intervention was limited to the recruitment of patients with COPD and did not include other patients with different lung conditions. HCPs felt the non-COPD population felt excluded and considered it important that a future intervention is inclusive of all patients, not just those with COPD:

> *HCP2: And the IPF patients felt left out.*
>
> *HCP1: Yeah. And I think really in terms of looking at your long term aims which is obviously to look at post pulmonary rehab, continuing to exercise, it should be inclusive of all those patients rather than just selective really, in the long run.*

Exclusion of patients with non-COPD lung conditions was a barrier to the trial. For example, exclusion of patients meant that WhatsApp groups were even smaller, and limited potential engagement of patients in the WhatsApp groups. PR included patients with various lung conditions, not limited to COPD, hence recruitment of COPD patients only may have negatively impacted the intervention. For example, it was possible that friendships developed

throughout PR could not be maintained throughout the intervention. Inclusion of all patients may positively impact recruitment in a definitive trial.

Inconvenience of the existing intervention components

HCPs believed that convenience was a factor that influenced patients' experiences of the intervention. Patients who enrolled in the intervention were provided with various study devices and materials, including a smart phone, pedometer, and a step diary. However, patients were using the study devices alongside their personal devices. HCPs suggested that some participants had difficulties wearing the pedometer and HCPs felt that using two smartphones would was inconvenient for participants.

Measures to protect patients' anonymity in the WhatsApp group included removing patients' names from the WhatsApp groups and asking group members not to share personnel details. HCPs believe the restrictions to protect patients' privacy on WhatsApp meant that WhatsApp felt impersonal for patients. Patients often shared their personal details over WhatsApp and told other group members who they were, suggesting that patients were not concerned about this.

HCPs believed a future intervention should focus on reducing the number of devices that patients are provided. Enabling patients to use their own smartphone and to use the step counters on their smartphone are methods to reduce the complexity of the intervention:

> *HCP2: The other thing with the phone is like you have two phones. They sort of. So for like app or something like that for somebody who wants to have a phone, rather than just on the phone, another thing to carry and to think about.*
>
> *HCP3: Do most phones have like a step count…*
>
> *HCP1: A step counter.*

HCPs considered other social networking applications, such as Facebook, as more appropriate than WhatsApp, as it enables patients to share personal information, such as a profile picture of themselves:

> *HCP3: Oh, another thing that I remember about it was the sort of anonymity of sort of 'patient 1, patient 2'…*
>
> *And you know, yeah, I don't even know. Often times on WhatsApp, maybe like on Facebook you have a picture of the person and I guess maybe a patient could have put a picture, could they?*
>
> *I think patients quickly figured out who they were talking to, didn't they?*
>
> *They just said 'hi it's me, X (patient name)' or something like that (laughs).*

Facebook would provide patients the option to both join and exit groups when they wish:

> *HCP1: If you set up Facebook messenger and get a messenger group set up, if you've got one particular set of patients that want to communicate with each other, but it's also easy to come off it.*

Based on the HCPs suggestions, researchers should consider reducing the complexity of the intervention, and enabling patients the freedom to share their personal information.

5.5.3.2 Facilitators to the acceptability and feasibility of the intervention

Integration of the research study with the PR service

Information about the study was circulated with HCPs prior to the study, and the research team communicated with staff to organise study practicalities such as the timing of patient recruitment and the education session. HCPs believed they had enough information to prepare for the intervention:

> *HCP1: I think I did because I was involved a lot in the setting up of the protocol…*

So, I was very much aware of what your plans were…

Obviously, I'm not sure about everyone else in the room.

HCP4: Yeah sorry I was as well.

HCP3: Yeah, we rearranged a lot of the dates between us with the courses with when would be the best times to come in…

HCP3: And I feel like that worked fairly well, yeah.

The feasibility study was designed in a way that the intervention would not impact the quality of PR. Time to enrol the patients in the study and to provide further information about the intervention was taken out of PR, however HCPs did not believe that this negatively impacted patients experience of the programme. Sometimes patients did not complete their exercises during PR, but this was not considered a problem because patients could complete these at home:

I: Ok and again, in terms of us impacting on pulmonary rehab itself, do you think that happened in a negative way during this study? Did we take maybe people in pulmonary rehab and you know, had it any way affected…

HCP2: I don't think it…

HCP1: I don't think it did.

HCP3: I think there was some people that maybe didn't complete their exercise programme on that day.

HCP2: Yeah but then you asked them to do it at home. So, you ask them to take responsibility and to do it at home.

HCP3: Yeah

HCP2: So, I don't think it's, its bad. I think it's good.

HCPs were satisfied with the delivery of the intervention and research procedures during PR. Regular contact between the HCPs and research team enabled the intervention to be integrated into PR.

Overall, the HCPs were mainly concerned with how to improve the study in a future definitive trial. They offered suggestions as how to improve the introduction of the intervention, including the most appropriate time and people to deliver this. HCPs also provided suggestions for ways to improve patients' comfort whilst wearing the activity monitor, as well as alternative intervention components and methods to improve the inclusivity of the study.

5.6 Discussion

5.6.1 Summary

The aim of the qualitative findings were to explore the acceptability and feasibility of the intervention and the research procedures for patients, WhatsApp leaders and HCPs. The qualitative work has highlighted common facilitators and barriers of the intervention between all groups.

All groups commented that patients would benefit from more familiarity with the intervention components, and therefore suggest that patients in a further trial would benefit from further education and training on the intervention components during PR. All groups also reported that the convenience of the intervention components and research procedures could be improved in the future and therefore researchers should consider alternative intervention components for a future trial, in addition to research procedures which suit all stakeholders. Rapport between the patients and WhatsApp leaders was also considered important and researchers should consider ways to support face to face communication between patients and lay volunteers in a future trial.

5.6.2 Comparison to previous literature

There was mixed familiarity and understanding of the intervention components, which therefore questioned the suitability of the use of technology and social media for people with COPD. This is an ongoing, evolving debate in research.[332] For example, evidence suggests that older populations are less engaged in social networking applications and that digital interventions have limited beneficial impact on patient outcomes.[333,334335] However, there has been a growth in the use of internet use for older adults[333], and research suggests that internet and social media are becoming more popular with people with COPD.[336] In a recent

systematic review of computer and mobile technology interventions for self-management in COPD, findings suggest that interventions incorporating smart technology was associated with higher levels of PA, compared to interventions using other means of support such as face-to-face or written.[337]

For some patients, the smartphone used in this study (Nokia 1) required time and energy and was therefore not considered convenient. However, WhatsApp leaders had no problem navigating the smartphone, suggesting that WhatsApp was a user-friendly social networking application. These results highlight the mixed ability of patients, suggesting that patients should be offered intensive training to support them to become familiar with technology. The importance of training has been considered in a previous study, whereby lay health workers received three days of training to use phones to communicate with patients, who indicated they required longer to become familiar with the phones.[185] Similarly, in a previous study including smartphone based PA telecoaching in COPD, some patients reported problems using technology and believed that the familiarisation period for the intervention was important.[321] However, others in the telecoaching study had no problems in using the smartphone and application, suggesting that acceptability of digital interventions is subject to individual differences. It could be that digital interventions are more beneficial to those with a greater interest in digital interventions, and therefore it is important to give patients some flexibility in the type of intervention component they want to be involved in.[337]

HCPs suggested that familiarity with a smartphone is more important to patient engagement than the type of social networking application used. However, WhatsApp leaders suggested that other social networking devices may be more appropriate than WhatsApp, as the interface of WhatsApp was restrictive and impersonal. These results reflect findings from similar interventions.[321193] Facebook was a suggestion as a future social networking application in a further intervention, as the interface is less formal and provides the option to

share personal details. Although a separate study which used both WhatsApp and Facebook for behaviour change purposes, found that there was less discussion on Facebook.[193] However, this may have been attributed to various reasons, such as patients' limited exposure to Facebook compared to WhatsApp and the distraction of Facebook newsfeeds. There are limited interventions providing patients with smartphones and/or inviting them to social networking applications which have also reported patient acceptability of the devices.[187,248,306] Therefore, there is limited research to offer guidance into the optimal social networking application, the most acceptable device to use, and the level of training that patients need to become familiar with these devices. This requires more research.

Social support was a key theme in this intervention, which reflects the importance of the BCT: social support (3.1-3.3). However, social interaction was perceived as both positive and negative, reflecting previous research.[136,241,321] Previous literature has outlined that family can facilitate PA in patients with COPD.[140,230] Throughout this intervention, families and partners took an interest in the study, offered support and sometimes even got involved by wearing a pedometer.[321] However, some patients negatively compared themselves to their family and did not believe they could achieve as many steps. This may reflect previous research which suggested that a barrier to PA following PR was having an uncomfortable reminder of disease progression.[241] However, there is limited research in involving family members and partners in interventions to promote PA following PR in COPD, and this requires further research.

Interestingly, support from HCPs was not a theme from interviews with patients, though this has previously been considered an important factor in the maintenance of PA following PR in COPD. For example, patients reported that HCPs provide a sense of security and comfort which helps ease anxiety associated with symptoms.[241] Inclusion of HCPs in the maintenance of PA was discussed in the WhatsApp leader focus group. Goal setting was

discussed as a method to keep people motivated to continue to be active. In a smartphone-based PA telecoaching intervention, a determining factor for patients to maintain PA was feeling monitored by coaches (a HCP).[321] However, WhatsApp leaders recognised that goal setting was dependent on input from HCPs, as goals were dependent on patients' physical capabilities. WhatsApp leaders and HCPs recognised that HCPs may have limited resources to contribute to the intervention. Nonetheless, it is possible that the presence of a HCP may have boosted engagement and impact of the WhatsApp group. Patient acceptability of the intervention may be based on the type of social support they received, rather than the frequency of support, and the platform that support was delivered.

Patients had competing demands in this study, and their days were often dictated by family and volunteering responsibilities and health concerns, which is reflected in previous literature.[136,241] Patient engagement in the intervention was therefore influenced by the convenience of the intervention components. The pedometer and step diary were considered easier to use than the smartphone and WhatsApp due to their simplicity. A large amount of research has reported that patients have positive experiences with the step counters.[306,338,326] The pedometer used in this study was the Yamax Digi-walker CW-700, which has been used in previous studies[91,327], and is considered the most reliable pedometer available.[340,341] However, difficulties associated with the wearability and sensitivity of this device have been reported both in previous research and in this study.[340] Wrist worn devices were considered as more acceptable.

A target of the intervention, which had been met, was to incentivise patients to be active based on their recognition of progress. This was possible via recording their step counts in the step diary. These results reflect findings from previous research that recognition of capabilities and improvements incentivises patients to maintain PA following PR.[241] Various studies have tested multicomponent interventions, incorporating pedometers and step

diaries, on their impact on PA following PR in patients with COPD.[331,91,121,137] Results from these studies are mixed, though most studies reported an increase in steps in the groups with the pedometer[85,94,148], though one study reported no difference.[91] However, there is limited understanding of the active ingredients of these interventions, meaning that little is understood about how and why these interventions were efficacious.

Though the research team dedicated time to the recruitment of WhatsApp leaders (Chapter 4), the feasibility results outlined that some WhatsApp leaders in this study withdrew from the study prior to the delivery of the intervention, which therefore disrupted the fidelity of the intervention. These findings reflect previous literature[185]. WhatsApp leaders reported that they were committed to their role as WhatsApp leader and most commented that they wanted to continue to support patients in a larger scale trial. However, WhatsApp leaders also reflected on the time it took to recruit lay volunteers for the study and suggested that a longer recruitment period could be beneficial.

5.6.3 Strengths and limitations

The interviews and focus groups were an important component of a mixed method study to develop and test the acceptability and feasibility of an intervention to promote PA following PR in COPD. The MRC guidance states that feasibility and piloting is an important part of the development of a complex intervention.[159] The interviews and focus groups enabled an assessment of the overarching acceptability of the intervention, including the identification of teething and/or contextual issues prior to a larger scale trial.[159]

As reported in Chapter 1, there is limited understanding of the active ingredients of intervention components within similar previous studies aimed to increase PA in people with COPD.[331–83,252,92,90,84,244,145,187,306,329,330] However, interviews in this study were able to explore the potential mechanisms of action of the intervention, and explore factors beyond the content of the intervention, for example the duration and mode of delivery of the intervention.

Qualitative data therefore captured individuals' insight and experiences of the intervention, going beyond the objective data on PA and health outcomes in this study.

A clear strength of the interviews and focus groups was the range and depth of insight they provided from various stakeholders, including patients, WhatsApp leaders and HCPs. For example, the decision to purposefully select patients for interviews based on maximum variation meant that data voiced experiences and insights of a wide variety of patients, including those patients who had declined the intervention, partially engaged in the intervention, engaged in the entire interview, and those that withdrew.[159,279] Similarly, there were a mix of individuals present at the focus groups. For example, for the HCP focus group, both physiotherapists and physiotherapist assistants participated, which was important as they had different levels of involvement in the study. There was also at least one HCP present from each region of Lincolnshire. Similarly, in the WhatsApp leader focus group, there was at least one WhatsApp leader present for each WhatsApp group in the intervention.

It was possible that the subset of patients who agreed to the interview did not represent everyone in the intervention, potentially introducing an element of bias into the study.[344] Also, only a limited number of patients who withdrew from the intervention agreed to participate in an interview, due to busy schedules and health concerns. However, maximum variation in the sampling meant that the interviews gained insight into patients' experiences and experiences of the intervention. Furthermore, data was collected until saturation, so it was unlikely that further interviews would capture different themes.

Patients had the option of engaging in interviews over the telephone or face-to-face, meaning that there was variation between the format of the interviews. This may have impacted the response from patients. For example, the setting of the interview may have impacted how comfortable they felt when answering the questions. However, freedom for patients to choose the format of the interviews was chosen to maximise their convenience and

comfort, and to provide patients with a sense of control, which is considered important when conducting interviews.[345,346]

Another potential limitation was the fact that interviews and focus groups were conducted with the Chief Investigator of the study, potentially introducing a response bias whereby patients were inclined to be positive about the intervention[347]. However, patients, HCPs and WhatsApp leaders in this study did report negative experiences of the intervention, hence it was likely that patients felt comfortable to offer advice on how the intervention could be improved.

A challenge of the study was delivering the study information to all patients during PR, as there is a high likelihood of patients missing PR sessions due to various reasons, such as illness, injury, and family responsibilities. This is a challenge with all PR research, based on the poor adherence and completion rates of PR.[348] A method to improve this in further studies could be to provide study information earlier during PR, and for HCPs to provide brief reminders to patients throughout PR.

The interviews and focus groups were conducted across different phases of the intervention, which may have impacted individuals' acceptability of the intervention and research procedures. However, this is considered positive, as the interviews and focus groups were able to capture periods that the intervention had the most or least impact for patients across the 52-week period. Though some participants were sometimes unclear about the details relating to the start of the study, for example the familiarity and training period for the intervention, this was often overcome by reminding individuals about details of the study. HCPs and WhatsApp leaders had different roles in the intervention, as some were involved in the design of the protocol prior to the feasibility study, which may therefore impact their acceptability of the intervention. However, this meant they had an overarching understanding of the trial and were able to reflect upon their previous considerations. **Table 5:7** reports the

timing of the patient interviews across the 52-week period, meaning it was possible to consider individual quotes alongside contextual factors.

A limitation of the trial was that there was limited data from patients who withdrew from the intervention. This was because most patients who withdrew from the trial refused to participant in an interview with the research team due to competing demands and health concerns. This means there was limited understanding of their acceptability and feasibility of the intervention and research procedures, but also limited understanding of the factors that impacted their PA following PR. However, it was unlikely that the data retrieved from patients in these subsets would capture different themes, due to maximum variation in sampling, and data collection until saturation.

As reported in the quantitative results (5.3) the results of the intervention did not point towards a beneficial impact of the intervention on the patients' disease specific QoL and anxiety and depression. In fact, the IG had a larger decline in their disease specific QoL and an increase in their anxiety and depression compared to the CG. The process evaluation mainly addressed patients' acceptability of the intervention and research procedures and PA, and their PA (the key aim of the thesis, and the proposed primary outcome of the definitive trial, respectively). Limited attention was directed towards understanding the results of the secondary outcomes, such as disease specific QoL and anxiety and depression. Further investigation in a future trial is warranted to understand whether this negative association is attributed to the intervention, or whether this is due to other variables. To gain further insight into these findings, a process evaluation within a definitive trial should aim to identify if and why this association exists.

The development of the intervention was facilitated by the APEASE criteria[145] and contributed to a systematic and comprehensive intervention development process. However, the results of the process evaluation identified that potentially important components of the

intervention were excluded in the intervention development. For example, stakeholders excluded the BCT 'goal setting' as it was not considered acceptable to stakeholders due to health and safety concerns i.e. the chance of patients over-exerting themselves and not having a HCP nearby. Despite this, the results of this study highlighted the potential beneficial impact of goal setting, and this is therefore represents' a recommended addition to the intervention, subject to agreement with HCPs. These findings highlight the challenging and iterative, non-linear process of intervention development, which requires dedicated time[145]. Use of the BCW, and the APEASE criteria are integral to the further modification and evaluation of the trial.[145]

Patients who contributed to the development of the intervention were limited to those who were active members of COPD patient groups. Though a strength of this thesis was collaborations with patients from COPD support groups, such as Breathe Easy[138], it is unlikely that these individuals represent the overarching patient population. For example, these patients were motivated to maintain social contact and to maintain PA. Therefore, it could be suggested that the intervention did not account for the factors that impact patients who struggle to be active and/or stay active following PR, or those who do not prioritise face to face social support. To address this potential limitation, feedback should be sought from those patients who are not actively involved in COPD patient support groups and those who are involved in social networking COPD support groups.

5.6.4 Conclusion

The interviews and focus groups represent an important stage in the development of a complex intervention. Overall, the intervention and research procedures were considered as positive and acceptable and feasible to deliver in a future definitive trial. However, researchers should consider the reported facilitators and barriers of the intervention and research procedures and strive to improve these for a future trial. Methods such as training

patients during PR to become familiar with the intervention components, incorporating alternative intervention components to suit patient preferences, and offering face to face communication between WhatsApp leaders and patients may improve patient and patient volunteers' experiences of the intervention. Research procedures could be improved by recognising the restraints of HCPs in PR and the convenience of the study visits for patients.

6 Chapter 6: Integration of quantitative and qualitative results

6.1 Abstract

Background: The previous chapter outlined that the intervention was considered acceptable and feasible for all stakeholders, and that higher intervention engagement was associated with a lower mean reduction in mean daily steps following pulmonary rehabilitation. However, limited attention has been directed at understanding the factors which impacted patients' PA following PR, and whether there were differences between those with different levels of intervention engagement. Furthermore, previous chapters have not reported how the factors relate to the COM-B model and the targets of the intervention.

Aim: This chapter reports the facilitators of PA following PR which were unique to those who engaged in the intervention, the barriers unique to those who did not engage in the intervention, and the common factors between both groups. Finally, this chapter mapped these factors onto the COM-B model to identify if the targets of the intervention had been met.

Methods: Patients were split into different subsets to identify those who did or did not engage in the intervention (higher or lower intervention engagement). A deductive thematic analysis of the interviews with patients was conducted to map the results onto the COM-B model. The facilitators unique to those who engaged in the intervention, the barriers unique to those who did not engage in the intervention, and the common factors which impacted PA following PR were reported. Finally, the targets of the intervention which had been met were identified.

Results: Facilitators unique to those with higher intervention engagement related to physical capability and reflective motivation. Barriers unique to those with lower intervention engagement related to automatic motivation and physical opportunity.

Only one factor which was unique to the sub-groups was categorised as an unmet target of the intervention, which related to the distance of PA opportunities. However, a common facilitator of PA for both sub-groups, which related to a target of the intervention, related to the pedometer and step diary which incentivised patients to be more active.

Conclusion: Integration of the quantitative and qualitative results offered further insight to explain the findings from previous chapters and previous literature. Though the results support the statement that there is not a 'one-size fits all' approach to PA behaviour change

interventions in COPD, these results will be important for informing the modifications of the intervention prior to a definitive trial.

6.2 Introduction

This thesis has identified the facilitators and barriers of PA following PR for patients with COPD (Chapter 2), which then informed the development of the intervention tested in the feasibility cluster RCT (Chapter 3, 4 and 5). The previous chapter identified the likely impact of the intervention on patients' PA and secondary health outcomes and patients' acceptability and feasibility of the intervention (Chapter 5). Key facilitators included benefits of support (peer and family), recognition of progress and convenience and preference of the intervention components. Key barriers included limited familiarity and confidence with the intervention components, competing demands and inconvenience of the intervention, and a negative perception and experiences of social interaction.

Interestingly, the quantitative results outlined that higher engagement in the intervention was associated with a smaller reduction in mean daily steps at 52 weeks. Understanding the facilitators of PA following PR behaviour for those with higher intervention engagement, as well as the barriers for those with lower intervention engagement would provide further insight and understanding the acceptability of the developed intervention. However, limited attention in previous literature, and this thesis, has been directed at understanding the differences between those with different levels of intervention engagement. The results would inform a future definitive trial by identifying whether the intervention was successful in targeting patients' PA following PR, and any important factors missing from this intervention, which could be incorporated into a future trial.

The development of the intervention was based on the COM-B model, which is situated at the core of the BCW (Chapter 3).[145] All sources of behaviour in this model, minus physical capability, were targeted in the developed intervention (Chapter 3,). So far there is limited understanding of whether patients' facilitators of PA following PR were related to the

targets of the intervention. As reported in the literature review (Chapter 1), there is limited research to identify if and how behaviour change is related to behaviour change models.[225]

The following chapter goes beyond the inductive analysis of the previous chapter and reports a deductive analysis to identify the factors which impacted PA following PR in patients with higher vs lower intervention engagement.

6.3 Methods

A deductive analysis of the interviews identified the facilitators of PA unique to those who engaged in the intervention, the barriers unique to those who did not engage in the intervention, and the common facilitators and barriers of PA following PR. These factors are mapped onto the COM-B model to identify the sources of behaviour which are important for PA maintenance following PR.[145] 'Engagement' in the study was based upon engagement in the step diary, as this implied engagement in both the pedometer and step diary. 'Intervention engagement' was based on the number of days that participants reported their steps. This was calculated by splitting participants into lower or higher engagement groups based on whether participants had reported their steps for more or less than half of the intervention period. Lower engagement was categorised as <50% engagement and higher engagement was categorised as >50% engagement. Data is only displayed for participants who were interviewed and returned their step diary following completion of the intervention.

6.4 Results

6.4.1 Patients

Of the twelve patients included in this analysis (patients who engaged in interviews during the study), six participants had 'lower' engagement in the intervention and six had 'higher' engagement in the intervention. In total, 5 patients were males (42%), and the mean (SD) age between groups were similar (MD, 1.5, CI, -8.89, 11.9). Patients' MRC score and BMI were also similar, with no notable differences (Cohen's d < 0.2). However, the group with lower

engagement did have a lower post-PR ISWT distance which exceeded the MCID of 37m[349], with a large effect size between groups (MD, -107, (CI, -281, 68.3). In the lower engagement group, the number of steps recorded ranged from 0-78 days, and in the higher engagement group, the number of steps recorded ranged from 245-377 days, with a large effect size between the two groups, (MD, -298, CI, -347, -248), **Table 6:1**.

Table 6:1: Level of intervention engagement for participants in the intervention group who were interviewed

Participant ID	Gender (M/F)	Age	BMI	MRC	ISWT	Number of days engaged in the step diary
Lower engagement in the step diary						
P5 (Full)	F	63	35.5	3	90	0
P8 (Full)	F	67	21.6	3	260	0
P10 (Full, withdrawn)	M	80	20.5	4	120	0
P4 (Full)	F	58	17.8	4	260	0
P2 (Full)	F	69	43.6	MD	110	44
P11 (Partial)	M	69	23.3	3	330	78
M (SD)	x	67.7 (7.37)	27 (10.2)	3.4 (.55)	195 (101)	20.3 (33.3)
Higher engagement in the step diary						
P7 (Full)	F	63	19.5	3	230	245
P9 (Full)	F	65	31.7	3	200	306
P3 (Full)	M	70	24.3	3	310	314
P12 (Full)	F	75	21.2	4	90	326
P6 (Full)	M	73	28.7	3	450	339
P1 (Full)	M	51	29.5	4	530	377
M (SD)	x	66.2 (8.73)	25.8 (4.9)	3.3 (.52)	302 (164)	318 (43.5)
MD (between groups)	x	1.5	1.23	.07	-107	-298
95% CI (Lower, Upper)	x	-8.9, 11.9	-9.06, 11.5	-.66, .79	-281, 68.3	-347, -248
Effect size (d)	x	.19	.15	.19	.79	7.69

Full = received all study components (WhatsApp, pedometer, step diary); partial = received pedometer and step diary only; full, withdrawn = enrolled in the intervention and subsequently withdrew: P: Person; CI: confidence interval; M: Mean; SD: Standard Deviation; MD: Mean Difference; d: Cohen's d; M: Male; F: Female; BMI: Body Mass Index; ISWT: Incremental Shuttle Walk Test; MD: Missing Data; MRC: Medical Research Council Dyspnoea Score, x: not applicable

6.4.2 Facilitators and barriers to PA following PR

The following text provides examples of the facilitators unique to those who with higher intervention engagement, and the barriers unique to those will lower intervention engagement. The unique factors are categorised as the behaviour source (capability, opportunity and motivation) that they relate to[145] and are defined as 'facilitators' or 'barriers' to PA. Following this text, the common facilitators, and barriers in both sub-groups are summarised. Finally, the text outlines if and how these factors related to the targets of the intervention, **Figure 6:1** and **Figure 6:2**.

6.4.2.1 Capability

A facilitator of PA following PR which was unique to one patient who had higher intervention engagement was that the frequency of their exacerbations had declined since PR (P3), which was therefore related to their physical capability:

> *P3: Now I think if I…funnily enough, since I walked, since I started to wear it (pedometer), I haven't had a chest infection.*

No barriers, related to capability, were unique to patients with lower intervention engagement.

6.4.2.2 Motivation

Those with higher intervention engagement reported two unique facilitators to PA follow PR. One of these facilitators included the ability to overcome mental obstacles (P6, P9, P12), which was therefore related to reflective motivation:

> *P12: Sometimes it's not very good I must admit (motivation). …I had a spell where I thought as though I couldn't do it but that's not like me, I usually pull myself out of that pretty quick and get on and do things. So, I motivate myself in other words. Yeah.*
>
> *P6: mm it would be so easy just to sit there and say 'oh I can't breathe, I'm not doing anything because if I get the hoover out and I do this and I do that, then I get short of breath and I'm not going to do it'. Cos that would make you worse…so you've gotta, in a sense you gotta make yourself get up and do it.*

Secondly, those with higher intervention engagement also reported that PA was part of their identity (P3, P9) and that they had always been active:

> *P9: Oh, I'm definitely motivated, yeah, yeah, couldn't vegetate…I mean I've always been a really active person…so it's hard not to be motivated cos you like, right, go….*

The lower intervention engagement group did not report unique barriers of PA related to their reflective motivation, though reported three unique barriers of PA related to their automatic motivation. One patient reported being frightened of certain activities (P8):

P8: Yeah but you see, I panic in water.

One patient reported that their mood could negatively impact their motivation to be active (P10). Similarly, another patient reported having a busy schedule which impacted their motivation to be active (P2):

P10: No, it's (PA) just dependent on my mood.

P2: Not having the time easily. I've lost a bit of the inclination to do it (PA).

6.4.2.3 Opportunity

Patients with higher intervention engagement did not report unique facilitators related to their opportunity to be active. Only one barrier that was unique to patients with lower intervention engagement was identified, which related to the distance of PA opportunities (P8, P2):

P2: There's nowhere to go.

… that would be, if there was something nearer, because I think there is sort of a meeting club or something in Skegness isn't there.

6.4.3 Common facilitators and barriers of PA following PR

Both subsets of patients reported several similar facilitators and barriers of PA following PR. The common facilitators related to all behavioural sources except physical capability and the common barriers related to physical opportunity and physical capability. The facilitators mostly related to opportunity, followed by motivation and capability, and are reported below in this order.

Common facilitators related to physical opportunity related to having a garden and proximity to town facilitates walking (P12, P8, P2); having pets that require walking (P1, P8, P2). Facilitators related to social opportunity included having an active and encouraging family who supports PA (P9, P3, P12, P8). Common facilitators of PA related to patients reflective motivation, included: motivation to avoid worsening health status (P7, P3, P2); reminding self to be active (P6, P11); and understanding the benefits of PA following PR (P7, P9, P6, P8). Facilitators related to patients' automatic motivation included being incentivised the pedometer and step diary to do more PA (P9, P8) and being in a habit of being active

(P12, P11). Finally, common facilitators of PA related to patients' psychological capability included being more knowledgeable about exercises from PR (2).

The common barriers of PA following PR mainly related to patients' physical opportunity, followed by their physical capability, and are reported below in this order: Common barriers of PA related to patients' physical opportunity, which include the weather and temperature impacting PA (P12, P8, P11) and family and volunteering responsibilities limit time for PA (P6, P2). Common barriers related to patients' physical capability related to their poor health and breathlessness, which impacted their ability to plan or complete PA (P7, P2), **Figure 6:1** and **Figure 6:2**.

6.4.4 Targets of the intervention

No facilitators of the intervention reported above, unique to those with higher intervention engagement, were related to the targets of the intervention, and only one barrier of the intervention reported above, unique to those with lower intervention engagement, was related to an unmet target of the intervention, which included 'PA opportunities being too far away'. For example, WhatsApp messages aimed to inform patients of their proximity to PA opportunities, and/or to encourage patients to be active at home (see Appendix K, p333 for examples of the WhatsApp messages within the WhatsApp guidelines).

Nevertheless, a common facilitator of PA, for those with both higher and lower engagement in the intervention, included being incentivised by the pedometer and step diary to do more PA (P9, P8). This related to a target of the intervention (**Figure 6:1** and **Figure 6:2**), see Chapter 3, **Table 3:4** for a detailed report of the targets of the intervention components. A few barriers of PA, unique to those with higher intervention, were related to unmet targets of the intervention. However, these were not considered as salient, as they did not impact patients' engagement in the PA intervention, nevertheless, they are reported in **Figure 6:2**.

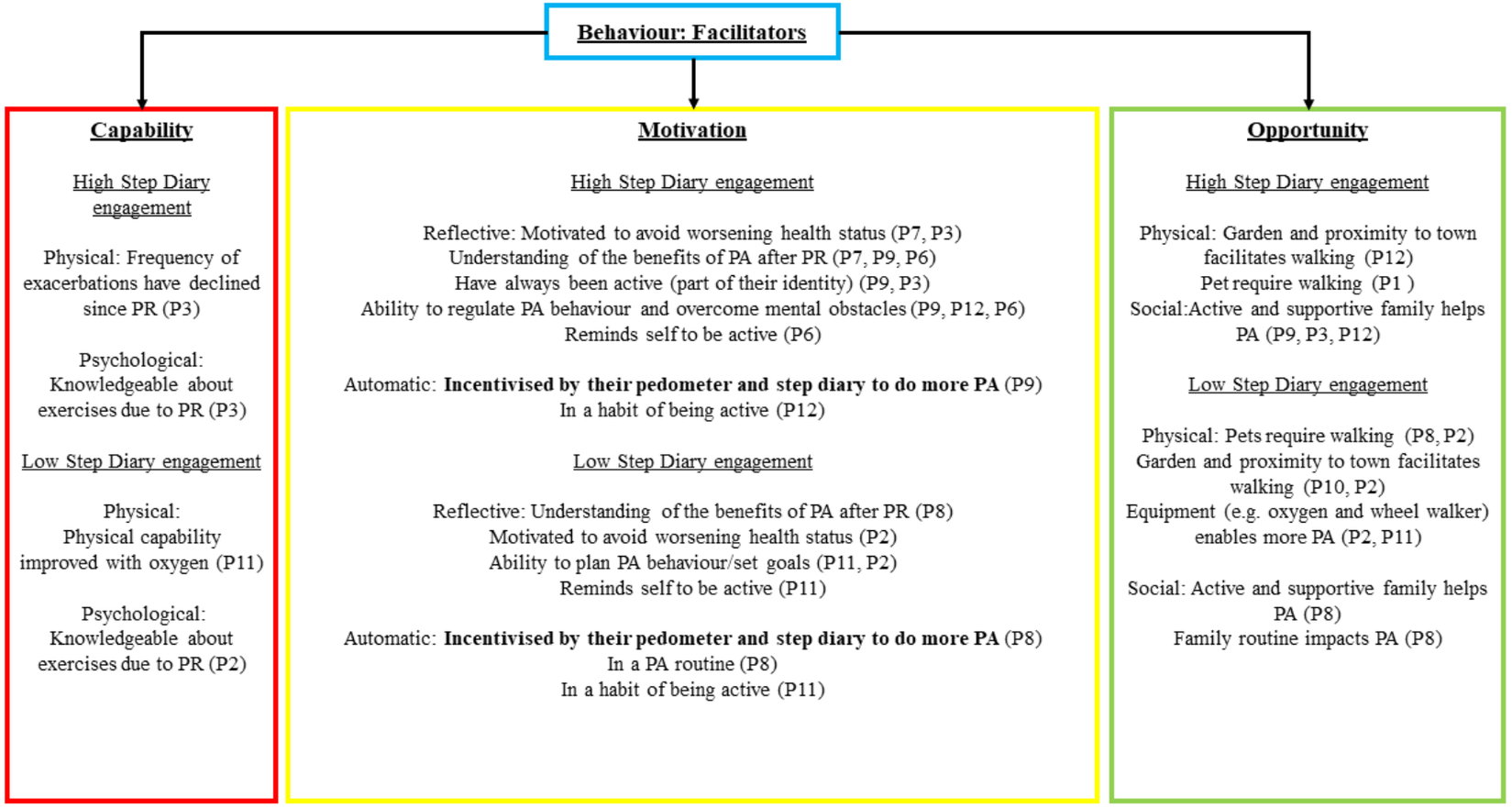

Figure 6:1: Facilitators of PA for participants with different levels of step diary engagement, mapped onto the COM-B behaviour change model. Highlighted text indicates the facilitators which were targets of the intervention

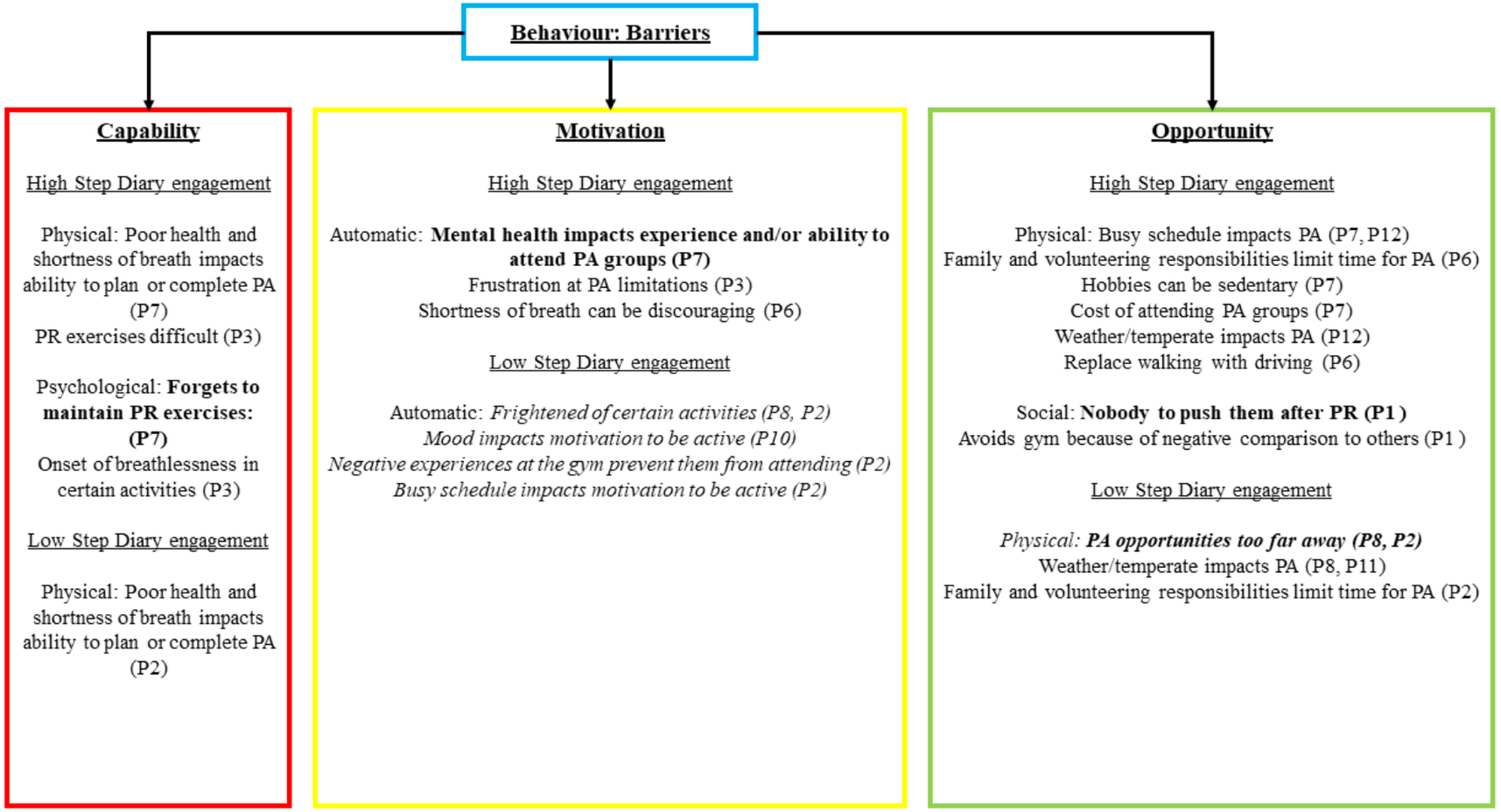

Figure 6:2: Barriers of PA for participants with different levels of step diary engagement, mapped onto the COM-B behaviour change model. Highlighted text indicates the facilitators which were targets of the intervention.

6.5 Discussion

6.5.1 Summary

The aim of this chapter was to report the facilitators of PA, unique to those with higher engagement in the intervention, and to report the barriers of PA, unique to patients with lower intervention engagement. Furthermore, this chapter aimed to identify if the factors which impacted patients PA were related to targets or unmet targets of the intervention. Overall, facilitators unique to those with higher intervention engagement related to physical capability and reflective motivation. Barriers unique to those with lower intervention engagement related to automatic motivation and physical opportunity.

Only one factor which was unique to the sub-groups was categorised as an unmet target of the intervention. This included the PA opportunities being too far away, though this was only reported for one patient. However, a common facilitator of PA for both sub-groups, which related to a target of the intervention included being incentivised by the pedometer and step diary to be more active.

6.5.2 Comparison to previous literature

The results outlined that the intervention was successful in incentivising patients from all subsets to do more PA via the pedometer and step diary. These results support the inclusion of these intervention components in a future trial and support previous reviews which outline the potential efficacy of these intervention components on patients' PA following PR.[85,94,148] However, as patients with both lower and higher intervention engagement reported being incentivised by the pedometer and step diary to be more active, these results suggest that this intervention component is simply not enough to increase PA in all patients. These results reflect findings from previous literature that simply understanding the benefits of PA, and owning a pedometer, is not enough to support long term PA.[130] Patients therefore require further support to stay active.

The results outline the importance of reflective motivation in impacting patients PA following PR in patients with COPD. This intervention aimed to target patients' reflective motivation by enabling them to reflect on their PA progress via the step diary and pedometer. However, the facilitators unique to those with higher intervention engagement, which included the ability to overcome mental obstacles, and believing PA was part of their identity,

were not targets of the intervention. Nevertheless, these results highlight the importance of reflective motivation in PA in COPD following PR, which has been reflected in previous literature. For example, previous research which mapped responders and non-responders facilitators and barriers of PA following PR in COPD, reported that PA was associated with higher perceived competence and controlled motivation following PR, for example the need to complete a task based on external or internal pressures.[225] The systematic review of the facilitators and barriers of PA following PR in patients with COPD also identified self-efficacy as a determinant of PA (Chapter 2). For example, previous PA experiences influenced patients' beliefs of their capability and confidence of being active. Similarly, previous findings have reported that PA was positively associated with self-efficacy for PA.[83] These findings contrast other reports that self-efficacy is only weakly associated with daily PA in patients with COPD.[83,350,351] Furthermore, the ability to plan PA and to overcome mental obstacles was not a target of the intervention, but it was important in influencing patients' PA in this intervention. These results provide a potential explanation for the proposed efficacy of previous interventions which target PA regulation, for example health coaching and goal setting.[130] These results also support the suggestions for modifications of the intervention from WhatsApp leaders, which include setting step goals for patients (0), which therefore rely on patients ability to plan their PA behaviour and their perseverance to complete these goals.

No subsets of patients reported that connection with peers or WhatsApp leaders via social networking facilitated their PA, therefore it could be suggested that social support is not an important contributing factor for patients following PR. Though these results may simply reflect the method chosen to measure intervention engagement. For example, interviews with patients based on their WhatsApp engagement may have focused on the perceived importance of peer connection. Nevertheless, the results highlight that social interaction was an important contributing factor to PA following PR, as reported in previous literature[221–186,221,73,339–341] and previous chapters in this thesis (Chapter 2, 3 and 4). For example, not having peers and/or HCPs to push patients to be active following PR was a barrier to PA reported by one patient with higher engagement in the intervention. Patients' families were also associated with both facilitators and barriers of PA, for example, a common facilitator in all subsets was that an active and supportive family encouraged

patients to be more active, and family routine was a facilitator to PA. The results from the systematic review in Chapter 2 reported that families and partners could both discourage and encourage patients to be active, for example, it was reported that negative pressure from relatives and family sometimes led to avoidance of PA. However, the findings from Chapter 5 and this study report that patients' only considered family support as positive. Nonetheless, family, and social responsibilities were a barrier to PA, as limited time prevented patients from engaging in PA. These findings reflect those in Chapter 5, for example competing demands was a common barrier to the acceptability and feasibility of the intervention. These results outline the need for families to understand the importance of PA for patients (as reported in the systematic review in Chapter 2) and to identify the activities which benefit their health.

The limited reports of peer support as a facilitator to patients' PA was surprising, based on the reported importance of this in previous literature[189] and results from previous Chapters (2 and 3). It was clear that patients do benefit from social support, due to the reported benefits of family support following PR. The results of the inductive analysis (Chapter 5) outlined that patients had limited understanding and confidence surrounding smartphones and WhatsApp, which has also been reported in previous literature.[321] This provides an explanation for limited interaction with peers. It is therefore likely that patients would benefit from peer support, but not solely via social networking, as suggested by patients, WhatsApp leaders and HCPs in Chapter 5.

Barriers unique to patients with lower intervention engagement, such as varying mood, and being frightened of participating in new activities, were related to patients' automatic motivation. These results outline the importance of automatic motivation in PA behaviour following PR. Although the intervention aimed to promote emotional social support via WhatsApp, the results from Chapter 5 reported that only a limited number of patients engaged in WhatsApp, for a limited period, possibly due to limited familiarity and confidence with the smartphone and WhatsApp. As reported above, it is possible that social support may address these barriers, but not solely via social networking. These results offer insight into the findings from the quantitative chapter, in that the disease specific QoL, and anxiety and depression of patients in the IG declined during throughout the study. Though, of course, it is not possible to conclude that this applies to all patients in the IG, due to these

interviews being limited to a small sample of patients. Another barrier, unique to those with lower engagement in the intervention was that PA opportunities were too far away, which reflects the findings in previous chapters (Chapter 2 and 5). Though WhatsApp leaders informed patients of their local PA opportunities, the results suggest these messages were not sufficient to meet patients' needs. However this may be due to the rurality of the Lincolnshire, for example 'local' opportunity PA opportunities may still be inaccessible for patients with reduced mobility and limited transport .[355]

Overall, the results outline the importance of the behavioural sources which were unique to those with higher and lower engagement in the intervention. These factors included physical capability, reflective and automatic motivation, and physical opportunity. However, the results also outlined the common facilitators and barriers of PA between both groups, and the suggest that facilitators related to all behavioural sources minus physical capability, and the common behaviour related to physical opportunity and physical capability. These results reflect those from the Chapter 2, which outline the complexity of PA behaviour, and how factors which impact PA in this population span patient's beliefs, social support, and the environment.

Health concerns were negatively associated with patients' PA, which is also reflected in previous literature[225], for example health concerns were reported as a barrier to PA maintenance following PR in Chapter 2. Physical capability was not a target of the intervention. The research team and stakeholders believed that individuals who completed PR would likely have the exercise capacity to maintain PA, which is also supported by the findings in the systematic review of the facilitators and barriers of PA following PR in patients with COPD (Chapter 2). When using the APEASE criteria[145] to develop the intervention, HCPs did not consider it feasible to offer additional support to patients following PR, due to HCPs limited capacity. However, these results suggest otherwise, and it is therefore necessary to re-evaluate the potential involvement of HCPs in offering support to target patients' physical capability.

The results outline that those with higher engagement in the step diary had a higher score in the post-PR ISWT. Though previous literature has outlined that exercise capacity following PR has limited association with maintenance of PA following PR[149], the results suggest that a higher level of exercise capacity is associated with higher levels of motivation

to engage in the intervention. The results from this chapter, and previous chapters (Chapter 2, section 0 Chapter 5, section 0) reported that positive feedback, i.e. from the pedometer (a higher number of steps) increased patients' motivation to be active. Hence a higher level of baseline exercise capacity, and positive feedback from the pedometer, may be important in incentivising patients to engage in the intervention components. These findings support previous literature which suggests that baseline exercise capacity can be predictive of a beneficial response to interventions to promote PA.[356] Therefore, further research should investigate whether lower baseline step counts negatively impact patients' motivation to engage in PA, and if so, the measures to control for this issue.

6.5.3 Strengths and limitations

Though application of mixed method research is a relatively recent method, it is considered as a powerful approach in addressing health research, and management of chronic conditions[265–252], and it is supported by the MRC[159] in process evaluations of complex interventions within RCTs.[160] The qualitative data provided complementary data in understanding the quantitative results.[261–263] As well as understanding the acceptability and feasibility of the intervention, the results outline the factors which influence patients' PA, hence provided further understanding into potential active ingredients of the intervention.[145]

There is limited research in the use of behaviour change models in the development and evaluation of behaviour change interventions.[225] This study added further understanding of the potential mechanisms of the intervention, how the determinants of PA related to the COM-B model, and how the facilitators and barriers of PA related to the targets of the intervention. In the development of the intervention, reflective motivation was identified as an important behavioural source to target patients' behaviour, which the results of this study support. However, this study identified that improvements in PA did not necessarily only relate to the targets of the intervention, but other factors related to reflective motivation. This study therefore offers further insight into the mechanisms of the trial, and further informs the modification of the intervention for a definitive trial. These results also offered tentative explanations for the clinical quantitative outcomes reported in Chapter 5 (5.3.5). However, as these interviews were limited to patients in the IG, it was not possible to determine the facilitators and barriers of patients in the CG, hence this study provided limited insight into the difference in the clinical outcomes between the IG and the CG. Nevertheless, the results

from this study were valuable in understanding the differences between those with higher or lower intervention engagement.

The results from this study also offer explanations to support the reported importance of intervention components used in previous trials. For example, in a systematic review of the interventions to modify PA in patients with COPD[130], the findings identified that counselling and coaching interventions could potentially have larger impacts on PA in patients with COPD. The results from this study suggest that this may be due to the focus of on intervention components to promote patients' reflective motivation, such as the ability to overcome mental obstacles.

A potential limitation of this study was that analyses were based on a small sample of participants who were in the IG, and it could be argued that the results do not represent all the possible facilitators and barriers of PA faced by patients with COPD, following PR. As reported previously (discussion of the inductive analysis), the decision to purposefully select patients for interviews based on maximum variation (e.g. those involved in the full intervention and those in the partial intervention) meant that data voiced experiences and insights of a wide variety of patients. The interviews were valuable in understanding the factors which impacted a subset of patients' PA following PR.[159,279]

6.5.4 Conclusion

The aim of this chapter was to identify the facilitators and barriers of PA for patients in the IG and to provide further insight into potential differences in the facilitators and barriers of PA between those with higher and lower intervention engagement. The facilitators unique to those with higher intervention engagement were related to their reflective motivation and physical capability, and the barriers unique to those with lower intervention engagement were related to their automatic motivation and physical opportunity. A common facilitator of PA for both groups included being incentivised by the step diary and pedometer. However, this facilitator was clearly not enough to engage patients in the PA intervention. A barrier, unique to those with lower intervention engagement, was that PA opportunities were too far away, which suggested that the target of the intervention to inform patients of their local PA opportunities was not sufficient. These results were able to offer insight into the findings from previous chapters and previous literature. Though the results support the statement that there is not a 'one-size fits all' approach to PA behaviour change interventions in COPD[254],

these results are important in the development of potential modifications of the intervention prior to a definitive trial.

7 Chapter 7: General Discussion

The aim of this thesis was to develop and test the feasibility of an intervention to promote PA following PR in patients with COPD. This thesis addressed the gaps in previous literature, which included the limited: understanding of the determinants of PA following PR in patients with COPD (Chapter 2); application of theory and behaviour change frameworks in intervention development (Chapter 3); understanding of the processes that contributed to the efficacy of an intervention (Chapter 5); involvement of stakeholders in the research process (Chapter 3, 5), and the short time-frame in the delivery of interventions (Chapter 4 and 5). In line with the MRC recommendations, a step wise approach was adopted in the development and feasibility testing of the intervention[159], whereby the successes and challenges of these steps were reported.

A systematic review (Chapter 2), collaboration with stakeholders (Chapter 3 and 5), adoption of the BCW (Chapter 3), and use of mixed methods (Chapter 4 and 5)facilitated the development of the feasibility cluster RCT with a qualitative process evaluation (Chapter 4). Following the trial, integration of the quantitative and qualitative data provided further insight into the acceptability of the intervention (Chapter 6). The overarching results from the trial outlined that the intervention was considered acceptable and feasible for a definitive trial, and data supports the likely impact of the intervention on patients' PA. However, the results from the trial confirmed that important modifications are required to optimise the acceptability and feasibility of the study prior to the definitive trial. An intervention revision period is considered necessary to make the recommended modifications to the trial. The results provided important implications for policy, practice and for researchers with an interest in COPD management, but also researchers with an interest in behaviour change and intervention development.

7.1 Structure of the general discussion

The following text reports the strengths and limitations of the thesis, the recommended modifications for the intervention and research procedures, the future directions of the intervention, the implications for policy, practice, and research and finally, the conclusion.

7.2 Strengths of the thesis

A clear strength of this thesis included addressing the gap in knowledge and limitations in previous research in promoting PA following PR in patients with COPD. Limited maintenance of PA following PR negatively impacts patients and contributes to social and economic demands (Chapter 1),[15,1617,18] for example, provision of care and the expense involved in treating COPD exacerbations. This thesis contributed novel knowledge and outlines an intervention which may beneficially impact patients' health and well-being following PR. The results from this thesis provided complementary evidence to aid evaluations of PA interventions already attempted in this area[197–199,130], but also adds further insight into future development of interventions targeting PA maintenance in COPD.

As reported in the literature review (Chapter 1), the MRC states that intervention development should be based on a relevant theoretical framework.[159] There has previously been calls for further adoption of the BCW framework within intervention development in the area[165,175], yet the BCW has had limited application in the development of interventions to promote PA following PR.[176] The BCW was beneficial in this study as it was able to categorise the many facilitators and barriers of PA following PR according to the behavioural sources (COM-B components) which they related to[145] (Chapter 3). The BCW facilitated the decision making processes involved in the development of the intervention, which also considered context-based factors.[145]. Consequently, a strength of this thesis was the use of the BCW in the development and evaluation of the intervention (see Chapter 3 and 6 for further detail about use of the BCW).

An important aspect of this thesis included collaboration with patients, patient volunteers (WhatsApp leaders), and HCPs, as they provided valuable input into the development of the intervention. They also offered insight into the different aspects of the acceptability and feasibility of the trial, which would not have been apparent from the quantitative data alone (Chapter 3 and 5). As reported in the literature review (Chapter 1), Patient and Public Involvement (PPI) facilitates research at various stages of the development-evaluation-implementation process of complex interventions.[159,343] Minimal involvement of patients in previous research has been attributed to limited understanding of the determinants of PA following PR in patients with COPD.[155] In this thesis, individuals from COPD patient support groups in Lincolnshire provided valuable input in the

development of the intervention, based on their own experiences and barriers and facilitators to PA following PR. Furthermore, inclusion of patients in the development of the trial meant that the intervention was guided by context-specific factors, such as limited opportunities to be active, and cost and travel associated with attending these opportunities. Though these barriers reflect those reported in previous literature (Chapter 2), they are arguably more salient in Lincolnshire, given the rurality of the county.[355]

Despite the benefits of conducting COPD research with input from stakeholders[181], the involvement of so many stakeholders in the development and evaluation of an intervention in previous research is rare. In addition to the involvement of patients and HCPs in the development of the intervention, other personnel in the NHS (e.g. communications officer) and staff at the University (e.g. the research and governance officer and the information compliance officer), were involved in the design of the digital component of the intervention, including the use of mobile phones and the use of social networking applications. Without their input, the development of the intervention may have been more time consuming, and less acceptable to participants.

As reported in the literature review and methodology (Chapter 1 and 4), mixed methods are associated with various strengths[261–263,278]. In the feasibility study (Chapter 5), the data from the interviews and focus groups provided further insight into the quantitative results, for example the qualitative data provided insight into patients' acceptability of the intervention, and why some patients declined to enrol in the intervention. Furthermore, the interviews provided insight into the factors which impacted patients' PA following PR and offered key stakeholders an important voice in the research process. The qualitative data offered an explanation into the differences between those who engaged in the intervention, vs those who did not (Chapter 6). This enabled further understanding of the mechanisms of the intervention[159,153] and contributed to recommendations for the modification of the study and implications for further research, which are reported below (7.4). Mixed method research is reportedly more time consuming than collection of qualitative or quantitative data alone[265], which could have been limiting if there was not enough time dedicated towards this approach. However, this approach did not interfere with any other aspect of the study and the use of mixed methods was only considered a strength in this study.

7.3 Limitations of the thesis

Though the sample size was acceptable for a feasibility study[296] (Chapter 5), the sample size was not powered for statistical data analyses, hence the quantitative data was only able to highlight the likely impact of the intervention on patients' PA and secondary health outcomes. Nevertheless, in accordance with the guidance from the MRC[159], the main aim of the feasibility study was to measure the acceptability and feasibility of the intervention and research procedures prior to a larger scale trial[159,296]. The results from this thesis have therefore informed the modification of this intervention which can be tested in a definitive trial.

The experiences of the CG were not gathered in this thesis, as the key aim was to measure the acceptability and feasibility of the intervention and research procedures. It was likely that the systematic review in Chapter 2 identified the key factors which impacted patients' PA following PR. Nonetheless, as this was a feasibility study, with a smaller sample size, it is not clear whether these results would be reflected in a definitive trial. Nevertheless, the process evaluation in a future trial should not ignore the CG, and researchers should aim to capture their experiences PA following PR.

Due to the complexity of PA behaviour change following PR in patients with COPD, there were a multitude of factors which impact patients' behaviour (Chapter 2). HCPs reported that limited time and funding was a barrier in supporting patients to keep active following PR (Chapter 3), and decided that it was not feasible to provide support for patients following PR. Despite this, the results of the process evaluation (Chapter 5) clearly outlined the need for continued support from HCPs after PR, hence the process evaluation was successful in identifying an intervention component that had previously been dismissed during the development of the intervention. These results outline the iterative and time-consuming nature of intervention development.[145] However, the feasibility study was successful in outlining modifications to the intervention (7.4), and implications for policy, practice and research, also reported below (7.1).

7.4 Modifications to the intervention

The overarching results of the feasibility study outlined that the developed intervention was acceptable and feasible for a definitive trial (Chapter 5). However, modifications to the intervention could be optimised prior to a definitive trial, and aspects of the intervention

should be continued, added to, or removed. The following text outlines the recommended modifications to the intervention, including: support from HCPs; face to face support with peers and lay volunteers; involvement from family and partners; freedom for patients to use their personal devices; use of a different social networking application; and a change in the role of the lay volunteers, also outlined in **Table 7:1**.

Support from Health Care Professionals

Maintenance of support from HCPs following PR is a recommended modification prior to a definitive trial (Chapter 5). The systematic review in Chapter 2 identified the importance of support from HCPs, for example they provided a sense of security in helping patients overcome anxiety surrounding physical symptoms. During the development of the intervention HCPs did not consider it feasible for them to provide additional support to patients following PR, due to limited time and resources of HCPs (Chapter 3). Time constraints from HCPs was also reported in Chapter 5, whereby they were limited in the amount of time where they could support patients. However, barriers to patients with lower intervention engagement included being frightened by certain activities, which discouraged patients from being active (Chapter 6). This suggests that patients would benefit from having support from HCPs in times of uncertainty. Previous interventions which included remote support from HCPs following PR have had a beneficial impact on patients' PA.[94,148] These interventions provided remote support to patients at monthly intervals between 6 to 12 months and provided evidence of the acceptability and feasibility of such interventions. Remote support is an alternative to face to face support, which is less time consuming and expensive for patients.[94,359] In the focus group with HCPs, it was reported that involvement and support from an additional HCP and/or a lay volunteer would facilitate the delivery of the education surrounding the intervention (Chapter 5). In a future trial, the inclusion from other HCPs and/or the research and development team, would assist PR staff. For example, PR staff would have more time to remotely follow up with patients following PR. Though there were limited resources for this feasibility study, a funded definitive trial could provide funds for additional HCP support. Furthermore, evidence suggests that support from HCPs can be delivered via telephone, or a smartphone application[321], which is a less time-consuming

alternative to face to face support.[94,359] HCP support therefore represents a feasible addition to the intervention.

Goal setting

Based on the results in the systematic review of PA following PR in patients with COPD (Chapter 2), goal setting was not considered a salient facilitator, nor was it a priority by other stakeholders in the development of the intervention (Chapter 3). However, in the results from the interviews in the inductive analysis, WhatsApp leaders discussed the potential beneficial impact of introducing individualised step count goals to patients, but recognised the need for these goals to be proposed by a HCP (Chapter 5). Also, in recognition of the facilitators and barriers of PA for patients involved in the IG, reflective motivation was reported as an important behavioural source for responders of the intervention (Chapter 6). As such, intervention components which focus on behavioural regulation would target the facilitators of PA reported by patients whose steps improved following PR. The addition of goal setting is a recommended modification of the intervention prior to a definitive trial. By setting a tailored step count target for patients, the intervention may address the reported barrier from patients; they did not feel pushed or motivated to achieve more PA (Chapter 5). Goal setting has been considered beneficial in previous research[130] and represents a feasible addition to the trial. Goal setting has been implemented in various interventions to promote PA for patients following PR[91,90], and this method should be based on those studies which have identified a beneficial impact of the intervention on patients' daily steps.[94] Therefore, it is recommended that goal setting is introduced throughout PR by HCPs, based on patients' baseline (pre-PR) daily steps. These goals should be short term and an increase in the step count goal should be dependent on achievement of the previous goal. Based on previous research, the increase in step count goals has been based on the addition of approximately 800 steps.[94] However, based on the results in this study, the mean daily steps decreased in both the IG and CG, and such an increase in the step count goal may not be feasible for many patients. Furthermore, Chapter 2, 5 and 6 reported the importance of self-efficacy on PA following PR. To nurture self-efficacy, it is therefore recommended that step count goals should be tailored to each patient, with recognition of differences in patient fitness levels and capabilities, and the emphasis should be on any achievement in step counts from the previous goal. In line with

previous research, patients should maintain the step goals, with contact from the HCPs every month[94148] via social networking..

Face to face support with peers and lay volunteers

WhatsApp leaders and patients suggested that they would benefit from building a rapport prior to the intervention (Chapter 5). Despite the costs and time associated with regular face to face contact between patients and WhatsApp leaders, this was considered an important method to complement social networking support and to maintain a rapport after PR. Face to face contact may also address the barriers reported by those with low intervention engagement which related and physical opportunity and automatic motivation, such as the distance to attend physical activities, and low mood and motivation to be active (Chapter 6). Face to face support with peers and lay volunteers is therefore a recommended modification to the intervention, which could take the form of regular (e.g. monthly) local meetings following PR to supplement the social networking component of the intervention. However, based on patients' reported restrictions with travel and cost (Chapter 5 and 6) it is important that these sessions are accessible to all patients in terms of location and cost of attendance. A viable option would be to rent a local community centre, for example, near to the local PR centre, to ensure that the location is accessible for those who attend PR. Though there is limited research on the effectiveness of non-formal follow-on groups following PR, there is evidence to support the social and educational benefits of formal groups such as Breathe Easy[138], which also aim to support patients with COPD[139].

Family and partner involvement

In the development of the intervention, inclusion of patients' families in the intervention was not prioritised by stakeholders, and was not pursued as the results from the systematic review in Chapter 2 reported mixed findings for the role of family members in patients' PA maintenance following PR. For example, negative pressure from family could result in avoidance of PA. On the other hand, families understanding of importance of PA was a facilitator to PA following PR (Chapter 2), as was family support and routine. This reflects the results from the feasibility study, of the benefits of support, whereby family members took interest in the intervention and supported patients following PR (Chapter 5). Inclusion and support from family members should therefore be pursued as a potential modification to the intervention. Specifically, inclusion of family members should be encouraged when

setting step-count goals, to inform family members of the PA tasks set for patients. This would facilitate family members to provide support and reminders for patients to complete their goals. In addition, family members of patients who report lower confidence and familiarity navigating social networking should be encouraged to join the social networking groups, as they could support patients to read and post messages to the groups. However, as barriers to the acceptability of the intervention for some patients was negative perception of social interaction with other patients following PR, this highlights the diversity in patient preference of social support following PR and provides further evidence that interventions should be tailored to individual patients following PR[127,192,361], as a 'one-size fits all' approach does not exist.[254] Family members should be encouraged to support patients, but refrain from comparing their own PA achievements.

Use of personal devices

A barrier that was unique to those with lower intervention engagement included patients having competing demands, which was also reported in Chapter 6 and supported by previous literature (Chapter 2). Recommendations to address patients' competing demands included making the intervention more accessible and convenient for patients. Provision of study phones in the feasibility study was based upon optimising patients' privacy throughout the study (Chapter 3). However, the results from the feasibility study (Chapter 5) suggest that patients are comfortable with using their personal devices and sharing their personal information, such as their contact number, name, and profile picture. Patients should be allowed to use their own step counter to record their PA and mobile device when connecting with other patients. Patients who do not have personal step counters should continue to be provided with a step counter from the research team. The pedometers (Yamax CW700/701 model) used in this study were not considered comfortable and convenient, as they were difficult to strap onto patients' waistbelts, and they also fell off easily, hence were lost at various points, which reflects previous research[91] (Chapter 5). All stakeholders suggested use of wrist worn devices, such as those used in previous interventions[91,327] rather than clip on devices, as these were considered more comfortable (Chapter 5). The flexibility for patients to use their own devices would also be beneficial in reducing the costs of the study.

Social networking application

Use of an alternative social networking application, such as Facebook, is a recommended modification to the trial. Facebook enables a further level of anonymity than WhatsApp and does not require patients to share any personal information, including their mobile number (unlike WhatsApp), if they choose not to. Similarly, patients are easily able to exit, and potentially re-join Facebook groups, dependent on whether they perceive social interaction as beneficial to them. Stakeholders also outlined that Facebook enables patients to have private conversations with peers or lay volunteers, but also provides less pressure for patients to communicate if they choose not to (Chapter 5). It is recommended that patients are added to a closed Facebook group, populated by all other patient cohorts who sign up for the intervention. This enables patients to have a wider group forum. To nurture the friendships made in PR, patients should be added to their own Facebook messenger chat. Finally, it is recommended that HCPs maintain contact with patients via video chat, enabling a check in with their step count goal progress. This modification addresses the finding that patients respond differently to different types of social interaction[241](Chapter 5), thus is it important to provide patients with the flexibility to choose who they interact with, and when and how often.. Facebook enables patients to join groups and identify other people that they would like to communicate with. Therefore, Facebook provides patients with more opportunity to communicate with peers, and develop sub-groups, in which they can chat with other people. This is beneficial, as stakeholders reported that the small size of the WhatsApp groups contributed to the limited patient engagement (Chapter 5). The mode of delivery of the intervention is important to patients, therefore patients should be asked if and how social support could encourage them to be active following PR, from whom, through what medium, and how often e.g. face to face, online, or a mixture of the two.

Role of the lay volunteer

Lay volunteers should be provided with more freedom in the messages they choose to send to patients. Prior to a future trial, researchers should emphasise that the lay volunteers have flexibility to send any appropriate messages to the group of participants. However, to ensure that patients across the groups receive similar levels of support, training is necessary before the delivery of the intervention, whereby lay volunteers agree on the type and level of support that they will provide to patients. As reported in the focus group with WhatsApp Leaders (Chapter 5), connection of the lay volunteers, for example through social networking, was a

suggested method to improve their confidence in their role as a lay volunteer. Finally, the research team should provide more time to recruit the lay volunteers prior to the delivery of the intervention.

Table 7:1: Modifications of the intervention, outlining the elements of the intervention to be continued, added to, or removed prior to a definitive trial

Continuation	Addition	Removal
Use of pedometers and step diaries to measure and record patients' daily steps and to promote patients' PA	Step count goal setting, initiated by a HCP during PR and supported following PR via monthly video calls with a HCP over Facebook	Replacement of the Yamax pedometer (CW700/701 model) with a wrist worn pedometer.
Provision of the Nokia 1 smartphone for patients with restricted access to social networking (e.g. patients who do not own a phone, tablet or computer)	Option for patients to use their personal devices (e.g. mobile phone and step counter)	
Use of social networking to maintain peer support following PR	Use of Facebook as an alternative social networking application to WhatsApp, including addition to an overarching Facebook group (involving all patients in the IG) and subgroups to maintain connection with fellow PR graduates	Removal of WhatsApp as the social networking application to connect patients following PR
	Family and partner involvement in social networking and step count goals	
Lay volunteers to send regular messages to patients following PR	Flexibility for lay volunteers to choose the messages sent to the patient group based on a group training session prior to the delivery of the intervention	Removal of the WhatsApp checklists
Involvement of lay volunteers to support and promote patients' PA following PR	Face to face support with peers and lay volunteers to supplement social networking Connection of the lay volunteers via Facebook to support each other to deliver the intervention	
Support from HCPs during PR to educate and familiarise patients with the intervention components	Maintenance of support from HCPs following PR	

7.5 Modifications to the research procedures

As reported above, the results from Chapter 5 outlined that the research procedures involved in the feasibility study were acceptable and feasible for a future trial. However, the results of the feasibility study and process evaluation highlighted various methods to improve and increase the acceptability and feasibility of these procedures. The following text outlines the aspects of the research procedures that should be continued and aspects that should be modified. The recommended modifications to the research procedures relate to the inclusivity of the trial for wider respiratory conditions; the introduction of the intervention and the delivery of study information to patients; methods to accommodate patients' comfort and convenience, and alternative methods to measure intervention fidelity and engagement, as outlined in **Table 7:2**.

Inclusivity of the study

A recommended modification to the trial is to recruit all patients with lung conditions, not limited to patients with a diagnosis of COPD, as stakeholders believed this was important (Chapter 5). A main component of the intervention was to facilitate social support among patients following PR. The results of the feasibility study identified that the exclusive recruitment of patients with a diagnosis of COPD inadvertently restricted existing social groups in PR to remain in contact following PR (Chapter 5). Other lung conditions, such as Bronchiectasis and Pulmonary Fibrosis present similar symptoms to COPD, such as coughing and breathlessness[362], and these conditions often overlap, but they are separate conditions to COPD. Literature outlines the beneficial impact that PR has on patients' short-term exercise capacity and disease specific QoL.[363,364] However, there is relatively limited research in the long-term maintenance of PA following PR in these conditions[365], and patients may report different facilitators and barriers to PA following PR, as well as differences in their acceptability of the intervention and research procedures. For example, competing demands was a reported theme in this study (Chapter 5 and 6), though patients with Bronchiectasis often have an even higher treatment burden due to airway clearance regimes.[362] Though inclusion of non-COPD patients in the trial is an important modification to the trial, it is possible that unique facilitators and barriers of PA will be reported for those with different

lung conditions in the definitive trial. It is therefore important for the differences in lung conditions to be reported and to outline any differences between clinical outcomes between the conditions. However, irrespective of any clinical differences in the lung conditions, all patients contribute to the friendships and peer support provided throughout PR. Therefore, it is important to maintain these groups as much as possible.

Introduction of the intervention and the delivery of study information to patients

Patients reported limited familiarity and understanding of the intervention components, particularly the phone and WhatsApp, during the intervention (Chapter 5). This was attributed to limited confidence in navigating these devices, and limited time for patients to familiarise themselves with the intervention, particularly if patients had low PR attendance due to health concerns and other responsibilities (Chapter 5 and 6). A recommended modification for the trial is to provide study information earlier during PR, and for HCPs to provide brief reminders to patients throughout PR, a method which was supported by all stakeholders in Chapter 5.

Methods to accommodate patients' comfort and convenience

Patients should also have the flexibility to wear the accelerometer on their wrist, rather than their waist. As reported above, a recommended modification to the trial is to provide patients with wrist worn pedometer, rather than the clip-on pedometer (Yamax CW700/701 model) used in this intervention. However, the pedometer used in this feasibility study represents a method to accurately record daily steps to the standard of the accelerometer (wGT3X-BT) (Chapter 5). Therefore, the pedometer should be an alternative primary outcome measure for patients if they refuse to wear the accelerometer. Previous recommendations have outlined that triaxial accelerometers, such as the accelerometer used in this study, are the optimal outcome measures for PA in patients with COPD.[53] However, the results identified that the pedometer and accelerometer used in this study counted similar daily steps (Chapter 5), which may suggest that the two measures are a valid tool in measuring patients' daily steps. The flexibility for patients to wear the pedometer would potentially increase the number of valid activity measurements, thus increase the validity of the results. Nonetheless, as the accelerometer has been validated and is considered the most reliable PA outcome measure[53,72], this measure should be used in future trials when possible.

To gather more feedback on the mechanisms of the intervention from harder to reach subsets, a process evaluation of the trial should provide patients with less time-consuming methods to provide feedback of their experiences of the trial. In addition to conducting semi-structured interviews, short surveys which identify patients' numerical ratings of the intervention and research procedures, should be provided to patients. Similarly, surveys which map individuals' capability, opportunity and motivation to participant in the target behaviour (PA), as used in previous research[366,367], would also facilitate the research team's understanding of the potential mechanisms of the trial, and the factors that impact patients' PA.

Measures of intervention fidelity and engagement

A method to increase the fidelity of the intervention was to provide WhatsApp leaders with checklists (Chapter 3), however, WhatsApp leaders did not use these, and they were time consuming and not considered necessary (Chapter 5). The definitive trial should be as convenient for lay volunteers as possible, thus checklists such as these will not be provided. Alternatively, lay volunteers should continue to be encouraged to send monthly exports of the conversations with participants, as this is less time consuming.

During the intervention, it was challenging to identify patients' engagement in social networking, as it was not possible to record how often patients read the messages sent by the WhatsApp leader (Chapter 5). In a future trial, to identify patients' intervention engagement in social networking and the step diary, researchers should collect data at various stages throughout the intervention to measure their engagement in the intervention, similar to previous studies[193,321]. Furthermore, it was also challenging to report patients' engagement in the step diary(Chapter 5). As some participants did not return their step diary at 52 weeks, it was challenging to measure patients engagement in this intervention component, therefore a copy of patients' step diary should be collected at the 12-week follow-up visit.[248,306]

Physical activity outcome measures

The primary PA outcome of the intervention, mean daily steps (Chapter 5), should remain the same in the definitive trial, as daily steps was connected to the intervention component (pedometer and step diary) and supported by previous research which states that steps are a common outcome measure which is readily interpretable.[53] The secondary PA and health outcome measures included in this study should remain in the definitive trial, as the results in

this study outlined interesting patterns of SB, LPA and MVPA throughout the study period and previous literature has outlined the importance of investigating these patterns.[82–78] Additional outcomes to measure intervention engagement and fidelity are defined in the text above, and should also be included in the definitive trial, as reported in **Table 7:2**.

Table 7:2: Modifications of the research procedures, outlining the continuation or addition of the research procedures prior to the definitive trial

Continuation	Addition
Lay volunteers to continue to send monthly exports of the conversations with participants to measure intervention fidelity	
Promotion of peer support following PR with fellow PR graduates	Increase the inclusivity of the study: recruit all patients from PR i.e. other lung conditions (e.g. Bronchiectasis and Pulmonary Fibrosis), not limited to COPD
Introduction of the intervention during PR; inclusion of a familiarity period	Earlier introduction of the intervention to patients during PR from HCPs
Measurement of patients' mean daily steps as the primary PA outcome of the intervention	Provide patients with options to measure their daily steps for the primary PA outcome of the study: e.g. accelerometer worn on the wrist or to wear the Yamax pedometer (CW700/701 model)
Measurement of the secondary outcomes measured in the feasibility study: time spent in SB, LPA and MVPA; disease specific quality of life (CRQ); anxiety and depression (HADS); and patient reported difficulty and amount of PA in addition to objective measurement (PROactive)	
Interviews with patients and focus groups with lay volunteers and HCPs to understand their acceptability of the intervention and research procedures	Provide patients with brief surveys to measure their experiences of the intervention and the COM-B factors[145] which impacted their PA following PR
Measurement of patient engagement in the intervention components via collection of the step diary and measurement of messages sent over social networking	Collection of patients' step diaries at 12 weeks in addition to collection at 52 weeks and measurement of patient engagement in the intervention via brief surveys

7.1 Future directions of the study ahead of a definitive trial

In moving forward with the modification of the intervention and research procedures, the results from the feasibility study should be shared with all stakeholders, to understand whether the recommendations and conclusions within this thesis reflect their views. As reported in previous chapters above, it is important to identify a wide range of individuals with COPD to contribute to the modification of the trial. All patients in the feasibility study who confirmed their interest in the findings will be sent a copy of the results and all patients will be invited to share their opinions of the results, hence widening the sample from which feedback is sought. To do this, patients will be invited to return written feedback.

Furthermore, to facilitate further communication with different stakeholders in this study, patients with all lung conditions, lay volunteers and HCPs will be invited to attend an open stakeholder event, to encourage discussion surrounding the acceptability and feasibility of the recommended modifications to the intervention and research procedures.

Based on the recommended modifications to the intervention and research procedures, the study requires a revision period prior to the definitive trial. A revision period represents an important element in the development of a definitive trial and is recommended by the MRC.[1] This would enable the stakeholders to examine the practicalities of the recommended modifications, such as facilitating face-to-face social support in addition to social networking alone, and identifying an acceptable wrist worn pedometer.

Further modification of the trial should be mapped onto the BCW, and the associated behavioural model (COM-B)[2], as this framework provides a comprehensive, systematic, and transparent process in the development and evaluation of an intervention.[2] The COM-B model is appropriate in this study as the model accounts for a wide range of behavioural sources that impact behaviour, such as those identified in this study, compared to previous behavioural models.[3,4]

Following stakeholders' consensus on the modification of the intervention and research procedures (Chapter 5), it is prudent to conduct small scale pilot studies to test the feasibility and acceptability of the intervention modifications.[1,6] These small-scale pilot studies would inform the training and support that patients may need to become familiar with aspects of the intervention, for example with Facebook.

For the design of a definitive trial, it may be appropriate for the sample size to be based on the current estimate of MCID for daily steps in COPD (350-1100).[7] To detect a between group mean difference of 350 daily steps (lower limit of the MCID range)/ 1357 (SD based on Chapter 5) with 80% power and 5% level of significance, 236 participants are needed per arm. The feasibility study (Chapter 5) in thesis provided further parameters that could help to inform a sample size calculation of a 52-week definitive cluster randomised trial. Findings revealed an average cluster size of 5 patients at baseline, intra-cluster correlation coefficient (ICC) for daily steps of 0.58 and a study attrition rate of 35%. To account for clustering by pulmonary rehabilitation programme (ICC = 0.58; cluster size = 5)

and 35% attrition, the required sample of a definitive cluster randomised trial would be 1058 per arm. There were approximately 326 patients in LCHS who completed PR in 2018-2019, in 44 programmes. Considering that the consent rate in the feasibility study (Chapter 5) was 55%, the definitive trial would need to recruit PR sites beyond Lincolnshire.

Previous literature, however, has suggested that estimates of sample sizes for definitive trials based on feasibility studies can lead to significant over or underestimation.[8,9] This is because feasibility studies are usually too small to inform the parameters (e.g. ICC and recruitment rates) needed to estimate the sample size for a cluster RCT. It has been considered as more appropriate to calculate the sample size based on the ICC reported in previous larger scale trials in a related field of research.[8] However, there is only one recently reported cluster RCT which aims to promote PA in participants with COPD[10], which reported an ICC of 0.005. A sample size calculation based on this figure would significantly decrease the estimated sample size for the definitive trial, thus increase the feasibility of a definitive trial. Based on the limited accuracy of the ICCs in calculating the target sample size in a definitive trial[8], the decision to continue to a definitive trial should also be based on other factors, such as the feasibility and the acceptability of the intervention and research procedures, success of the intervention revision period, and stakeholder input. Nevertheless, to move forward with a future trial, it is important to continue to gather information (e.g. ICCs reported in upcoming cluster RCTs) to inform the parameters needed to estimate the sample size for the definitive trial.[8]

Surrounding areas, such as South Yorkshire and Nottinghamshire, could support the recruitment of PR programmes in a definitive trial. The identification of sites is dependent on various factors, particularly as the current health and economic climate has been severely impacted by COVID-19.[11] For example, access to funding, the workload of HCPs who deliver PR, and the number of patients who agree to participate in PR is not yet well understood. Consequently, the decision to conduct a definitive trial should be based on discussions with stakeholders, including patients with lung conditions, lay volunteers who were involved in the feasibility study and HCPs involved in the delivery of PR in Lincolnshire and HCPs involved in PR in the surrounding areas.

If stakeholders agree that it is feasible to deliver the definitive trial, an internal pilot study should be considered. The internal pilot study should consider progression criteria, i.e.

whether the trial should continue after a set period. For example, stakeholders would set a target recruitment rate per site per month[12], and regularly assess whether the sites can achieve a sufficient number of participants per cluster. This technique is in line with the traffic light system used in previous trials which has been used to reduce unnecessary funding in clinical trials.[13] The target recruitment rate would be dependent on discussion with stakeholders, and calculations based on the number of sites and the average number of patients who enrol and complete PR per month.

7.2 Implications for policy, practice, and research

Each study in this thesis identified implications for policy, practice, and future research. In fact, many of the implications identified in each chapter supported those in previous chapters throughout the thesis, hence these are reported together. The implications reported below extend beyond the aim of this thesis but need to be addressed in further research.

7.2.1 Policy and practice

As reported above, it was clear that HCPs involved in the delivery of PR have limited time to provide support for patients to be active following PR (Chapter 5). This was more apparent following the delivery of the intervention, as the duration of PR had been reduced during the study to 6 weeks (12 sessions), as opposed to 8 weeks (16 sessions). Though the results from the study highlighted the value that patients place on support from HCPs (Chapter 5). Providing HCPs with the opportunity to follow up with patients after PR is a modification of the intervention which may beneficially impact patient outcomes following PR. Theoretically, this would reduce the economic burden on the NHS, for example reduce the money spent on exacerbations and health concerns associated with physical inactivity. Hence the results from this study outlined the need for further resources for HCPs involved in the delivery of PR.

The results from the systematic review (Chapter 2) and the feasibility study (Chapter 5 and 6) outlined that barriers to patients' PA, particularly for the non-responders of the intervention (Chapter 6), were related to their social and physical opportunity to be active, and required further support to help them act on their positive intentions to maintain their activity. For example, patients had limited transport and funds which were necessary in attending PA follow on groups, and limited support from peers and HCPs following PR.

These results highlight the need for patients to be supported following PR, and for these barriers to be addressed, for example including, but not limited to, free transport and attendance for structured PA classes.

Successful self-management is integral to the physical health and QoL for all patients with chronic conditions[374], and theoretically results in a reduction of the burden on patients' social network and the economic burden on the NHS. As reported in the literature review (Chapter 1), there is a substantial gap between the economic burden of respiratory conditions, and the money spent on research directed at respiratory conditions.[19] This is also apparent in the funding directed at treating other chronic conditions, such as Stroke and Coronary Heart Disease.[375] The implications from this study outline that there is limited funding for the NHS to deliver beneficial support to help patients self-manage their chronic condition. Hence these findings outline the need for policy makers to direct funding for acceptable and feasible methods to improve self-management of chronic conditions.

Results from this thesis have important implications for HCPs with an interest in COPD management. The results from the systematic review of the facilitators and barriers of PA following PR in patients with COPD (Chapter 2), which are support by the results of the feasibility study (Chapter 5), supported the statement that there is no 'one size fits all' approach to managing behaviour change following PR.[254] It is therefore recommended that physiotherapists consider these factors when discussing individualised self-management plans on discharge from PR. The results from this thesis provide important information for clinicians and HCPs in these settings to consider when delivering long-term COPD management. Furthermore, Chapter 3 and 4 have provided an example of how the facilitators and barriers of PA following PR can be used to inform the development of an intervention which is relevant to the local setting.

The development and testing of the feasibility study (Chapters 3 and 4) was conducted prior to the outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and the COVID-19 pandemic, which resulted in mass social isolation and the shielding of people with lung diseases such as COPD.[376] The development of the intervention reported in this thesis was based on the factors which impacted patients' behaviour following PR. However, COVID-19 represents further barriers to PA following PR

in COPD than those that have been identified in this thesis (Chapter 2, 3, and 6), for example social isolation means that patients are further limited in how and where they can remain active.[371,377] Many PR providers have had no option but to deliver digital and remote PR. This thesis is particularly important, as it outlines a method on the development of an intervention to promote PA following PR which can also be delivered digitally and remotely (minus the addition of face to face contact with peers). This is important, as recent literature has outlined remote contact, such as social media, as the optimal method to support patients during COVID-19.[376–378] Furthermore, this intervention has the potential to improve and maintain patient outcomes following PR, and therefore reduce the growing economic burden on the NHS.[379] The implications from this thesis are not limited to management of COPD. Due to the importance of restricted physical social contact, all digital interventions are becoming increasingly important and socially desirable.[380] The results from this thesis outline a method to develop a digital, remote intervention which can be applied to other health promoting behaviours.

7.2.2 Research

Results from this thesis also have important implications for researchers. These relate to: reporting of qualitative studies (Chapter 2); reporting of an intervention (Chapter 5); behavioural framework and behaviour change theory (Chapters 1, 3, 5, 6); mixed methods research (Chapter 1, 4, 5 and 6); collaboration with stakeholders (Chapter 1, 3, 4 and 5); informing future interventions (Chapter 5); lay volunteers for future research (Chapter 5) and digital exclusion (Chapter 5).

Reporting of qualitative studies

The systematic review (Chapter 2) reported limitations within the reporting of previous qualitative studies and outlines recommendations for researchers. For example, researchers should strive to be transparent in the relationship between researcher and individual, clearly list the study limitations, and increase access to participant quotations. It would be prudent for future studies in the area to therefore adhere to the Consolidated Criteria for Reporting Qualitative Research[381] which facilitates critical appraisal and interpretation.

Reporting of an intervention

The results from the feasibility study outlined that patients had limited interaction in WhatsApp (Chapter 5). Though these findings alone suggest that patients are indifferent to peer support, results from the process evaluation outlined that patients highly valued social support, and that limited interaction in WhatsApp was attributed to the mode of delivery of the intervention. For example, patients had limited familiarity and confidence in using this social networking application, hence avoided using WhatsApp. It was therefore apparent that slight differences in the delivery of the intervention can potentially result in different patient outcomes. However, there is limited reporting of the mode of the delivery of previous interventions, including the provider of interventions, and the frequency and intensity of the interventions in previous literature.[145] Limited understanding of the procedures in previous interventions, and the active ingredients of interventions[145] is both detrimental for researchers interested in intervention development, and the patients/individuals who should benefit from the intervention. For example, limited evidence-based interventions are less likely to result in beneficial outcomes for patients[145] and are not a good use of resources from researchers.

It was challenging to compare the results of this intervention to previous literature. Researchers should clearly list the intervention development process to enable other researchers to identify the rationale of the intervention components, for example to highlight any context specific factors which impacted the development of the intervention. This would inform other researchers of the potential suitability of this intervention in other contexts.[145] Similarly, it is recommended that researchers clearly describe the intervention delivered in a study, for example to adhere to the Tidier checklist.[382] Researchers should also ensure that the level of patient engagement in the intervention components is reported in the studies.

Behavioural framework and behaviour change theory

Based on the reported strengths associated with using the BCW, and the included behaviour change model (COM-B), these are recommended tools for researchers in the development and evaluation of an intervention (Chapters 1, 3, 5, 6). In particular, the COM-B model is recommended for behaviours in which there is limited understanding of the determinants of behaviour and/or those who identify a broad range of behavioural sources which impact behaviour.[382]

Mixed methods research

Based on the reported strengths in adopting a mixed methods design (Chapter 1, 4, 5 and 6), it is recommended that future research should also adopt mixed methods designs, incorporating qualitative methods within RCTs to provide a more comprehensive evaluation of the factors influencing the efficacy of their interventions but also provide evidence as to how such interventions can be implemented in practice.

Collaboration with stakeholders

Based on the reported strengths associated with collaboration with stakeholders (Chapters 1, 3, 4 and 5), it is therefore recommended that researchers seek to include as many stakeholders as appropriate to guide the development of an intervention, as this would likely increase the acceptability and feasibility of the intervention and research procedures, but also reduce the time taken to decide upon the proposed intervention.

Informing future interventions

This thesis cannot inform other researchers on the type of intervention to deliver for different health promoting behaviours, across different populations, as the optimal intervention is dependent on the unique behavioural sources that impact patients' behaviour.[382] However, based on the results from the feasibility study (Chapter 5), it is unlikely that a 'one-size fits all' approach is possible in the development of a health promoting intervention, as behaviour change is a complex phenomenon, and is often determined by individual differences.[241] As such, dependent on the behavioural sources that are identified as important in behaviour, intervention developers should consider including a variety of BCTs which target various factors which may impact patients' behaviour. Patient preference should be prioritised in an intervention, for example patients should have the freedom to only engage in the intervention components that suit them.

However, researchers may decide to incorporate similar intervention components in the delivery of their intervention. Therefore, the results from the feasibility study (Chapter 5) which outline the successes and challenges in the delivery of these components are useful in the development of these interventions. Researchers should identify the modifications which are recommended in this trial and consider whether these modifications are appropriate in their study.

Lay volunteers in further research

Lay volunteers in this study reported that they were enthusiastic about supporting patients to be active following PR (Chapter 5), and previous literature has outlined patient preference of the inclusion of lay volunteers during PR.[189,383] Given the successes in the involvement of lay volunteers in the delivery of previous health promoting interventions[188,384] and the limited resources of HCPs during PR, further involvement from lay volunteers is a potential method to decrease pressure on the NHS. Further research should be directed at understanding the feasibility and acceptability of the inclusion of lay volunteers in health promoting services including, but not limited to, PR for COPD management.

Digital exclusion

As reported above, there is growing importance and application of digital and remote health care provision during COVID-19. Consequently, digital health literacy is also becoming more important, as this impacts patients' capability and opportunity to access digital health services. According to previous research, older adults (65+) are less likely to use the internet[385], hence placing COPD patients at increased risk of digital exclusion. The results from the feasibility study implied that many COPD patients who enrolled onto the intervention did not regularly use social media (Chapter 5). This was mainly due to barriers such as limited familiarity and confidence in navigating social networking, but also due to internet access and connection issues. These results provide further evidence of potential digital exclusion, and the possibility that COPD patients are inadvertently excluded from health services. Prior to COVID-19, there were mixed views on the appropriateness of digital interventions, such as social networking applications, for patients with COPD and/or older individuals[332–334,336,386] (Chapter 5). Evidence suggested that there has been a growth in the use of internet use for older adults[333], and that internet and social media were becoming more popular with people with COPD.[336] However, it is still not clear the extent to which patients would choose to use technologies which support digital interventions.[385] These findings imply that more research should be directed at understanding the digital health literacy of patients, and methods to support the inclusivity of patients who may struggle to access digital health services.

7.3 Conclusion

The aim of this thesis was to develop and test the feasibility of an intervention to promote PA following PR in patients with COPD. This thesis addressed the gaps in previous literature and

adopted a step wise approach in the development and feasibility testing of the intervention. Overall, the results outlined that the intervention was considered acceptable and feasible for a definitive trial, and data supports the likely impact of the intervention on patients' PA. Modifications are required to optimise the acceptability and feasibility of the intervention and research procedures prior to the definitive trial, which are possible during an intervention revision period. The results provided an original contribution to knowledge and outlined implications for policy, practice, and research relevant for stakeholders interested in behaviour change in both COPD and non-COPD fields.

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Appendices

Appendix A Example of a search strategy used in MEDLINE

Medline	Search term	Field
1	(MH"Lung disease, Obstructive")	MH
2	(MH "Pulmonary Disease, Chronic Obstructive+")	MH (Explode)
3	“COPD”	TX
4	“COAD”	TX
5	“COBD”	TX
6	“AECB”	TX
7	“Emphysem*”	TX
8	“Chronic N3 bronchit*”	TX
9	“Obstruct* N3 airflow*” OR “airway*” OR	TI, AB
10	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9	
11	Exercise	(MH "Exercise+")
12	Exercise movement techniques	(MH "Exercise Movement Techniques+")
13	Physical and rehabilitation medicine	(MH "Physical and Rehabilitation Medicine+")
14	(MH ”Physical fitness”)	MH
15	Exercise therapy	(MH "Exercise Therapy+")
16	Activities of daily living	(MH "Activities of Daily Living+")
17	Self-care	(MH "Self Care+")
18	Physical endurance	(MH "Physical Endurance+")
19	Health behavior	(MH "Health Behavior+")
20	Health N3 behav*	TX
21	Physical* N3 activ*	TX
22	Physical* N3 rehabilitat*	TX
23	Physical* N3 mobil*	TX
24	Physical* N3 fit*	TX
25	Endurance	TX
26	maintain* N3 exercis*	TI/AB
27	maintain N3 activ*	TI/AB
28	“Program*” or “training”	TI/AB
29	11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR	
30	Facilitat*	TI/AB
31	Enabl*	TI/AB
32	Barrier*	TI/AB
33	Hinder*	TI/AB
34	Overcom*	TI/AB
35	Promot*	TI/AB
36	Limit*	TI
37	Support*	TI
38	30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR	
39	Qualitative research	(MH "Qualitative Research+")
40	Interview	(MH "Interview")
41	Focus groups	(MH "Focus Groups")
42	Qualitativ*	TI, AB
43	Interview*	TI,AB
44	Mix* N3 method*	TX
45	Process* N3 eval*	TX
46	Program* N3 eval*	TX

47	Method* N3 triangulat*	TX
48	Focus group*	TX
49	Ethnograph*	TX
50	Phenomenol*	TX
51	Ground* N3 theor*	TX
52	Discourse analys*	TX
53	Purposive	TX
54	Narrative*	TX
55	Content* N3 analys*	TX
56	thematic	TX
57	Verbatim	TX
58	Theme*	TX
59	Belief*	TI
60	39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR	
61	10 AND 29 AND 38 AND 60	

Appendix B A full list of excluded studies, together with reasons for exclusion

	Study reference	Exclusion based on: Study design, Population, Outcome
1	Apps et al., 2013	Population: History of PR participation not reported (Conference abstract)
2	Arnold, Bruton, & Ellis-Hill, 2006	Population: Not all individuals had completed PR Outcome: Focus on experiences during PR only
3	Beauchamp et al	Data already included in review.
4	Burge et al., 2013	Population: COPD patients could not be distinguished from other participants. Outcome: No discussion of PA.
5	Caress, Chalmers, & Luker, 2010	Population: Not all individuals had completed PR
6	De Sousa Pinto et al., 2013	Study design: Systematic review
7	Desveaux, Goldstein, Mathur, & Brooks, 2016	Outcome: Quantitative data only
8	Fabienne Dobbels et al., 2014	Population: History of PR not reported.
9	Fabienne Dobbels et al., 2011	Population: History of PR not reported. (Conference abstract)
10	Halding, Wahl, & Heggdal, 2010	Outcomes: No discussion of PA.
11	Hamir et al., 2012	Outcome: No discussion of the barriers and facilitators to PA.
12	Hardy & Coe, 2011	Outcome: No discussion of the barriers and facilitators to PA (Conference abstract)
13	Hartman, ten Hacken, Boezen, & de Greef, 2013	Outcomes: No discussion of PA
14	Lahham et al., 2015	Outcome: Focus on experiences during PR only

	Study reference	Exclusion based on: Study design, Population, Outcome
15	Langley-Johnson et al., 2010	Conference abstract without access to primary data Mentioned in the discussion
16	Larson, Fernandez, & Vos, 2015	Population: History of participation in PR not reported
17	Leidy & Haase, 1996	Population: History of participation in PR not reported
18	Matheson et al., 2010	Conference abstract without access to primary data Mentioned in the discussion
19	Meis et al., 2014	Population: Not completed PR
20	Nonoyama, Holmes, King, & Brooks, 2010	Population: No distinction between participants with COPD and participants with Asthma. Outcome: Quantitative data only
21	O'Connor et al., 2009	Population: No participation in PR
22	O'Shea, Taylor, & Paratz, 2007	Population: No participation in PR
23	Pillard, 2014	Outcome: Quantitative data only
24	Poureslami et al., 2017	Population: Not all individuals had completed PR
25	Small et al., 2012	Population: No history of participation in PR
26	Thomas, Williams, & Stern, 2015	Population: Not exclusively COPD patients Outcome: No discussion of PA (Conference abstract)
27	Thorpe, Kumar, & Johnston, 2014	Population: Not participated in PR
28	Valenson et al., 2016	Population Not participated in PR
29	Verwey et al., 2014	Population: No history of participation in PR
30	Walters et al., 2012	Population: Not participated in PR
31	Wang et al., 2013	Population: Not all individuals had completed PR

	Study reference	Exclusion based on: Study design, Population, Outcome
32	Williams, Hardinge, Ryan, & Farmer, 2014	Population: Not all individuals had completed PR
33	Wong et al., 2014	Study design: Quantitative data only
34	Wortz et al., 2012	Population: No history of PR completion
35	Yang & Chen, 2005	Outcome: Quantitative data only
36	Yorke et al., 2012	Conference poster: Restricted access to primary data
37	Young et al., 2014	Population: History of PR not reported
38	Zanaboni et al., 2016	Population: Not participated in PR

Appendix C Characteristics of Included studies

Author, year, country	Design	Qualitative data collection methods; setting; analytical approach	Sample size (n)	Gender (M/F)	Age (years)	COPD characteristics	Pulmonary rehabilitation setting; duration; intensity	Data collection context: duration after pulmonary rehabilitation; participation in usual care or intervention; duration/intensity of the intervention
Camp et al (2000), Canada [215]	Mixed methods	Semi-structured interview; participants home; *established guidelines for data analysis.	7	M2/F5	Range: 82-86	Severe to moderately severe; (FEV1 % predicted mean (SD), 43 (14)), range = 23-69; Smoking (pack-years): mean (SD) 37 (21), range= 0- 80	Hospital based/ In-patient PR; 5 weeks; 3 x weekly sessions	<2 weeks; Usual care
Desveaux (2014), Canada [214]	Qualitative	Focus groups; Setting: NR; Thematic content analysis	12	M6/F6	Range: 52-85	Severe; (FEV1 % predicted mean (SD): 44 (18)); MRC: Median = 3	Hospital based PR; Inpatient PR: 6 weeks Outpatient PR: 12 weeks;	>6 months; Individuals were participating in community exercise maintenance programme; 12 months/ 2 x 1 hour sessions per week
Desveaux (2017), Canada [220]	Qualitative	Semi-structured interviews; Participants rehabilitation hospital; Deductive thematic analysis	6*	M3/F3	Range: 65-74	**Number of comorbidities range: 1-6*	Hospital-based PR	>3 months; Usual care

Appendix C Characteristics of Included studies

Author, year, country	Design	Qualitative data collection methods; setting; analytical approach	Sample size (n)	Gender (M/F)	Age (years)	COPD characteristics	Pulmonary rehabilitation setting; duration; intensity	Data collection context: duration after pulmonary rehabilitation; participation in usual care or intervention; duration/intensity of the intervention
Halding (2012) Norway	Qualitative	Semi-structured Interviews; Participants' homes or at the researcher's office; Thematic analysis	T1= 18, T2 = 15*	M13/F5	Range: 52-81	Mild to severe; Smoking status (n): Former = 11, Current = 5	Hospital based PR; Outpatient PR programme; 12-week; (1 day/week)	T1 = <2 months, T2 = <12 months; Usual care
Hoaas * (2016) Norway	Mixed methods	Focus group; Rehabilitation centre; Thematic analysis; Systematic text condensation	10	M5/F5	Mean: 55.2 years	Moderate to severe Oxygen users (n): 3	Inpatient programme; 4-weeks; (5 days/week)	T1: <18 months T2: <30 months T3: *<42 months Tele-rehabilitation Intervention; 24 months/3 x 30 minutes per week
Hogg (2012) England	Qualitative	Focus groups; Community hospital; Informed by Grounded theory	16 Group A:9; Group B:7*	Group A: M4/F5; Group B: M5/F2	Mean (SD): Group A: 71 (10); Group B: 67 (11)	Mild to severe (FEV1 % predicted mean (SD): Group A: 67 (16); Group B: 59 (17)); MRC: mean (SD): Group A: 2.1 (.5); Group B: 2.3 (.4)	Outpatient programme; 8-week; Intensity: NR	<24 months; Usual care*

Appendix C Characteristics of Included studies

Author, year, country	Design	Qualitative data collection methods; setting; analytical approach	Sample size (n)	Gender (M/F)	Age (years)	COPD characteristics	Pulmonary rehabilitation setting; duration; intensity	Data collection context: duration after pulmonary rehabilitation; participation in usual care or intervention; duration/intensity of the intervention
Lewis and Cramp (2010) England	Qualitative	Focus groups; Setting: NR; Inductive thematic analysis	6	M1/F5	Mean: 69 .3 years; Range: 61-83	Moderate to very severe; MRC: 2 (n= 5) 4 (n=1)	NR	<48 months; Usual care
Norweg (2008) USA	Qualitative	Semi-structured interviews; Interviews at home or rehabilitation centre; Informed by grounded theory	4	M1/F3	Mean: 73; Range: 69-80	Disease length (years): 0.25 -20; Oxygen users (n): 1	Outpatient programme; 7.5 weeks*; 2 x week	6 - 11 months; Usual care
Rabinowitz (1998) USA	Qualitative	Open ended Interviews; *Interviews at participants homes;* Informed by Phenomenological *approach*	8	M3/F5	Mean: 64; Range: 45-75;	Smoking status (n): had a smoking history (7), current smoker (1); Oxygen users (n): kept oxygen in the home (8), continuously used oxygen*	In-patient programme; 3 weeks; (3 x 1hr daily sessions)	<18 months; Usual care

Appendix C Characteristics of Included studies

Author, year, country	Design	Qualitative data collection methods; setting; analytical approach	Sample size (n)	Gender (M/F)	Age (years)	COPD characteristics	Pulmonary rehabilitation setting; duration; intensity	Data collection context: duration after pulmonary rehabilitation; participation in usual care or intervention; duration/intensity of the intervention
Rodgers (2007) England	Qualitative	Focus groups; Setting: NR; Template analysis	23	M14/F9	Range: 63-70 years	FEV1 in litres per minute: mean (SD) [% predicted] (range between focus groups 1-4): 0.87 (0.28) [40%] - 1.26 (0.63) [49%]; MRC median: (range between focus groups 1-4): 3-4	Outpatient programme; 6 weeks; 2 x week	<4 months; Usual care
Stewart (2014) Netherlands	Qualitative	Semi-structured interviews; Setting: assessment centre or patients' home; Qualitative content analysis	22	M14/F8	Mean (SD) 63.5 (7.8); Range: 45-78,	Mild to very severe; FEV1, % predicted: Mean (SD): 52.5 (14.4); range 25- 90; Disease length (years) mean (SD): 5 (3.9); range: 0-13; MRC: mean (SD) 2.9 (1.3); range 1-5 .	Outpatient programme; 4 months; Intensity: NR	<8-11 months; Participants were involved in an ongoing nutritional supplement trial during supervised exercise training*
Sundfor (2011) (Norway)	Qualitative	Semi-structured Interviews; Participants homes; Systematic text condensation,	6	M2/F4	Mean: 64.5, Range: 55 - 75	Moderate to severe; Disease length (years): 0.5 – 20	Hospital programme; 4 weeks; 1+ session daily.	Between 4-6 months; Usual care

Appendix C Characteristics of Included studies

Author, year, country	Design	Qualitative data collection methods; setting; analytical approach	Sample size (n)	Gender (M/F)	Age (years)	COPD characteristics	Pulmonary rehabilitation setting; duration; intensity	Data collection context: duration after pulmonary rehabilitation; participation in usual care or intervention; duration/intensity of the intervention
Williams (2010) England	Qualitative	Semi-structured Interviews; Participants homes; Inductive approach informed by Grounded theory methods	9	M6/F3	Range: 54-84	Moderate to very severe; Disease length range (years): <5 - >10; Oxygen users (n): 1	Outpatient 8 weeks; 2 x weekly	T0: interview pre-PR, T1: interview post-PR; 1-2 weeks; Usual care
Zakrisson (2014) Sweden	Qualitative	Semi-structured interviews; PHC and participants homes; Qualitative content analysis	20	M13/F7	Mean (SD): 68 (4.1); Range: 62–78	Moderate to severe; FEV1 (% of predicted): Mean (SD): 46 (10); range: 27–67 Smoking status (n): Current smoker (4)	PHC; 6 weeks; 2hrs per week	< 36 months* Usual care

Appendix C Characteristics of Included studies

Author, year, country	Design	Qualitative data collection methods; setting; analytical approach	Sample size (n)	Gender (M/F)	Age (years)	COPD characteristics	Pulmonary rehabilitation setting; duration; intensity	Data collection context: duration after pulmonary rehabilitation; participation in usual care or intervention; duration/intensity of the intervention

n = number; COPD = chronic obstructive pulmonary disease; PR = pulmonary rehabilitation; M/F = male/female; FEV1 (% predicted) = percentage of forced expiration volume in one second divided by the average FEV1% in the population for any person of similar age, sex and body composition; SD = standard deviation; NR = not reported; PHC = primary health care; GOLD stages = global initiative for chronic obstructive lung disease stages; MRC dyspnoea = medical research council dyspnoea scale; T1/T2 = time 1/time 2 etc;

*Camp [215]: Analytical approach was: "established guidelines for data analysis."; *Desveaux [220]: This study involved participants with heart failure but only the COPD subgroup was reported in this table; *Halding [222]: two people did not provide follow up interviews because of death, and one could not be reached; *Hoaas[211,212]: T3 refers to a second paper which followed up the same participants' experiences of PA following tele-rehabilitation;*Hogg[192]: Using records held by the pulmonary rehabilitation team, eligible participants were placed into two groups (Group A: had received input from pulmonary rehabilitation staff to assist with ongoing exercise following completion of the pulmonary rehabilitation course; Group B: had not received any input from pulmonary rehabilitation staff regarding ongoing exercise); *Norweg[230]: estimated duration of PR programme, based on "six, 1-hour weekly sessions of occupational therapy" and "15 sessions held twice weekly" of the exercise training programme;* Rabinowitz[232]: All participants had oxygen in the home which was used as needed, mainly upon exertion, however only participant used oxygen continuously; *Stewart[225]: individuals were involved in an "ongoing NUTRAIN trial investigating the efficacy of nutritional supplementation during 4 months of supervised exercise training on physical performance and cardio-metabolic risk, in a placebo-controlled design."; Zakrisson [233] data collection timescale post-PR estimated from reported information: PR during: 2007-2008, Interviews in spring 2009.

Appendix D Picture of an Alcatel Pixi 4

Appendix E Brief script read by the HCPs to inform patients (intervention and control group) of the research study

Script: Intervention Group

Title of Project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD)

We, at the Lincolnshire Community Health Services NHS Trust, are currently working with the Lincoln Institute for Health at the University of Lincoln.
We will be inviting all people diagnosed with COPD to take part in a research study, which is part of an educational project at the University. If you agree to take part, you will be provided with additional support to remain active after the pulmonary rehabilitation programme and you will be asked to provide information about your physical activity and health status.
This information sheet describes the study and research procedures. Participation is entirely voluntary. The research team from the University will attend pulmonary rehabilitation next week to talk to you about this study and to provide you with a consent form which you will be asked to complete if you agree to participate.
The research team's contact details are listed at the end of this sheet. If you have any questions before next week, please contact the research team on the contact details provided.

Script: Control Group

Title of Project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD)

We, at the Lincolnshire Community Health Services NHS Trust, are currently working with the Lincoln Institute for Health at the University of Lincoln.

We will be inviting all people diagnosed with COPD to take part in a research study, which is part of an educational project at the University. If you agree to take part, you will be asked to provide information about your physical activity and health status.

This information sheet describes the study and research procedures. Participation is entirely voluntary. The research team from the University will attend pulmonary rehabilitation next week to talk to you about this study and to provide you with a consent form which you will be asked to complete if you agree to participate.

The research team's contact details are listed at the end of this sheet. If you have any questions before next week, please contact the research team on the contact details provided.

Appendix F PowerPoint slides the research team delivered to patients in the educational talk

01/07/2020

NHS Lincolnshire Community Health Services NHS Trust

IRAS project ID: 229697
REC reference: 18/SC/0199

University of Lincoln Lincoln Institute for Health

Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD)

Intervention slides: Version 2.5: 02.07.2018

1

Introduction

- Physical activity is associated with benefits in both physical and psychological well-being.
- Pulmonary rehabilitation results in reduced breathlessness and increased walking capacity and quality of life.
- However, it does not always result in increased daily physical activity levels in the long-term.

2

Why are we doing this study?

Research suggests that people find it easier to stay active after pulmonary rehabilitation if they:

- Stay connected with other people who have completed pulmonary rehabilitation
- Are able to see their physical activity progress
- Know about the opportunities to stay active e.g. local activities such as walking groups, Tai Chi, etc.

3

During this study

- We hope to motivate you to keep active after pulmonary rehabilitation.
- We aim to measure and understand your physical activity levels and health status after pulmonary rehabilitation.
- To do this, we will conduct a study for 12 months.

4

Today

We will:

- Introduce you to this study which aims to keep you active after pulmonary rehabilitation.
- Show you how to use each part of the study: pedometer, step diary, mobile phone and WhatsApp.
- Give you time to ask questions.

5

Pedometer

Research suggests people with COPD can benefit from being active and doing more steps.

Pedometers show:

- How many steps you have walked each day.
- Any progress in your physical activity levels.

Pedometers can:

- Motivate you to keep active after pulmonary rehabilitation.

6

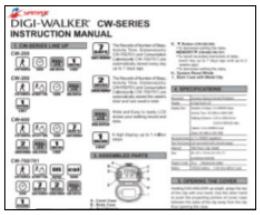
Pedometer: number of steps in different activities

Physical activity	Steps per hour
Golf	4,200
Gardening (low intensity)	4,380
Housework, general, vacuuming	5,400
Tai Chi	480

7

Questions?

- Pedometer manual



8

Step diary

A step diary can:

- Help you keep track of your progress after pulmonary rehabilitation.
- Motivate you to keep active after pulmonary rehabilitation.

9

Step diary

Date	Number of steps	Comments (optional)
01/04/2018	2606	Felt motivated.
02/04/2018	.....	Felt tired so I did less steps.
03/04/2018	.....	Cycled today. Pedometer did not register any steps.

Note: You might do other activities that the pedometer will not register.

10

Step diary: instructions

- At the end of each day (before you go to bed), check the pedometer to see how many steps you have done.
- Record how many steps you have done in the diary.
- Write a brief comment about the number of steps you have done.

11

Step diary

- This diary is for you to review your progress.
- Try to record your steps every day.
- Do not worry if you forget to record your steps for a period of time.
- Keep using the step diary whenever you can.

12

Questions?

13

Mobile phone

- We will provide you with a mobile phone for 12 months.
- This is a 'Pay As You Go' phone.

14

WhatsApp

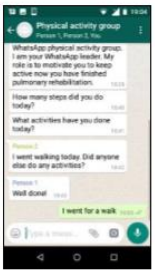
- This phone is installed with 'WhatsApp'.
- An application on your mobile phone.
- Free to use.

15

WhatsApp: what is it?

WhatsApp allows you to:

- Send and receive instant messages to other people.
- Stay in touch with other members involved in pulmonary rehabilitation after you have finished the programme.



16

WhatsApp: group chat

- You will be added to a group chat on WhatsApp.
- Populated by other members of pulmonary rehabilitation and a WhatsApp leader.

WhatsApp leader:

- A volunteer from a COPD support group.

17

WhatsApp: messages from the WhatsApp leader

The WhatsApp leader will send messages to:

- Encourage you to keep active following pulmonary rehabilitation.

18

WhatsApp: messages from the WhatsApp leader

These messages may include:

- Information about local activities in your area, for example....

- I have searched for local activities in your area. 'Walking groups, Tai Chi, Vitality...' will be held at...
- How do you feel about those options?

19

WhatsApp: messages from the WhatsApp leader

These messages may include:

- Reminders to monitor your physical activity levels, for example...

- How many steps did you do today?
- What activities have you done today?

20

WhatsApp: messages from the WhatsApp leader

These messages may include:

- Suggestions to form routines or habits to help you keep active, for example...

- Is anyone attending any physical activity classes this week? It might help to meet up with other people in this WhatsApp group so that you can support each other to be active. Please let other group members know if you would be interested in meeting up and being active together.

21

WhatsApp: group chat

- Participate in the group to a level that benefits you.
- Please respect all group members and act in a manner that is considered polite, friendly and helpful.

22

WhatsApp: practise

Today we will all:

- Practise using the phone
- Practise using WhatsApp

Please ask questions as we go along

23

WhatsApp: practise

Turn the phone on and off:

- Hold down the smaller button on the right-hand side of the phone for up to 5 seconds.
- Note: press this button to check if your phone is on.

24

WhatsApp: practise

- The message 'To start Android, enter your PIN' will appear
- Enter the passcode: **1234**
- Tap the tick button

25

WhatsApp: practise

- This screen shows that the phone is on, but it is locked.

26

WhatsApp: practise

To unlock the phone:

- Use your finger to swipe the centre of the screen up.

27

WhatsApp: practise

To unlock the phone:

- This screen will then show numbers.
- Enter the PIN: **1234**
- Press the tick button.

28

WhatsApp: practise

The home screen will then show.

To access WhatsApp:

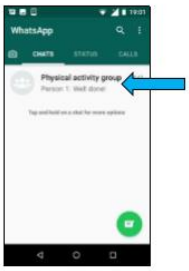
- Tap on the WhatsApp logo on the home screen.

29

WhatsApp: practise

To access the WhatsApp group chat:

- Tap on the 'Physical activity group'.

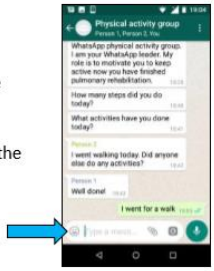


30

WhatsApp: practise

To write a message to the group:

- Tap on the white bar at the bottom of the page.

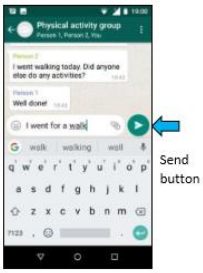


31

WhatsApp: practise

To write a message to the group:

- A keyboard will be displayed.
- Write your message using this keyboard.
- Press send when you are ready to send your message to the group.



32

WhatsApp: practise

To make the keyboard bigger:

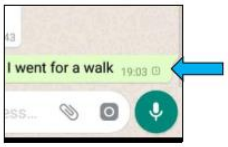
- Rotate the phone.

33

WhatsApp: practise

To check if the message has been sent:

- This symbol shows that the message has not been delivered.

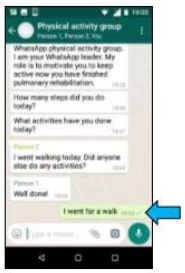


34

WhatsApp: practise

To check when the message has been sent:

- One grey tick next to the message will show when the message has been sent.

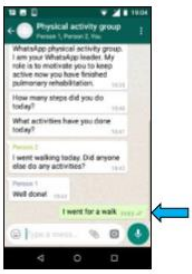


35

WhatsApp: practise

To check when the message has been sent:

- Two grey ticks next to the message will show when the message has been sent to everyone's phones.

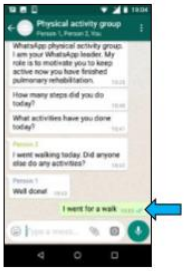


36

WhatsApp: practise

To check your message has been read:

- Two blue ticks will show when everyone in the group has read your message.

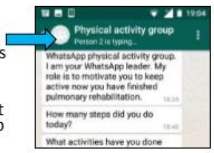


37

WhatsApp: practise

To know when someone is writing a message:

- A message will appear at the top of the WhatsApp group to show when someone is typing a message.
- For example, 'Person 2 is typing…..'



38

WhatsApp: practise

How to reach the home screen:

- Press the middle circular button on the bottom of the phone

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WhatsApp: practise

To know when someone has sent a message:

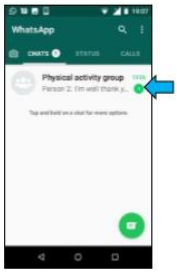
- A notification at the top of your screen will show when someone has written a message in the 'Physical activity group'.
- Your phone has also been set to buzz/beep when a message has been sent.

40

WhatsApp: practise

To know how many messages have been sent to the group:

- A number will also appear next to the 'Physical activity group' which will show how many messages have been sent to the group from other people since the last time you used the group chat.



41

WhatsApp: practise

To change the volume on the mobile phone:

- Use the long button on the right hand side of the phone (turn up and down)
- Or turn on silent

42

WhatsApp: practise

To charge the phone:

- Connect the charger to the mobile phone and plug this into a plug socket.
- 1 hour for the phone to completely charge.

43

WhatsApp: practise

To connect to the internet

44

What happens now?

45

WhatsApp: familiarisation period

- You and the WhatsApp leader are connected on WhatsApp.
- The WhatsApp leader will send you a message everyday before you are discharged from pulmonary rehabilitation.
- Try to reply to this message every day.
- This will help you become familiar with the phone and WhatsApp.
- Keep your phone with you when you have access to internet/broadband (at home)

46

Next week

- You will have chance to ask the research team any further questions at pulmonary rehabilitation.

47

After you have been discharged from pulmonary rehabilitation

- The WhatsApp leader will add you to the group chat.
- The WhatsApp leader will send a message to the group a minimum of 1-2 times a week for the first month.
- Use WhatsApp to a level that benefits you e.g. ask questions, reply to other peoples messages or congratulate others (it is up to you).

48

After you have been discharged from pulmonary rehabilitation

- You will be provided with a step diary.
- Try to wear the pedometer everyday.
- Try to record how many steps you have done everyday.

49

Questions?

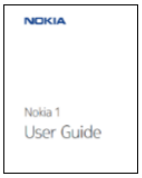
50

Further information: manuals

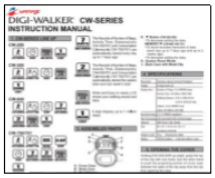
51

Further information

Phone manual and website



Pedometer manual



52

Your Health and Safety

- The WhatsApp leader is not medically or clinically trained and is not a member of the research team.
- If you have questions or concerns about your health, please contact your GP or other relevant healthcare services.

53

Problems and questions

Report to a member of the research team if you:

- Encounter any problems with the pedometer or mobile phone (for example the device is lost or broken).
- Wish to report any inappropriate comments on WhatsApp.
- Have any questions about the study, or your involvement in it, either now or in the future, please contact the research team.

54

Contact details: research team

Miss Hayley Robinson (Chief Investigator/PhD Student)
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Dr Arwel Jones (Academic Supervisor)
Lincoln Institute for Health, University of Lincoln, LN6 7TS
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Email: arjones@lincoln.ac.uk

55

Contact details: NHS research and development team

If you would like to speak to someone about the project who is not a member of the research team, contact:

Katy Ward (Research Governance Facilitator)
Tel: 01522 308808
Email: Katy.ward@lincs-chs.nhs.uk

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Appendix G Pictures of the intervention components

Nokia 1:

Appendix H Pedometer: Yamax CW700-CW701 Digi-walker

:

Lincolnshire Community Health Services NHS Trust

UNIVERSITY OF LINCOLN
LINCOLN INSTITUTE FOR HEALTH

Title of Project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD)

IRAS project ID: 229697
REC reference: 18/SC/0199
Participant identification number: Date:

Step Diary 1

Date	Number of steps	Comments (optional)

Title of project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary Disease (COPD)

Pedometer, Step Diary and WhatsApp manual

This leaflet will use the pedometer,

Device manual: Version

1: 21.03.2018

provide you with information and step diary and WhatsApp.

instructions on how to

Contents Page

Pedometer

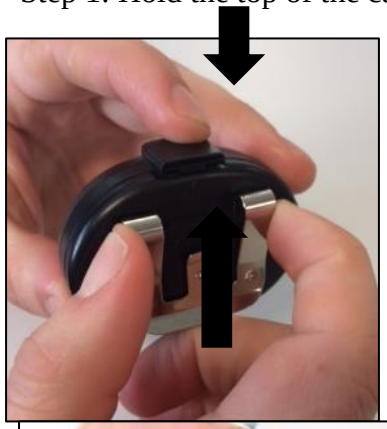
- Individuals with COPD have been shown to benefit from small improvements in the number of steps walked. For example, it was recently reported that an improvement in 600-1100 steps per day is associated with a meaningful reduction in hospital admissions for COPD patients.

- Pedometers are used to provide an indication of your daily activity levels by displaying your daily step count. The regular use of pedometers has been found to improve physical activity levels and quality of life in people with COPD.

- We hope that by using a pedometer to identify your daily steps, you will become motivated to keep active following pulmonary rehabilitation.

To open the pedometer:

Step 1: Hold the top of the case with one hand.



Step 2: Use the other hand to pull the silver clip down and away from the top of the case.

To view the display screen:

The display screen shows that this person has walked 2606 steps today.

Instructions

1. Clip the pedometer onto a piece of clothing
   (e.g. trouser pocket, waist belt, top of skirt).

2. Wear this device everyday (take off before sleep).

Step 1: pull the clip away from the case.

Step 2: attach the pedometer to your belt or on the waistband of your trousers/skirt using the clip.

Note:

- No activity monitor is completely accurate, they only give an indication of how active you are.

- Your stride length and walking pace can affect the number of steps you do. This means that the number of steps can vary between people even when they are doing the same activity.

- See the table below for the average number of steps you can do during different activities.

Average number of steps in different activities	
Physical activity	**Steps per hour**
Golf	4,200
Gardening (low intensity)	4,380
Housework, general, vacuuming	5,400
Tai chi	480

Step Diary

- It is understood that people enjoy recognising their progress during pulmonary rehabilitation. Recording your steps every day will help you identify any progress that you make after pulmonary rehabilitation.

- You have been provided with a step diary. We hope that the step diary will motivate you to keep active after pulmonary rehabilitation. This diary includes three columns: Date, Number of steps, Comments (optional). See below for an example.

- The pedometer shows that this person has done 2606 steps today

Example step diary		
Date	**Number of steps**	**Comments (optional)**
01/04/2018	2606	Felt motivated
02/04/2018	……	Felt tired so I did less steps.
03/04/2018	……	Cycled today. Pedometer did not register any steps.

Instructions

1. Use the pedometer to identify how many steps you complete every day and record this in the diary.

2. We recommend writing a brief comment about the number of steps you complete. This can help you identify the reason for any changes in the number of daily steps you do throughout the 12 months.

3. Aim to record your steps every day at the same time (preferably before you go to sleep). We recommend setting a daily alert to remind yourself to report your steps (e.g. on your phone or watch).

4. Recording your steps shouldn't take you more than 1-2 minutes.

Note:

- The number of steps you do in a day is only an indication of how active you are. You might do other activities such as swimming, cycling or upper body activities and the pedometer will not register this activity. It might be useful to record these activities in your step diary, so you can remember when you were active.

WhatsApp

- Research suggests that one of the main benefits of attending pulmonary rehabilitation is meeting and socialising with other people who have a lung condition.

- We have provided you with a phone, to allow you to stay in touch with other members involved in pulmonary rehabilitation once you have finished the programme. We hope this will help you keep active after the programme.

- You have been added to a group chat on "WhatsApp", which is populated by other members of pulmonary rehabilitation and led by a volunteer from a COPD support group (Breathe Easy). Their role is to encourage you to keep active after pulmonary rehabilitation.

- You will be able to send and receive instant messages to and from other people in this group chat. Any messages sent/received in this chat will be visible to all members of the group.

- The WhatsApp leader will send regular messages to the group. These messages will include information about local physical activity opportunities.

Note:

- WhatsApp uses the internet to send messages, meaning that it is free to use.
- The messages sent by the WhatsApp leader will be structured around guidelines written by the research team. However, you will still be encouraged to ask the WhatsApp leader any questions you may have.
- You are free to participate in the group to a level that benefits you. If you do not wish to send messages, that is completely fine.
- Respect all group members and act in a manner that is considered polite, friendly and helpful.
- Be patient with the phones as they can occasionally be slow. Wait up to 10 minutes to use your phone after you have turned it on, as it may need this time to load. Pop ups may appear on the phone but please ignore these.
- Please find the instructions on the next page.

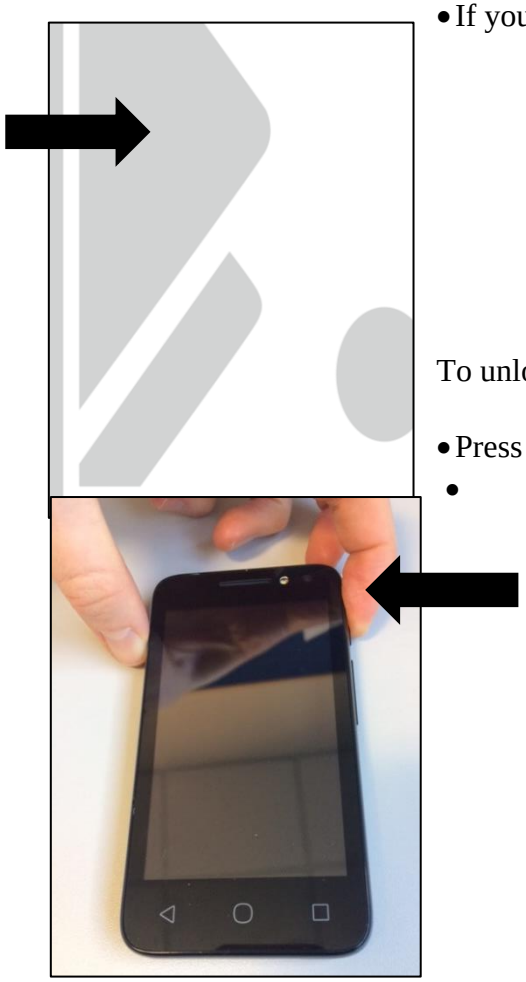
Instructions

To turn the phone on:

- Hold down the top button on the right-hand side of the phone for up to 5 seconds.

To charge the phone:

- Connect the charger to the mobile phone and plug this into a plug socket. It may take up to 1 hour for the phone to completely charge.



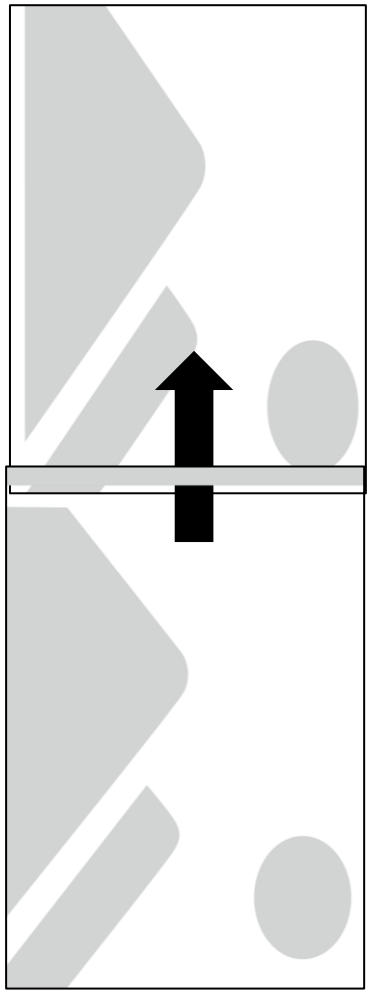
- If you have already turned the phone on, this screen shows that the phone is on, but it is locked.

To unlock the phone:

- Press the top right-hand button.
- Note: if you are unsure whether your phone is on, press this button for a few seconds.

To unlock the phone:

- Use your finger to swipe the centre of the screen up



- This screen will then show numbers.
- Enter the PIN: 1234
- Press OK

The home screen will show

To access WhatsApp:

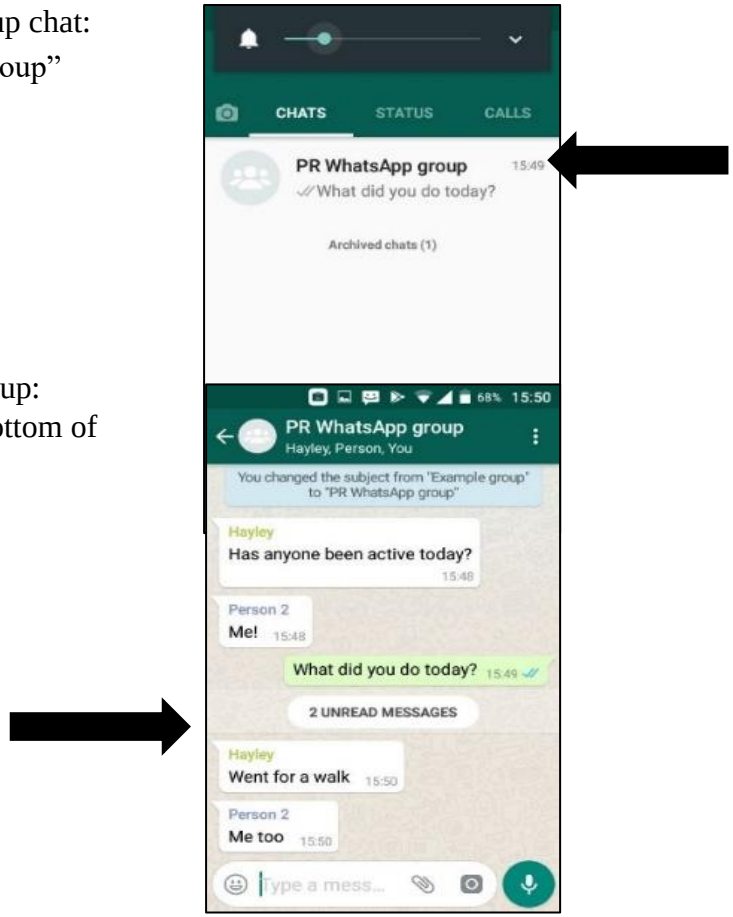
- Tap on the WhatsApp logo on the home screen

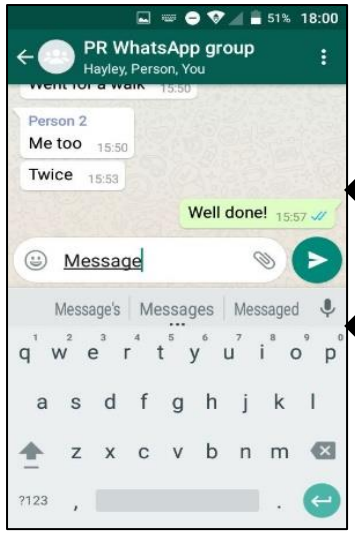
To access the WhatsApp group chat:

- Tap on the “PR WhatsApp group”

To write a message to the group:

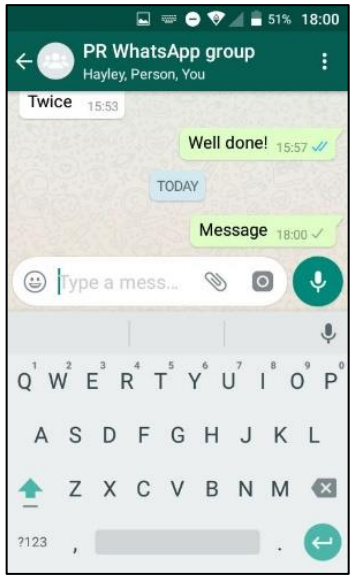
- Tap on the white bar at the bottom of the page.





Send button

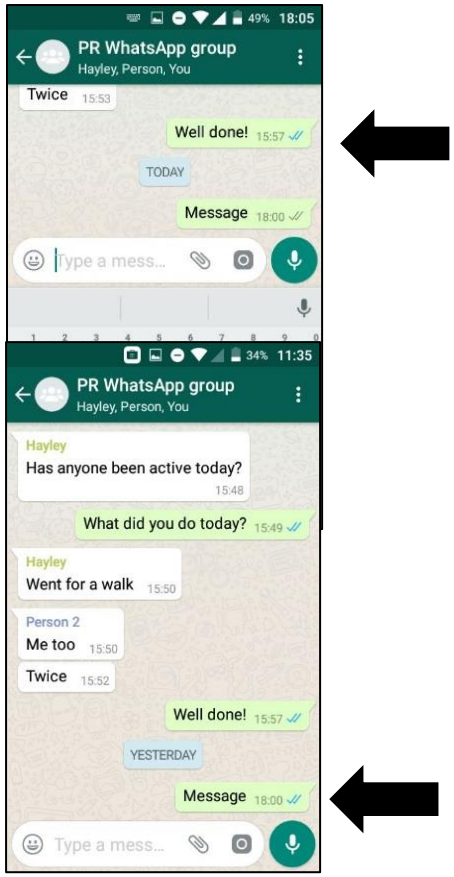
Keyboard



A keyboard will be displayed. Write your message using this keyboard and press send when you are ready to send your message to the group.

To check when the message has been sent:

One grey tick next to the message will how when the message has been sent.



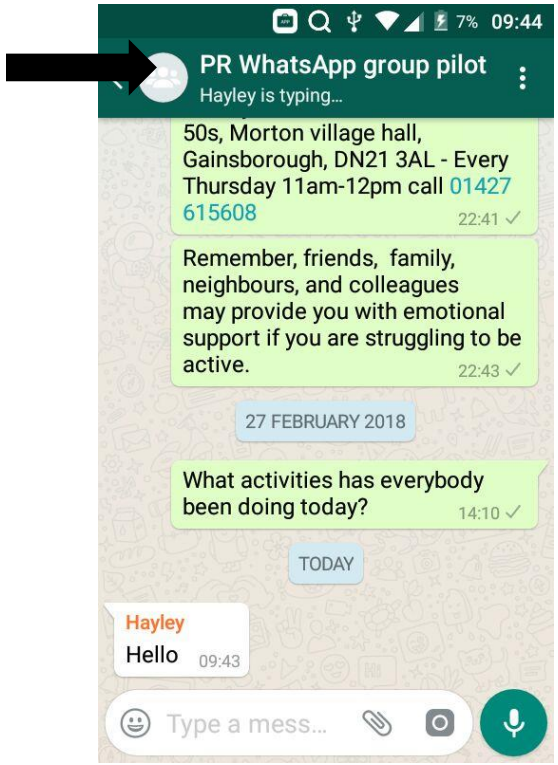
Two grey ticks next to the message will show when the message has been sent to everyone's phones

To know when your message has been read:

Two blue ticks will show when everyone in the group has read your message.

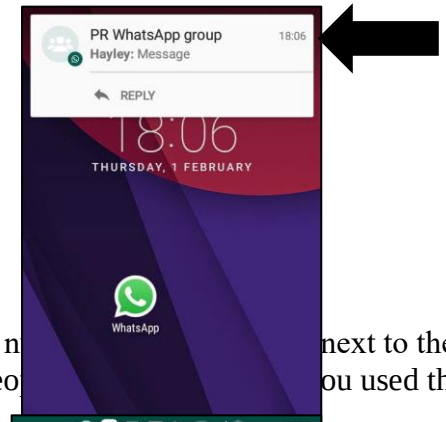
A message will appear at the top of the WhatsApp group to show when someone is typing a message.

- For example, “Hayley is typing….”.

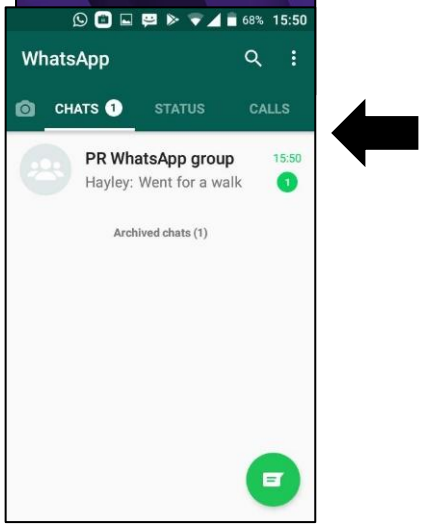


A notification at the top of your screen will show when someone writes a message in the “PR WhatsApp group”.

- Your phone has also been set to buzz/beep when a message has been sent).



A n next to the “PR WhatsApp group” which will show how many messages have been sent to the group from other peo ou used the group chat.



Your health and safety

- The WhatsApp leader is not medically or clinically trained and is not a member of the research team.
- If you have questions or concerns about your health, please contact your GP or other relevant healthcare services.

Problems

- If you have further questions about the phone or pedometer, please read the specific manuals for these devices.
- Alternatively, please ask a member of the research team (contact details on the last page).

Please report to a member of the research team if:

- If you encounter any problems with the pedometer or mobile phone (for example the device is lost or broken).
- If you wish to report any inappropriate comments on WhatsApp.

If you have any questions about the study, or your involvement in it, either now or in the future, please contact the research team on the contact details provided on the next page.

Contact details

Miss Hayley Robinson
Chief Investigator/PhD Student
Lincoln Institute for Health, University of Lincoln, LN6 7TS
Tel: XXX
Email: XXX

Dr Arwel Jones
Academic Supervisor
Lincoln Institute for Health, University of Lincoln, LN6 7TS
Tel: XXX
Email: XXX

If you would like to speak to someone about the project who is not a member of the research team, contact:

XXX
Tel: XXX
Email: XXX

NHS
Lincolnshire Community Health Services
NHS Trust

UNIVERSITY OF LINCOLN
LINCOLN INSTITUTE FOR HEALTH

Lincolnshire Community Health Services NHS Trust

University of Lincoln – Lincoln Institute for Health

WhatsApp Group Leader Guidelines and Checklists

Title of the project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary Disease (COPD)

The Checklists and guidelines are to help you during the study and to make sure that the intervention is consistent across different areas in Lincolnshire.

WhatsApp Checklists

- The research team will send you a Checklist for Week 1 (see below for the example).
- After Week 1, the research team will send you two WhatsApp Checklists every four weeks (Checklist 1 and Checklist 2). See below for the examples.

Checklist Week 1

- This Checklist will show you which messages to send every day during Week 1. Report in the table whether you sent these messages.

Checklist 1

- Checklist 1 will show what type of message to send every day.
- See the lists of messages below to find the different types of messages.
- For each type of message, choose a message (or a selection of messages) from the list and send these to the WhatsApp group.
- Complete Checklist 1 every day to report whether you have sent the indicated message type/s.

Checklist 2

- This Checklist will be blank (see below).
- Use this Checklist every day to record any additional messages that you have sent.
- Choose a message from the list and send to the group if/when you think it is appropriate. For example, if group members report that they have made an effort or report any physical activity progress, send them a message from the List titled 'Congratulatory messages'. If group members report that they are worried about being active, send them a message from the list titled 'Social Support' (See page 7 for the full list of messages).

After each 4-week period

- The research team will send you a reminder to send across your completed WhatsApp Checklist after each 4-week period.

Week 1 Checklist: WhatsApp message schedule		
Day	Messages to send	Y/N
1	6pm: • Hello and welcome to the WhatsApp group. My name is XXX and I am your WhatsApp leader. My role is to motivate you to keep active now you have finished pulmonary rehabilitation. • I will send the group a message every day of this week except for Sunday. Listen out for your phone so you don't miss any messages that I send. I recommend charging your phone every day, so it does not run out of battery. If your phone isn't on, you might not see any messages from the WhatsApp group. • Become familiar with the manuals you have been provided as they may help answer any questions you may have about the devices or WhatsApp. I recommend keeping these with you, or keeping them somewhere you remember, e.g. on your bedside table. • Remember that I am not medically trained, and therefore cannot give medical advice. If you are concerned about any aspect of your health, please seek professional help as you would otherwise. • I recommend recording your daily steps in the Step Diary each day, starting today. I will send a message to the group every day during the first week to remind you to do this.	
2	12pm: • Good afternoon, I will send and/or reply messages to the group in two, 2-hour slots every day. One time slot in the afternoon (12-2pm) and one time slot in the evening (6-8pm). • I can change these timeslots to be earlier/later if that suits the group? Let me know if these times do not suit you. Leave time for the group to respond • Starting from next week, I will send information about the different activities that you could participate in. If these interest you, I will send out reminders three days before the activities/classes. Will this be enough time to prepare you to attend the activities/classes? Leave time for the group to respond • Has everyone managed to use the pedometer today? If you are struggling to use the pedometer, please check the manual or ask a question in this group. Leave time for the group to respond • Remember to record your daily step counts in the Step Diary. It might be helpful to put your Step Diary somewhere that you can see it easily. For example, you could stick it to your wall, put it on a pin board, hang it on the fridge etc. Has anyone got any other suggestions of where to put the Step Diary?	
Agreed time slots: Time 1: Time 2: Enough time to prepare the group for classes? (e.g. 3 days)		

Agreed time:		
3	<u>Time 1</u> • You might be surprised at the number of activities where you live that are suitable for someone with a lung condition. For example, there are various activities, exercise classes and a number of walking activities and walking sports that are popular with people with lung conditions. In addition, local gyms, community halls etc. may have a lot of activities in your area. If you also like being active at home, there are plenty of ways that you can do this. • Next week I will start sending you information about the local physical activity opportunities in your area. Make a note of any activities that you would be interested in attending. • Remember to record your daily step counts in the Step Diary.	
4	<u>Time 1</u> • You might find that being active with other people helps motivate you to keep active after pulmonary rehabilitation. You could be active with other members of this group, or friends, family or colleagues. Look out for opportunities to be active with other people. • This WhatsApp group is to encourage you to keep active after pulmonary rehabilitation. If you need some encouragement to be active/feeling unmotivated, post a message to this group and together we can offer each other support. Remember that other people in this group are going through a similar experience, so don't feel nervous about sending a message to the group. • Remember to record your daily step counts in the Step Diary.	
5	<u>Time 1</u> • Some people find it easier to be active by sticking to a schedule or a routine. Does keeping a routine/schedule help any of you in the group? <u>Leave time for the group to respond</u> • Prompt: If so, is there anything that you do that helps you stick to a routine? <u>Leave time for the group to respond</u> • Remember to record your daily step counts in the Step Diary.	
6	<u>Time 2</u> • Good afternoon/evening. • Remember to record your daily step counts in the Step Diary. • I won't be posting any messages to the group tomorrow but remember to record your steps!	
7		
Your comments from the Week:		

Checklist 1: Essential messages; Month 1 (Week 2-4)									
Day		**Week 1**	Y/N	**Week 2**	Y/N	**Week 3**	Y/N	**Week 4**	Y/N
Mon	Time 1								
	Time 2			Active Linc & Vitality summary & Monitor activity levels		Active Linc & Vitality summary & Monitor activity levels		Active Linc & Vitality summary & Monitor activity levels	
	Reminders			Vitality (Thu)		Vitality (Thu)		Vitality (Thu)	
Tue	Time 1			Social support		Social support		Social support	
	Time 2			Monitor activity levels		Monitor activity levels		Monitor activity levels	
	Reminders								
Wed	Time 1			Activities at home		Activities at home		Activities at home	
	Time 2			Monitor activity levels		Monitor activity levels		Monitor activity levels	
	Reminders								
Thu	Time 1								
	Time 2			Monitor activity levels		Monitor activity levels		Monitor activity levels	
	Reminders								
Fri	Time 1			Habits/ routines		Habits/ routines		Habits/ routines	
	Time 2			Monitor activity levels		Monitor activity levels		Monitor activity levels	
	Reminders			Exercise prescription (Mon)		Exercise prescription (Mon)		Exercise prescription (Mon)	
Sat	Time 1								
	Time 2			Monitor activity levels		Monitor activity levels		Monitor activity levels	
	Reminders			Vitality (weds)		Vitality (weds)		Vitality (weds)	
Sun									
Your Comments from the 4-week period:									

Checklist 2: Additional message checklist; Month 1 (Week 1-4)					
Day		**Week 1**	**Week 2**	**Week 3**	**Week 4**
Mon	Time 1				
	Time 2				
Tue	Time 1				
	Time 2				
Wed	Time 1				
	Time 2				
Thu	Time 1				
	Time 2				
Fri	Time 1				
	Time 2				
Sat	Time 1				
	Time 2				
Sun	Time 1				
	Time 2				
Your comments from the 4-week period:					

Instructions and message types

Active Lincolnshire

Instructions for WhatsApp leaders

Active Lincolnshire lists the activities/sports that are running across Lincolnshire. There are reminders in the Checklists to send the group messages about the different physical activities/classes around Lincolnshire. The full details for these classes will be sent to you with the Checklists every 4 weeks.

(Example of a class listed near Gainsborough)

Exercise prescription

- Day/time: Monday, 1-3.30pm; Venue: Roses Sports Ground, North Warren Road, Gainsborough, Lincolnshire, DN21 2TU; Cost: free for a 10-week course

When you have received the Checklists with the full details of the activity classes, double check the website: http://www.activelincolnshire.com/activityfinder/: and 'What's on this week' at: http://activelincolnshire.com/activityfinder/whats-on to check upcoming activities and to see whether these classes are still running. If they are not, do not list these in the group. If there are any additional classes/activities running that the group could be interested in, report these to the group. If you are unsure whether this activity is relevant, you could contact the class leader from the details listed on the website or contact the research team. Report these activities/classes to the group, informing them of the day/time, venue and cost. If you report any more activities/classes, inform the group of the day/time, venue and cost of the activity.

When to send these messages:

- Send the group a summary of the activities at the start of each Week (when indicated on the Checklist)
- If group members ask for information about how they can keep active.
- Send a follow-up message and question/s (follow-up) after sending information about the different ways for people to keep active. This may help generate discussion and get some feedback about what type of activities people are interested in.

Note:

- There may be a lot of information listed for Active Lincolnshire. However, many of the activities will not be relevant.
- Do not report the Vitality classes listed on the Active Lincolnshire website. VitalityLincs shows a Live update of the Vitality classes and will provide more up to date information (see below).
- If you do find additional relevant classes/activities (that aren't already reported in the Checklist), send the group information/reminders about these. Try to send reminders about the classes when you can give people at least 3 days warning before the activities/classes. For example, if a class is on Thursday, try to report this to the group by Monday.

Messages to send to the group

- This week, XXX and XXX will be running. Here are the details:

(report the day/time, venue and cost of each indicated activity in the Checklist for that week)

- XXX is coming up in 3 days' time. Here are the details:

(report the day/time, venue and cost of the indicated activity in the Checklist)

- I have searched for local activities in your area. XXX will be held at:

(report the day/time, venue and cost of the activity that you have found on ActiveLincolnshire)

Follow-up messages

- Here is the link to the Active Lincolnshire website, where these activities are listed: http://activelincolnshire.com/activityfinder/
- If you would like more information about any of these activities, please visit this website or ask me. I can provide you with the link to the activity website where you can find more information about the activity/class, as well as contact details for this activity.

Questions (follow-up)

- I may not be aware of some activities that are going on and therefore I might have missed some activities off this group. Does anyone know of any other activities that are scheduled in this area? I am sure it would be helpful for other people in the group to hear about the different physical activity opportunities.
- How do you feel about those options?
- Is anyone thinking of going to any of these activities this week?
- What would you be interested in attending/Would anyone like to attend this week?
- Are these physical activity classes/events of interest to anyone in this group?
- Would anyone like more information on the activities that I have listed here?
- Are there any other activities, not listed here, that anyone would be keen to have more information about?
- These activities are up to X miles from (postcode). How far would people be interested in travelling to get to these classes/activities?
- You might find that travelling to these classes together could be helpful. If anyone is thinking of driving to the class and would like to offer lifts, let the group know.

Vitality exercise classes

Instructions for WhatsApp leaders

Vitalitylincs.co.uk lists the classes that are running across Lincolnshire. There are reminders in the Checklists to send the group messages about the different Vitality classes around Lincolnshire. The full details for these classes will be sent to you with the Checklists every 4 weeks

(Example of a class in Ruskington)

- Day/time: Monday/11:30-12:15pm; Venue: Ruskington- Winchelsea Centre, 11 High Street North; Type of Class: Seated; Teacher: Kimberley; Cost: The first class is FREE, after that it's £4.00 per class as a visitor with no commitment or £12.00 per month as a member

When to send these messages:

- Send the group a summary of the Vitality classes at the start of each Week (when indicated on the Checklist)
- If group members ask for information about how they can keep active.
- Send a follow-up message and question/s (follow-up) after sending information about the Vitality classes. This may help generate discussion and get some feedback about whether/if people are interested in attending the classes.

Note:

- These classes can get cancelled, so remind group members to double check that these are on: e.g. recommend that they phone the group leaders on the day of the class.
- If you do find additional Vitality classes on the website (that aren't already reported in the Checklist), send the group information/reminders about these. Try to send reminders about the classes when you can give people at least 3 days warning. For example, if a class is on Thursday, try to report this to the group by Monday.

Messages to send to the group

- Vitality is a specialist exercise class that runs across the UK for people living with a lung condition.
- The classes vary in levels from seated to part seated, part standing to fully standing routines all to a wide range of music. The classes cater for all levels of abilities and participants are encouraged to work to their own level at all times.
- There's no need to book, although we advise checking with the office or the website before coming along for the first time. The first class is FREE, after that it's £4.00 per class as a visitor with no commitment or £12.00 per month as a member.
- The classes also cater for those younger than sixty with medical conditions which prevent them from exercising in any other way. Please note that you will be required to complete brief health screening process with your teacher at your first session, just to ensure that it's safe for you to exercise.
- There is a short video on Vitality's website which explains what it is and how it works:

http://www.vitalitylincs.co.uk/about/

- Here is a list of Vitality classes near you that may help you to keep active:

(Report exercise class, including the day/time, venue, type of class, teacher and cost.)

Follow-up messages

- Here is the link to the Vitality website, where these activities are listed: http://www.vitalitylincs.co.uk/find-a-class/
- If you would like more information about any of the Vitality classes, please visit this website or ask me.

Follow up questions

- Is anyone thinking of going to any of these classes this week?
- Are these classes of interest to anyone in this group?
- Would anyone like more information on the classes that I have listed here?

- These classes are up to X miles from (postcode). How far would people be interested in travelling to get to these classes? You might find that travelling to these classes together could be helpful. If anyone is thinking of driving to the class and would like to offer lifts, let the group know.

Activities at home

Instructions for WhatsApp leaders

When to send these messages:

- When indicated on the Checklist.
- If group members ask for information about how they can keep active at home.

British Lung Foundation (BLF) has a number of resources that could help patients keep active at home. Report the link to BLF's exercise handbook and DVD if people request this:

- BLF Active: Resources
- Report the link to BLF's exercise handbook and DVD if people request this:
- https://shop.blf.org.uk/
- Report the link the BLF's YouTube videos:
- XXX

Messages to send to the group

- Being active at home can allow you to work at your own pace, in the comfort of your own home. If you would prefer to keep active at home, there are a number of ways that you could do this.
- The British Lung Foundation has an exercise DVD and a handbook to support you through these simple activities. You can order this DVD online or call for more information on: 03000 030 555. I can provide you with the link to the website.
- The British Lung Foundation also have online videos of similar exercises you completed in pulmonary rehabilitation. They can be found here:

(Insert link)

Follow-up messages

- Do home activities interest any of you in the group?
- Has anyone used the exercise DVD? If so, how did you find it?
- Has anyone watched the online videos from the British Lung Foundation? If so, how did you find them?

Social support

Instructions for WhatsApp leaders

When to send these messages:

- When indicated on the Checklist.
- If group members say that they do not feel motivated or they report feeling worried/unmotivated about keeping active.

Note:

- There are numerous messages in this list. Only choose one/or a select few from this List. It is up to you to choose which ones you think are most relevant.

Messages to send to the group

- Research suggests that one of the main benefits of attending pulmonary rehabilitation is meeting and socialising with other people who have a lung condition. This WhatsApp group is to encourage you to be active. If you need some encouragement to be active/feeling unmotivated, post a message to this group and together we can offer each other support.
- Is anyone attending any physical activity classes this week? It might help to meet up with other people in this WhatsApp group so that you can support each other to be active. Please let other group members know if you would be interested in meeting up and being active together.
- Walking groups are popular for people who have COPD. What do you all think about arranging a time to meet up for a walk? What day and time would suit people?
- Ask family or friends to do daily activities with you, for example go out for a walk or go cycling. They might make it more fun or provide you with a distraction.
- Friends, family, neighbours, colleagues etc. may provide you with emotional support/support if you are struggling to be active. Share your plans to be active with them so that they can support you.
- If you are worried about being active by yourself, attend a group activity session or ask someone else to be active with you.
- If you are worried about being active by yourself, arrange to be active with a "buddy".
- Another member of this group could be an exercise buddy. If anyone in this group wants an exercise buddy, please let the group know. With an exercise buddy, you could meet up to go for walks, or discuss attending any activity classes together? You might find that this keeps you motivated to keep active after pulmonary rehabilitation.

Monitor activity levels

Instructions for WhatsApp leaders

When to send these messages:

- When indicated on the Checklist.

Note:

- There are numerous messages in this list. Only send one/or a select few from this list. It is up to you to choose which ones you think are most relevant.
- Listed here are several closed and open questions. The closed questions encourage the group members to reflect on their step counts. The open questions encourage the group members to discuss their physical activity experiences. Send the closed questions to the group first and use the open questions to prompt the group to discuss their experiences with physical activity.

Messages to send to the group

Closed questions

- How many steps did you do today?

- How many steps have you done since last Thursday?
- How many steps have you done since last Tuesday?
- Did anyone do more steps than yesterday?
- How long have you spent being active today?
- What activities have you done today?
- Did anyone go walking outside today?
- Did anyone manage to be active today?
- Has anyone noticed improvements in their step counts since pulmonary rehabilitation?
- Has anyone noticed improvements in their step counts since last week?
- Has anyone noticed any improvements in their activity levels? This doesn't have to be related to the number of steps you have done.

Open questions

- It would be interesting to hear how you got these steps. Perhaps tell the group what activity you have done today/how you got this many steps.
- It would be interesting to hear about any improvements you have noticed in your step count since pulmonary rehabilitation. Perhaps tell the group about any improvements you have noticed

Habits/routines

Instructions for WhatsApp leaders

When to send these messages:

- When indicated on the Checklist.
- When group members report that they are struggling to keep active
- When group members report that they are struggling to form a habit/routine.

Note:

- There are numerous messages in this list. Only send one/or a select few from this list. It is up to you to choose which one/s you think are most relevant.
- The suggestions about habits/routines are to encourage group members to get into a regular pattern of being active. The suggestions about activities of daily living are to remind group members that there are simple things they could do every day to help them keep active. The open questions may encourage group members to discuss their habits/routines.
- Send suggestions to the group and then send open questions. This might help start a group discussion.

Messages to send to the group

Suggestions: habits/routines

- Some people find it easier to be active by sticking to a schedule. Try and do your daily activities every day at the same time (for example XX).
- If it helps, set an alert on your phone to remind you to be active at a certain time.
- Try and do your daily exercises at the same time every day. This may help you form a routine.

- Try and attend the same class every week. Organise your schedule so that you can try to attend every week.

Suggestions: Activities of daily life/living

- There are simple habits that you could get into which would increase your physical activity levels. During your daily life, a few things you could do would be to sit less, take the stairs or walk and carry the shopping instead of driving/getting the bus.
- You could use prompts to remind yourself to stay active. You could: put your trainers by the front door; hang the clothes you do exercise in outside your wardrobe; put your daily steps diary on the wall/somewhere you can easily see it.
- Would these help to remind you to be active?

Open questions

- Can you think of any other ways to remind yourself to stay active?
- Can you think of any other ways to help you form a habit/routine to keep active?
- You could increase your steps by walking around the house when the TV adverts come on;
- What things could you change in your current routine to be more active? Any tips or advice from anyone in this group may be helpful for other people.

Congratulatory messages

Instructions for WhatsApp leaders

There are numerous messages in this list. Only send one/a select few from this list. It is up to you to choose which one/s you think are most relevant.

When to send these messages:

- When indicated on the Checklist.
- When group members have reported: making an effort, making progress, being active, maintaining their activity levels.

Note:

- There are numerous messages in this list. Only send one/or a select few from this list. It is up to you to choose which one/s you think are most relevant.

Messages to send to the group

- Well done!
- Good effort!
- Congratulations on maintaining your step count (since… yesterday/last week/since you finished pulmonary rehabilitation)
- Congratulations of achieving a higher step count (than… yesterday/last week/since you finished pulmonary rehabilitation)
- Well done for being active!

Health

Instructions for WhatsApp leaders

We do not expect you to advise group members about their health. If group members report their symptoms, or ask for medical advice, please send them any relevant messages from these standardised messages.

Messages to send to the group

- Please remember that I am not medically trained, and therefore cannot give medical advice. If you are concerned about any aspect of your health, please seek professional help as you would otherwise.
- You should call 111 if you don't know who to call for medical help or need information about a health issue.
- If you require non-urgent medical advice please contact your GP, your local NHS walk-in centre or local pharmacist.
- You can call 111 if you think you need to go to A&E or another NHS urgent care service.
- If you need emergency medical help to save your life, you must call 999.

WhatsApp leader Guidelines

WhatsApp messages

We have provided lists of messages for you to send in the WhatsApp group. Become familiar with the lists of messages. This will help you choose which messages you think are most suitable to send to the group. You are free to choose and send which message/s you think are most relevant at the time. However, if you feel that these messages are not suitable, please contact the researchers to make them aware.

Timings

1. Send and reply to the messages from individuals in two time slots (12-2pm and 6-8pm or the times you agree on with the WhatsApp group) on Monday to Saturday. Posting in other time is optional.

2. Complete the checklist every day during the study and send to the Chief Investigator (Hayley Robinson) at the end of the 4-week period.

WhatsApp Security

- Do not change the security settings on your phone. These setting will make sure that:
    - A passcode or pin is set on your mobile phone as soon as you start using it.
    - Your phone will automatically lock 5 seconds after it is set to 'sleep'.
    - WhatsApp notifications are hidden on your phone when it is locked (notifications are on private).
- Only use this phone to communicate with individuals involved in the intervention.
- Check that you are communicating with the correct person or group.
- Take care of your phone as losing it may impact individuals' experience of the intervention.
- Don't let anyone else use your phone at any time.
- Keep all the posts in the group confidential and do not share and discuss the information in the group to others except the research team.

WhatsApp behaviour

- Be the role model for the group and do not post offensive statements.
- If individuals post inappropriate/offensive comments, remind them to adhere to appropriate standards. Remove group members if they continue to post inappropriate/offensive comments.
- Respect all group members and act in a manner that is considered polite, friendly, helpful and unbiased.
- Respect individuals' decisions to interact at different levels within the group. Individuals also have the right to withdraw from the social group.

End of the study

- At the end of the study, we will collect the mobile phones used in the intervention.

Contact with the research team

- At the end of the 4-week period, export the content of the WhatsApp conversation, pseudonymise the posts, and send the content to the research team.

- If you encounter any problems during the study, please contact the research team (contact details below).
- If you have any questions about your involvement in the study, either now or in the future, please contact the study team on the contact details provided below.

Miss Hayley Robinson
Chief Investigator/PhD Student
Lincoln Institute for Health, University of Lincoln, LN6 7TS
Tel: 01522 835483
Email: hrobinson@lincoln.ac.uk

Dr Arwel Jones
Academic Supervisor
Lincoln Institute for Health, University of Lincoln, LN6 7TS
Tel: XXX
Email: XXX

If you would like to speak to someone about the project, who is not a member of the research team, please contact:

Katy Ward
Research Governance Facilitator (Lincolnshire Community Health Services)
Tel: XXX
Email: XXX

Appendix L Patient demographic data collection form

NHS
Lincolnshire Community Health Services
NHS Trust

UNIVERSITY OF LINCOLN
LINCOLN INSTITUTE FOR HEALTH

Patient Demographics Record Sheet

Title of Project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD)

IRAS project ID: 229697
Participant identification number:

Age:	**Date of birth:**
Gender:	**Ethnicity:**
	Race:
Body Mass (kg):	**Height (cm):**
Body Mass Index (BMI):	
COPD diagnosis (severity):	

Previous 12 months no. of exacerbations (antibiotics/oral steroids, hospitalisation):

Co-morbid conditions:

Medications (including dosage):

Smoking history (no. of years smoked/no. of cigarettes per day):

Exhaled Carbon monoxide (ppm):

Appendix M Topic guide for semi-structured interviews with patients

Lincolnshire Community Health Services NHS Trust

University of Lincoln
Lincoln Institute for Health

Interview topic guide for patients

Title of project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD).

Introductions

Introduce yourself to the participant. Talk through the topic of conversation for the telephone interview and how long it may last. Provide opportunity for questions about the interview, re-confirm that patients agree to take part.

Note: Ask the questions that are relevant to each patient (account for cluster allocation, participation/length of participation). Only ask the questions and use the prompts when required, e.g. do not repeat questions or prompts.

Experience of taking part in the research:

Recruitment

<u>All patients</u>

Q. Can you tell me how did you first hear about this research?
Prompt: Information sheet from the lead health care professional, spoke to the research team.

Q. What was your initial reaction to receiving the invitation to take part in this research?
Prompt: What were your reasons for deciding to take part?

Q. What did you think about the way that you were recruited to participate?
Prompts: provided with an information sheet, approached by the research team, what did you like/dislike about this process? Could this be improved?

Q. What do/did you like/dislike about the written information about the research?
Prompts: Could the information sheet be improved? If so, how?

<u>Patients that declined participation (additional questions)</u>

Q. What was/were your reason/s for deciding not to take part in this research?
Prompts: Was there anything that you didn't like about the recruitment process? Could this be improved? If so, how? Was there anything that you didn't like about the research procedures?

<u>Patients that consented participation and withdrew (additional questions)</u>

Q. What was/were your reason/s for deciding to withdraw from this research?
Prompts: Was there anything that you didn't like about the research procedures? Could the research procedures be improved? If so, how?

Experiences of using the devices

Intervention group only

Q. What did you think of the pedometer?
Prompt: Did you use the pedometer? Was it comfortable/uncomfortable to wear? How many days did you wear it for? If you didn't remember to wear it, how might we make it easier for you to remember to wear it (e.g. receive reminders)? What did you like about it? What did you dislike about it?

Q. What did you think of the step diary?
Prompts: Did you record your steps in the diary during the study? If yes, how often did you record your steps in the diary? How might we make it easier for you to record your steps (e.g. receive reminders?) How might we encourage other people to use it? What did you like about it? What did you dislike about it?

Q. What did you think of the study mobile phone (Nokia 1)?
Prompts: Did you use it? What did you like/dislike about the phone?

Q. What did you think of the WhatsApp group?
Prompts: Were you able to view the WhatsApp messages? Did you engage in WhatsApp? Was there anything that you liked/disliked about the group chat? Do you think anything could be done to improve these messages (e.g. timing, frequency)?

Patient training

Intervention group only

Q. What did you think about the education session for the phone, pedometer and step diary?
Prompts: Were you provided with enough information during the education session? Was the training easy to follow? Did you understand how to use the phone and pedometer after the education session? Was there anything that you liked/disliked about the education session? Do you think anything could be done to improve the education session?

Q. What did you think about the device manual?
Prompts: Did you use this manual? Was this manual easy to read? Was this manual useful in answering any questions about the pedometer, step diary, phone (if used)? What did you like/dislike about this manual? Do you think anything could be done to improve the device manual?

Familiarisation period

Intervention group only

You were provided with a phone 2-weeks before the end of pulmonary rehabilitation. This allowed you to communicate with the WhatsApp leader before you were added to the WhatsApp group chat.

Q. What did you think about the familiarisation period for the phone?
Prompts: Did you have enough time to become familiar with the phone (2 weeks)? If not, how much time do you think we should give people? Was there anything that you liked/disliked about the familiarisation period? Do you think anything could be done to improve the familiarisation period?

Q. What did you think about the familiarisation period for the pedometer?

Prompts: Did you have enough time to become familiar with the pedometer (2 weeks)? If not, how much time do you think we should give people? Was there anything that you liked/disliked about the familiarisation period? Do you think anything could be done to improve the familiarisation period?

Capability, Opportunity and Motivation

<u>All patients: Control/Intervention and those that declined/withdrew</u>

These questions will be based on COM-B components, based on those provided in the BCW guide (p68-69)[387], adapted to physical activity maintenance following pulmonary rehabilitation.

Q. Do you believe that you were/are capable of maintaining physical activity following pulmonary rehabilitation?

Prompts:

Do you need to:

- Know more about why it was important e.g. to have a better understanding of the benefits of maintaining physical activity
- Know more about how to do it e.g. have a better understanding of effective ways to be active
- Have better physical skills e.g. learn how to perform certain activities/ use equipment to help me to be active
- Have better mental skills e.g. learn how to plan and structure physical activity into a daily/weekly routine
- Have more physical strength e.g. increase my exercise capacity/train my muscles so I can perform more activities
- Have more mental strength e.g. develop more resilience against falling back into unhealthy routines
- Overcome physical limitations e.g. get around mobility/breathlessness issues
- Overcome mental obstacles e.g. reduce anxiety surrounding physical activity and breathlessness
- Have more physical stamina e.g. develop greater capacity to maintain physical effort
- Have more mental stamina e.g. develop greater capacity to maintain mental effort

Q. Do you believe that you had/have the opportunity to maintain/perform physical activity following pulmonary rehabilitation?

Prompts:

Do you need to:

- Have more time to do it e.g. create dedicated time during the day
- Have more money e.g. be provided funds to support the behaviour
- Have the necessary materials e.g. acquire materials/equipment for physical activity (trainers, sports clothing/gym equipment etc.)
- Have it more easily accessible e.g. provide easier access to facilities
- Have more people around them doing it e.g. be part of a 'crowd' who are doing it
- Have more triggers to prompt them e.g. have more reminders at strategic times
- Have more support from others e.g. have friends and family's support

Q. Do you believe that you had/have the motivation to maintain/perform physical activity following pulmonary rehabilitation?

Prompts:

Do you need to:

- Feel that you want to do it enough e.g. feel a sense of pleasure/satisfaction from doing it
- Feel that you need to do it enough e.g. care more about the negative consequences of not doing it
- Believe that it would be a good thing to do e.g. have a stronger sense that one should do it
- Develop better plans for doing it e.g. have clearer and better developed plans for achieving it
- Develop a habit of doing it e.g. get into a pattern of doing it without having to think

Data collection (including accelerometer) and measurement time points

Both Intervention and Control

Follow up visits:

Q. We asked to collect data from you during this research. We collected data from you during pulmonary rehabilitation. We then contacted you to arrange two follow-up visits (3 and 12 months) after pulmonary rehabilitation to collect data from you. How did you find this process?

Prompts: Were you contacted by the research team before the follow-up visits? Were you able to attend both follow-up visits? If you didn't, what would have helped you to attend? (time/place); Was there anything that you liked/disliked about these follow-up visits? How might we improve these follow-up sessions?

Q. What did you think about the Activity monitor?

Prompts: Was it comfortable/uncomfortable to wear? How many days did you wear it for? If you didn't remember to wear it, how might we make it easier for you to remember to wear it (e.g. receive reminders)?

Q. What did you think about the PROactive daily questionnaire that we provided you with when you wore the Activity Monitor? *(list the types of questions provided in the questionnaire)*

Prompt: Were they easy/difficult to complete every day? How might we make it easier for you to fill in these questionnaires (e.g. receive reminders, computerised copy, etc.)

Q. What did you think about the Sleep diary that we provided you with when you wore the Activity Monitor?

Prompt: Was it easy/difficult to complete every day? How might we make it easier for you to fill in this sleep diary? (e.g. be asked to put it on bedside table, asked to set alerts, etc.)

Q. What did you think about the other Questionnaires that we provided you with when you attended the follow up visits? (remind participants about the HADS and CRQ questionnaires)

Prompt: What did you think about the length/number of questionnaires? Were they easy/difficult to complete?

Q. What did you think about the Incremental Shuttle Walk Test?

Prompt: Were you prepared to perform this test? Were you confident in performing this test?
General Prompts: What went well? What went less well? How can we make this easier for patients?

Impact of the Intervention on Physical Activity

Intervention group only

Instructions: Ask patients whether they thought the following had any impact on their physical activity levels using the below prompts.

I will now ask you a series of further questions about the factors that may have influenced your physical activity levels following pulmonary rehabilitation.

You talked about the XX earlier….
(If patients have mentioned the use of the Intervention components, use the prompts below to ask about the components)

Pedometer:

Q. Did you check/monitor your daily steps on the pedometer display screen?

Did the pedometer have any impact on your physical activity levels?
Prompts: change, increase, decrease? If so, why? If not, why?

Step diary:

Q. Did you report your daily steps in this diary?

Did you check/monitor your physical activity progress during the past 12 months?
Did the step diary have any impact on your physical activity levels?
Prompts: change, increase, decrease? If so, why? If not, why?

WhatsApp communications:

Q. Did the WhatsApp group have any impact on your physical activity levels?

Prompts: (provide a reminder about the WhatsApp messages)
Did the WhatsApp group change, increase, decrease your activity levels? If so, why? If not, why?

The WhatsApp leader sent the group messages which:
Told you about the physical activities your local area.

Q. What did you think about these messages?

Told you about the different ways to be active at home

Q. What did you think about these messages?

Encouraged you to be active with other people.

Q. What did you think about these messages?

Suggested that you to seek support from other people if you were worried about being active/struggling to motivate yourself.

Q. What did you think about these messages?

Suggested that you form habits/routines to stay active.

Q. What did you think about these messages?

You were sent congratulatory messages when you reported being active/making an effort to be active,

Q. What did you think about these messages?

Prompts: did they have any impact on your physical activity levels?

Q. Finally, is there anything else you want to tell us about your experiences of physical activity after pulmonary rehabilitation?

Prompts: Was there anything else (other than what we discussed) that you think had any impact on your physical activity levels after pulmonary rehabilitation?

Q. Do you think that this Intervention could be improved to help you keep active after pulmonary rehabilitation?

Prompts: Could any component/s be added/removed from the Intervention e.g. WhatsApp, pedometer, Step Diary?

Plans to keep active

Patients who declined or withdrew from the study

- Do you have any plans to keep active after pulmonary rehabilitation?

Prompts: If you do, how do you plan to keep active?

Intervention and Control

Q. Do you have any plans to keep active following the study?

Prompts: If you do, how do you plan to keep active?

Intervention group only

Q. Will you continue to use any components of the intervention now the study has ended?

Prompts: will you continue to use WhatsApp, the pedometer or the step diary? If so, what plans do you have to continue using these (e.g. use personal phone/pedometer or buy these?) If you do not plan to continue using WhatsApp, pedometer or the step diary, what are your reasons?

End interview

All patients

Q. Thank you for taking part in this telephone interview. Do you have any questions about the study?

If you have any further questions about the study in the future, please contact the research team on the contact details that you have been provided.

Appendix N Topic guide for the semi-structured focus groups with HCPs

Lincolnshire Community Health Services NHS Trust

University of Lincoln
Lincoln Institute for Health

Focus Group Topic Guide Healthcare professionals

Title of project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary disease (COPD).

Introductions

Introduce yourself to the healthcare professionals. Talk through the topic of conversation for the focus group and how long it may last. Provide opportunity for questions about the focus group, re-confirm that healthcare professionals agree to take part.

Note: Only ask the questions and use the prompts when required, e.g. do not repeat questions or prompts.

Pulmonary rehabilitation programme recruitment

R. Can you tell me how did you first hear about this research?
Prompt: participant information sheet.

R. What did you think about the information you were provided about the study?
Prompt: Was it enough information? Was anything unclear? Did you have enough time to prepare for the study procedures (e.g. patient training?) Could anything be improved? If so, how?

Q. What was your initial reaction to the intervention?
Prompt: What did you think about providing patients with phones, pedometers and step diaries? Did you think that it was/was not a good idea? Why?

Patient recruitment

R. What did you think about the way that patients were recruited to participate?
Prompts: Patients were provided them with an information sheet and they were then approached by the research team a week later. What did you like/dislike about this process? Could this be improved?

You provided patients with an information sheet.

R. What did you like/dislike about the written information about the research?
Prompts: Could the information sheet be improved? If so, how?

Patient training

During an education session, the research team and WhatsApp leader provided patients with information and training about how to use the phone, pedometer and step diary.

Q. What did you think about the training that patients received during the education session?

Prompts: Did you think patients were provided with enough information during the education session? Do you think the training was easy to follow during the education session? Do you think patients understood how to use the phone, WhatsApp, pedometer and step diary after the education session? Did the patients report any difficulties or ask about any of the components? Was there anything that you liked/disliked about the education session? Do you think anything could be done to improve the education session?

R. What did you think about the device manual?

Prompts: Do you think patients found this manual easy to read? What did you like/dislike about this manual? Do you think anything could be done to improve the device manual? If so, what?

Phone and pedometer familiarisation period

The patients were then provided with the phone and pedometer before they finished pulmonary rehabilitation (2 weeks/couple of days) to become familiar with the devices.

R. What did you think about the familiarisation period for the phone?

Prompts: Do you think patients had enough time to become familiar with the phone (2 weeks)? If not, how much time do you think we should give patients? Was there anything that you liked/disliked about the phone familiarisation period? Do you think anything could be done to improve the familiarisation period?

Q. What did you think about the familiarisation period for the pedometer?

Prompts: Do you think patients had enough time to become familiar with the pedometer (couple of days)? If not, how much time do you think we should give patients? Was there anything that you liked/disliked about the familiarisation period? Do you think anything could be done to improve the familiarisation period?

Impact of the study on the Programme

Q. Do you think the study impacted the on the delivery of your usual service?

Prompts: Did it change any aspect of the patients' experience? Did the Intervention integrate well with the usual pulmonary rehabilitation programme? Did you have enough time to prepare for being involved in the project/delivering the standard care?

Impact of the study on Healthcare professionals

Q. Do you think that the study impacted you during pulmonary rehabilitation?

Prompts: Did it affect your workload? Could anything have been done to make your role in the study easier during pulmonary rehabilitation?

Impact of the Intervention on Physical Activity

Ask healthcare professionals about their view of the Intervention

R. Do you think that this Intervention could be improved to help patients keep active after pulmonary rehabilitation?

Prompts: Could any component/s be added/removed from the Intervention e.g. WhatsApp, pedometer, Step Diary?

Feasibility questions

Q. Is there anything that could be done to improve the study procedures?

Prompts: Data collection timings? Amount of outcome measures? Arranging follow-ups?

Q. What do you think about this Intervention being conducted on a larger scale?
Prompts: Would this be feasible?

Q. What do you think about recruiting patients for a larger scale study?
Prompts: Do you think this would be easy/hard?

End Focus Group

R. Thank you for taking part in this Focus group. Do you have any questions about the study?

If you have any further questions about the study in the future, please contact the research team on the contact details that you have been provided.

Appendix O Topic guide for the semi-structured focus groups with WhatsApp Leaders

Focus Group Topic Guide: WhatsApp leaders

Title of project: Physical activity following pulmonary rehabilitation in patients with Chronic Obstructive Pulmonary Disease (COPD).

Introductions

A focus group moderator and note taker should be present. The note taker should list the seating arrangements and capture any nonverbal behaviour e.g. positive or negative reaction towards a certain topic/question.

Introduce yourself and each WhatsApp leader to each other. Talk through the topic of conversation for the focus group and how long it may last. Provide opportunity for questions about the focus group, re-confirm that WhatsApp leaders agree to take part in an audio recorded focus group.

Note: Only ask the questions and use the prompts when required, e.g. do not repeat questions or prompts.

1) **Introductions:**
   - Where are you from?
   - Which WhatsApp group are you/have you been sending messages to?

2) **Recruitment:**
   - How did you first hear about the research?
   - What did you think about the information you received about the research?

3) **Training:**
   - Could you tell us about your understanding of the research at the beginning of the study?
   - Could you tell us about your experiences becoming familiar with all aspects of the study? E.g. the phone, pedometer and step diary.

4) **Experience of using the intervention components:**
   - Could you tell us about your experience of using the phone?
   - Could you tell us about your experience of using the pedometer?
   - Do you think these devices could be improved for a future study?
   - Could you tell us about your experience of using the step diary?
   - Do you think the step diary could be improved for a future study?

5) **Experience of messaging the WhatsApp group:**
   - Could you tell us about your experiences of talking with the WhatsApp groups? For example, were there positive or negative experiences during the study?
   - Could you tell us about your relationship with other WhatsApp group members?
   - Prompts: Did you feel comfortable sending messages to the group?

6) **Messages:**
   - Were there any messages that did/did not work well (e.g. monitor activity, social support, information about opportunities).
   - How did you feel about the content of the messages?
   - How did you feel about the frequency of the messages?
   - How much time did you spend messaging the group each week?
   - Prompts: was it too much/too little time?
   - Do you think that any changes should be made to the messages before a future study? Please explain.

7) **Support:**
   - Could you tell us about your levels of contact with the research team? E.g. do/did you feel that you had enough support from the research team?
   - Could you tell us about your levels of contact with the other WhatsApp group leaders? E.g. did you talk with other individuals involved as a WhatsApp leader?
   - Do you think that there are ways to improve upon the levels of support individuals receive during the study? Please explain.

8) **Future involvement:**
   - How would you feel about getting involved in a future study?
   - Prompt: would you be willing to participate in the future? Please explain.