Factors influencing the implementation of aerobic exercise after stroke in the UK from stroke survivor, staff and system perspectives: a mixed methods approach

by

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A thesis submitted in partial fulfilment for the requirements for the degree of Doctor of Philosophy at the University of Central Lancashire

May 2024

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***Observational study (Chapter 4)** - The author was responsible for leading this research study and was the main contributor to the conceptualisation, methodology, validation, formal analysis, investigation, data curation, writing the original draft of the thesis chapter, and visualisation. Dr Alexander Harrison (PhD supervisor) contributed to the conceptualisation, methodology, validation, formal analysis, investigation, data curation, review of the thesis chapter and supervision. As part of the dissemination of this research, a peer-reviewed paper was produced. This was initially drafted by Dr Alexander Harrison, which the author reviewed and edited. The full write-up of this work contained within this thesis was solely produced by the author and reviewed by the PhD supervisors, Dr Alexander Harrison, Professor Louise Connell, and Dr Emma Bray. Professor Patrick Doherty leads on project administration of the NACR and granted approval for the use of the NACR data for this analysis. Professor Patrick Doherty and Professor Louise Connell also contributed to the review and editing of the published paper.

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ABSTRACT

Introduction

Aerobic exercise is beneficial after stroke and recommended in the UK National Clinical Guidelines for Stroke (2023), but there are challenges to its implementation.

Aim

To determine the factors influencing the implementation of aerobic exercise after stroke in the UK from the perspectives of stroke survivors, staff, and a system.

Methodology

A convergent mixed-methods design was used comprising three studies exploring perspectives on the implementation of aerobic exercise. A qualitative systematic review, analysed using the Consolidated Framework for Implementation Research (CFIR), explored staff perspectives. A quantitative retrospective observational study using data from the UK National Audit of Cardiac Rehabilitation (NACR) explored a system perspective. A mixed method (primarily quantitative) survey investigated stroke survivor perspectives. The study's findings were integrated in a joint display using the CFIR.

Findings

The integrated data showed points of convergence, but no divergence, with some single perspective factors. Convergent findings included the importance of aerobic exercise, support following stroke, and available resources. Stroke survivors and staff identified fear, lack of knowledge and motivation as barriers, and confidence as a factor. Stroke survivors' comorbidities, deprivation, and exercise preferences are factors in implementation planning. Single perspective factors included safety and perceived risk to the stroke survivor, skill-sharing, training, collaboration, and organisation of services.

Conclusion

This integration generated the most comprehensive understanding of the factors influencing implementation of aerobic exercise after stroke to date. First steps towards increasing implementation in the UK could involve development of an educational 'how-to' guide to

delivering aerobic exercise post-stroke to improve knowledge and confidence amongst staff, and therefore stroke survivors. Development of an implementation strategy should include collaboration and stakeholder involvement to maximise success.

Contributions to knowledge

This research comprises the first time that implementation of aerobic exercise after stroke in the UK has been explored by integrating staff, stroke survivor, and system perspectives. This has enabled identification of factors common to multiple perspectives, thereby providing unique insight into how targeting one modifiable factor could, in fact, simultaneously address others.

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ACKNOWLEDGEMENTS

There are so many people who have helped and supported me over the last 6 years of this PhD, far too many to name here. I would like to start by thanking my fantastic supervisory team, Professor Louise Connell, Dr Emma Bray, and Dr Alex Harrison, who have been with me for the entire duration of my PhD. I really appreciate your consistent support and kindness, and for sharing your knowledge with me. It's been a real privilege to learn from you all.

To Louise, who encouraged and supported me to embark on this journey and was my Director of Studies (DoS) at UCLan for over 5 years. I'm so grateful that you continued as my supervisor for this last year after moving to Lancaster University. Thank you for being unwaveringly positive and going above and beyond. You have been such an encouraging, wise, motivating, and pragmatic presence, as well as an inspirational role model and leader. I honestly couldn't have asked for anything more.

To Emma, thank you for your support and constructive feedback throughout, and for taking up the role of DoS in Louise's absence, which I very much appreciated.

To Alex, who spent many hours expertly explaining statistics and the NACR to me, thank you for being so generous with your time and knowledge, and for your incredible patience.

To my fabulous friend Hayley Lowther-Payne – a massive thank you for the chats, sensible advice, writing sessions, and your encouragements, especially over the last year. A very special thank you for helping to format my thesis, for proof-reading, and for sharing your organisational skills. I am more grateful than you will ever know.

Dr Alison McLoughlin and Dr Kez Warburton whom I met on UCLan's postgraduate remote writing sessions whilst we were all doctoral students during COVID – thank you for being such supportive friends and peers, for sharing your PhD experiences, both positive and negative, and for cheering me on to the end!

My grateful thanks to Prof Patrick Doherty at the University of York – thank you for your time and for collaborating with me on the work involving the NACR.

Thanks also to my manager, Dame Professor Caroline Watkins, for encouraging me with my PhD and enabling me to work very part-time over the last year so I could focus on completing it.

A special thanks to the stroke survivors, carers, and healthcare staff who shared their experiences and knowledge with me – you were hugely helpful in ensuring this work was relevant and useful. Thank you to the PRF, CSP and RDS for the funding awards that contributed towards this research.

To my friend, Sara Fisher – thank you for keeping me sane, listening patiently and providing wise advice during our open-water swimming (therapy) sessions!

Finally, thank you to my husband, family, and friends for supporting me during the 6 years of PhD. You will no doubt will be highly relieved that I've finally finished!!

PUBLICATIONS ARISING FROM THIS THESIS

Gaskins, N. J., Bray, E., Hill, J. E., Doherty, P. J., Harrison, A., & Connell, L. A. (2021). 'Factors influencing implementation of aerobic exercise after stroke: a systematic review', *Disability and Rehabilitation*, 43(17), pp. 2382–2396. doi: 10.1080/09638288.2019.1704075.

Harrison, A.S., **Gaskins, N.J.,** Connell, L.A. and Doherty, P. (2020). 'Factors influencing the uptake of cardiac rehabilitation by cardiac patients with a comorbidity of stroke', *IJC Heart & Vasculature*, 27, p.100471. doi: 10.1016/j.ijcha.2020.100471.

CONFERENCE PRESENTATIONS ARISING FROM THIS THESIS

Gaskins, N.J., Bray, E., Harrison, A.S, & Connell, L.A. (2024). 'UK stroke survivors' perspectives of aerobic exercise: an online survey'. *(Poster - European Life After Stroke Forum (ELASF) 2024).*

Gaskins, N.J., Harrison, A.S., Bray, E., Connell, L.A. (2023). 'What factors influence the uptake and completion of cardiac rehabilitation by people with comorbid stroke in the UK?'. *(Oral presentation - Physiotherapy Research Society (PRS) Conference 2023)*

Gaskins, N.J., Harrison, A.S., Connell, L.A., & Doherty, P. (2021). 'Comorbid stroke and cardiac rehabilitation: What factors influence completion?'. *(Oral e-poster presentation – Association of Chartered Physiotherapists in Neurology (ACPIN) Conference 2021)*

Gaskins, N.J., Bray, E., Hill, J., Doherty, P., Harrison, A.S., & Connell, L.A. (2019). 'Factors Influencing Implementation of Aerobic Exercise after Stroke: A Systematic Review'. *(Poster – Research @ UCLan Event 2020; Poster presentation - Society for Research in Rehabilitation (SRR) Winter Conference 2019; Poster - National Physiotherapy UK (PTUK) Conference 2019)*

FUNDING AWARDS

December 2021	National Institute for Health Research (NIHR) Research Design Service Public Involvement Fund - £350

November 2019	Chartered Society of Physiotherapy (CSP) Charitable Trust Academically Accredited Course Award - £1,200
May 2018 to April 2019	Physiotherapy Research Foundation Chartered Society of Physiotherapy (CSP) Charitable Trust Novice Researcher Award (Grant Number PRF/17/B01) – £25,000

DECLARATION OF CONTRIBUTIONS

Systematic review (Chapter 3) - The author led this review and held overall responsibility for the conceptualisation, methodology, validation, formal analysis, investigation, writing of the original draft of the published paper and thesis chapter, and visualisation. This included developing the objectives and search strategy, conducting the searches, title and abstract screening, data extraction and analysis. Professor Louise Connell (PhD supervisor) and Dr Emma Bray (PhD supervisor) contributed to conceptualisation, data extraction to fulfil the methodological requirements for systematic reviews, and reviewed and edited the published paper. Dr James Hill, an evidence synthesis expert, provided training and guidance to the author in the use of Rayyan, the automated screening software, and contributed to reviewing and editing of the published paper. Dr Alexander Harrison (PhD supervisor) and Professor Patrick Doherty (Director of the National Audit of Cardiac Rehabilitation (NACR)) contributed to conceptualisation, and review and editing of the published paper.

Observational study (Chapter 4) - The author was responsible for leading this research study and was the main contributor to the conceptualisation, methodology, validation, formal analysis, investigation, data curation, writing the original draft of the thesis chapter, and visualisation. This included using her clinical experience and findings from the systematic review to inform development of the study objectives and identification of the variables to be included in the analyses. Dr Alexander Harrison (PhD supervisor) contributed to the conceptualisation, methodology, validation, formal analysis, investigation, data curation, review of the thesis chapter and supervision. As part of the dissemination of this research, a peer-reviewed paper was produced. This was initially drafted by Dr Alexander Harrison, which the author reviewed and edited. The full write-up of this work contained within this thesis was solely produced by the author and reviewed by the PhD supervisors, Dr Alexander Harrison, Professor Louise Connell, and Dr Emma Bray. Professor Patrick Doherty leads on project administration of the NACR and granted approval for the use of the NACR data for this analysis. Professor Patrick Doherty and Professor Louise Connell also contributed to the review and editing of the published paper.

Survey (Chapter 5) - The author was the main contributor and responsible for leading this research study. She held overall responsibility for the conceptualisation, methodology, validation, formal analysis, investigation, writing of the original draft of the thesis chapter, and visualisation. This included developing the study objectives, study design, establishing and facilitating a patient and public involvement group, data collection and analysis. In their roles as PhD supervisors, Professor Louise Connell, Dr Alexander Harrison and Dr Emma Bray contributed to study conceptualisation and provided support with the analysis and feedback on the chapter drafts.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACPICR	Association of Chartered Physiotherapists in Cardiovascular Rehabilitation
ACSM	American College of Sports Medicine
AEx	Aerobic exercise
AEROBICS	Aerobic Exercise Recommendations to Optimize Best Practices In Care after Stroke
AHA	American Heart Association
APEASE	Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability, Safety/side-effects, Equity
ARNI	Action for Rehabilitation in Neurological Injury
ASA	American Stroke Association
BACPR	British Association for Cardiovascular Prevention and Rehabilitation
BHF	British Heart Foundation
BMI	Body Mass Index
CABG	Coronary Artery Bypass Graft
CAG	Confidential Advisory Group
CASP	Critical Appraisal Skills Programme
CCP UK	Cardiovascular Care Partnership UK
CERQual	Confidence in Evidence from Reviews of Qualitative research
CFIR	Consolidated Framework for Implementation Research
CHD	Coronary heart disease
CI	Confidence Interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
COM-B	Capability, Opportunity, Motivation - Behaviour
CHD	Coronary Heart Disease
CR	Cardiac Rehabilitation
CV	Cardiovascular
CVD	Cardiovascular disease
DGH	District General Hospital
DNA	Did Not Attend

EMBASE	Excerpta Medica database
GDPR	General Data Protection Regulation
GP	General Practitioner
GRADE	Grading of Recommendations Assessment, Development and Evaluation
GRIPP2-SF	The Guidance for Reporting Involvement of Patients and the Public Short Form
ICS	Integrated Care System
ID	Identification
IMD	Index of Multiple Deprivation
INTEGRATE-HTA	Integrated Health Technology Assessment for Evaluating Complex Technologies
ISDN	Integrated Stroke Delivery Network
MDT	Multidisciplinary team
MI	Myocardial infarction
NACR	National Audit of Cardiac Rehabilitation
NCP_CR	National Certification Programme for Cardiac Rehabilitation
NHS	National Health Service
NPT	Normalisation Process Theory
NROL	Neuro Rehab OnLine
PA	Physical Activity
PAD	Peripheral arterial disease
PARIHS	Promoting Action on Research Implementation in Health Services
PCI	Percutaneous Coronary Intervention
PCPI	Patient, Carer and Public Involvement
PICO	Population/problem, Intervention/exposure, Comparison, and Outcome
PIS	Participant Information Sheet
PRISM	The Practical, Robust, Implementation and Sustainability Model
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	Prospective register of systematic reviews
RCT	Randomised controlled trial

RETREAT	Review question, Epistemology, Time/Timescale, Resources, Expertise, Audience and purpose, Type of Data
SOEE	Short Outcome Expectations for Exercise Scale
SPIDER	Sample, Phenomenon of Interest, Design, Evaluation, Research type
SPSS	Statistical Package for the Social Sciences
SSNAP	Sentinel Stroke National Audit Programme
START	Stroke Aerobic Exercise Implementation Toolkit
STROBE	STrengthening the Reporting of OBservational studies in Epidemiology
TDF	Theoretical Domains Framework
TIDieR	Template for Intervention Description and Replication
TIA	Transient ischaemic attack
UCLan	University of Central Lancashire
UK	United Kingdom
US	United States
USA	United States of America
UCLan	University of Central Lancashire
WHO	World Health Organisation

CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 Chapter overview

This chapter sets the context for this thesis, providing an overview of the key concepts considered for this research including the aetiology and epidemiology of stroke, the impact of stroke, stroke care in the United Kingdom (UK), and evidence for exercise after stroke. Current knowledge of challenges associated with implementing aerobic exercise after stroke is presented, along with a rationale for this research. The chapter concludes with the aims and objectives of the thesis, and an outline of the structure of the thesis.

1.2 Aetiology of stroke

The World Health Organisation (WHO) states that cardiovascular disease (CVD) is a non-communicable disease which accounts for the deaths of 17.9 million people annually across the globe (WHO, 2018). It affects around 7.6 million people in the UK alone (British Heart Foundation, 2018). Healthcare costs associated with stroke are estimated at £10 billion per year with around a £25 billion overall cost to the UK's economy (British Heart Foundation, 2018, Patel et al., 2019). Stroke is a type of CVD (WHO, 2021), defined by the WHO as "rapidly developed clinical signs of focal or global disturbance of cerebral function, lasting more than 24 hours or until death, with no apparent non-vascular cause" (WHO, 1988).

1.2.1 Classification

The National Health Service (NHS) classifies two main types of stroke, ischaemic and haemorrhagic, with transient ischaemic attacks described as an associated condition. Ischaemic stroke is the most common type and occurs when the blood supply to part of the brain is blocked or reduced, sometimes by a blood clot (NHS, 2022). Haemorrhagic stroke is caused by bleeding inside the brain due to a burst, or leaking, blood vessel. Transient ischaemic attacks are classed as mini-strokes, whereby the blood supply is temporarily interrupted and symptoms last no longer than 24 hours (NHS, 2022).

1.3 Epidemiology

Globally, the prevalence and incidence of stroke continues to increase, and it is now the second greatest cause of death and third-greatest cause of death and disability combined

(Feigin et al., 2021). In the UK, a 60% increase in the number of strokes by 2035 has been predicted, unless preventative measures are taken (King et al., 2020). Furthermore, around 1.4 million people in the UK have survived a stroke or transient ischaemic attack (British Heart Foundation, 2018), and this number is projected to double by 2035 (King et al., 2020). As well as being the main cause of severe disability in the UK, stroke carries a significant economic burden (Bhatnagar et al., 2015, British Heart Foundation, 2018, Stroke Association, 2018). In light of the projected increase in incidence of stroke and the increasing number of people living with disability caused by stroke due to improvements in survival rates, the NHS Long Term Plan published in 2019 identified stroke as a 10-year priority (NHS, 2019).

1.3.1 Risk factors

Risk factors for CVD, and therefore stroke, can be divided into behavioural factors, including smoking, an unhealthy diet, physical inactivity and excessive use of alcohol, and physiological factors, such as hypertension, hypercholesterolaemia, and hyperglycaemia (WHO, 2024a). A family history of CVD is also linked with an increased risk of CVD (National Health Service (NHS), 2018). Some behavioural factors can lead to physiological factors, for example, an unhealthy diet can lead to hypertension and hypercholesterolaemia.

These risk factors are linked to the wider social determinants of health, the conditions in which people are born, live, work and age (WHO, 2024b). Inequalities in these determinants cause health inequalities which are unfair and avoidable differences in access to and experiences of healthcare (Williams, 2022). Socioeconomic inequalities in the UK are measured using the Index of Multiple Deprivation (IMD), which is described in more detail in Chapter 4. Socioeconomic deprivation is associated with stroke risk factors, incidence and severity (Avan et al., 2019, Bray et al., 2018), with people living in the most deprived areas of England four times more likely to die prematurely from CVD than people living in least deprived areas (Public Health England, 2018b).

1.4 Impact of stroke

Stroke is the leading cause of severe disability in the UK (British Heart Foundation, 2018). The symptoms vary, both in terms of severity and type, depending on the part of the brain affected (National Institute for Health and Care Excellence, 2019). Stroke patients often experience cognitive, psychosocial, and physical impairments, as well as poor cardiovascular health (Baert et al., 2012, Stroke Association, 2024a). Cognitive impairments may include changes in concentration or memory and difficulties in understanding, planning and carrying out tasks (Husseini et al., 2023). A person's psychosocial well-being can also be affected, examples of which are depressive symptoms, anxiety, and social isolation (Kirkevold et al., 2018). Physical effects range from poor balance or mobility and changes in muscle tone to fatigue and visual problems. Hemiparesis or weakness on one side of the body is a common neurological consequence of stroke, leading to movement impairments, and reduced mobility and function (Saunders et al., 2020). Aside from the direct effects on the person, stroke impacts other aspects of life, including employment for stroke survivors and carers, informal caring, health and social care, and the economy (Stroke Association, 2018). The overall cost of stroke is projected to rise to £43 billion in 2025 and then to £75 billion by 2035 (Stroke Association, 2018).

1.5 Sedentary behaviour and physical inactivity

Sedentary behaviour, defined as waking time spent lying, reclining or sitting with a low expenditure of energy, is high amongst stroke survivors (Morton et al., 2019, English et al., 2014), accounting for around 81% of their daytime up to one year after stroke (Tieges et al., 2015). Sedentary behaviour has been linked with increased risk of CVD in adults (Morton et al., 2019). Low levels of physical activity after stroke have also been evidenced (Fini et al., 2017). Physical activity is any movement of the body using skeletal muscle which involves expending energy (WHO, 2023), and therefore physical inactivity differs to sedentary behaviour. Current UK recommendations are for a minimum of 150 minutes of moderate-intensity physical activity per week for adults (Department of Health & Social Care, 2019). Bernhardt et al. (2004) reported that the majority of patients in stroke rehabilitation spent most of their time sitting or lying, doing very little. It is concerning that inactivity and sedentary behaviour have continued to be reported in the literature since then (English et al., 2016, Fini et al., 2017, Tieges et al., 2015, Luker et al., 2015, Morton et al., 2019), despite stroke survivors' acknowledgement of the importance of physical activity and exercise for their recovery (Reinholdsson et al., 2024) and its inclusion in clinical guidelines (Intercollegiate Stroke Working Party, 2023).

Post-stroke physical inactivity and sedentary behaviour, due often to physical and cognitive effects of stroke (Fini, Bernhardt and Holland, 2022), lead to a negative cycle of decreased function, deconditioning, and reduced levels of fitness (Saunders et al., 2020), and are linked to recurrent stroke (Saunders et al., 2021). In the UK and the United States of America (USA), around 25% of all strokes are recurrent strokes (National Institute for Health and Care Excellence, 2019, Benjamin et al., 2018). Overall, the effects of physical inactivity and sedentary behaviour decrease a person's ability to carry out activities of daily living and reduce their quality of life after stroke (Winstein et al., 2016).

1.6 Stroke and cardiovascular health

Stroke can lead to cardiovascular complications such as myocardial infarction and heart failure, even in people without known heart disease at the time of their stroke (Sposato et al., 2020). Stroke survivors with new onset cardiovascular conditions have been reported to have more than 50% prevalence of further stroke five years after their initial stroke (Buckley et al., 2022), further highlighting the importance of secondary prevention. Physical inactivity and sedentary behaviour are in themselves risk factors for stroke, as well as influencing other risk factors such as hypertension (Hayes et al., 2022, O'Donnell et al., 2016), and may be linked to some of the consequences of stroke (Reinholdsson, Palstam and Sunnerhagen, 2018). Their negative effect on cardiovascular health is also linked with the physical and cognitive impairments of stroke, and so, form a vicious circle which is illustrated in *Figure 1.1* (Welsh 2020).

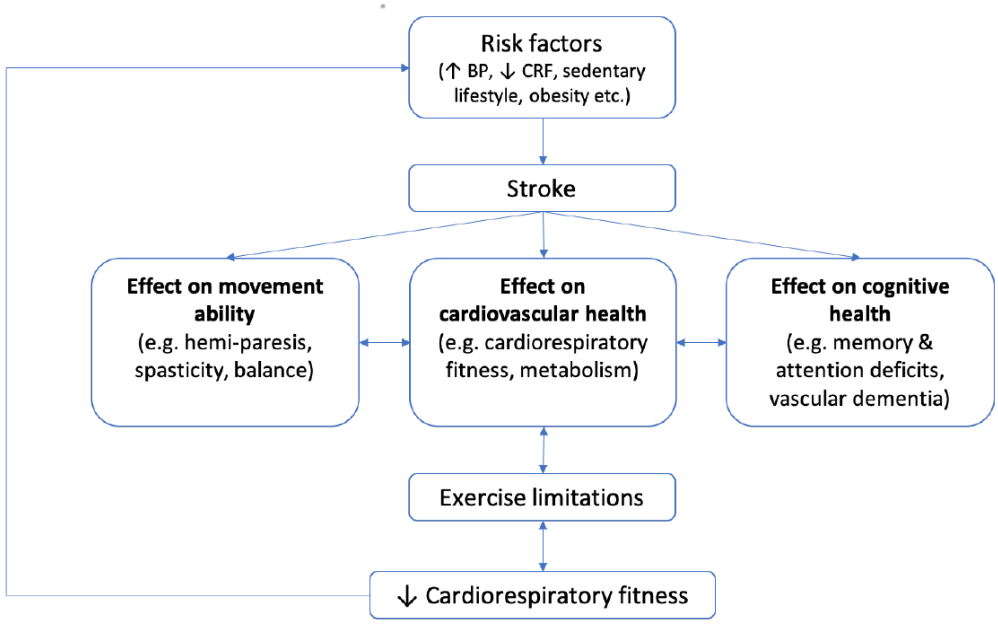

Figure 1.1. The cyclical process of the impact of stroke and exercise limitations. Welsh (2020), adapted from Saunders et al. (2020). Physical fitness training for stoke patients. Cochrane Database of Systematic Reviews.

1.7 Overview of stroke care in the UK

The stages of recovery following stroke have been defined as hyper-acute (0 - 24 hours), acute (1 - 7 days), early subacute (7 days – 3 months), late sub-acute (3 – 6 months) and chronic (> 6 months), and are linked to biological processes which occur at different timepoints (Bernhardt et al., 2017). In the UK, the hyperacute stage generally covers the first 72 hours post-event (NHS England, 2021). Stroke is a complex condition, so it follows that rehabilitation after stroke should be a multi-faceted person-centred complex intervention. Stroke care consists of core elements, but delivery varies widely across the UK (Sentinel Stroke National Audit Programme (SSNAP), 2023, Fulop et al., 2019), so the following subsection provides a brief overview of stroke care in general in the UK.

1.7.1 Stroke pathway

The UK stroke pathway has a total of five stages, with the first stage focussed on prevention, delivered through Integrated Stroke Delivery Networks (ISDNs) (*Figure 1.2*). The other four stages map out the person’s journey following a stroke, beginning with urgent care, then acute care, rehabilitation, and long term support (NHS England, 2021), as follows:

- **Urgent care** – Hyperacute care involves investigations such as brain imaging, and emergency treatments including thrombolysis and thrombectomy which may be administered at a hyperacute stroke unit (NHS England, 2021).
- **Acute care** – The focus of acute care is to preserve the person's life, limit damage to their brain, and prevent complications, and is ideally provided on a stroke unit. At this stage, those with movement difficulties are assessed regarding safe transfers and mobilisation. Once the person is medically stable, they can mobilise short distances daily if they are able (Intercollegiate Stroke Working Party, 2023).
- **Rehabilitation** – For an effective rehabilitation stage, multidisciplinary team members from inpatient rehabilitation, early supported discharge, and community stroke or neuro-rehabilitation services must work collaboratively for the benefit of the stroke survivor (NHS England, 2021). Services that may be required at this stage include physiotherapy, occupational therapy, speech and language therapy, orthoptics psychological support, and vocational rehabilitation (National Institute for Health and Care Excellence, 2023). Some of these services may also continue to be required in the last stage of the pathway, life after stroke.
- **Life after stroke services** – These provide tailored support for long-term needs as they arise, to facilitate condition management, minimise the risk of further cardiovascular events and maximise health and well-being (NHS England, 2021). They should be accessible from the acute stage (NHS England, 2021).

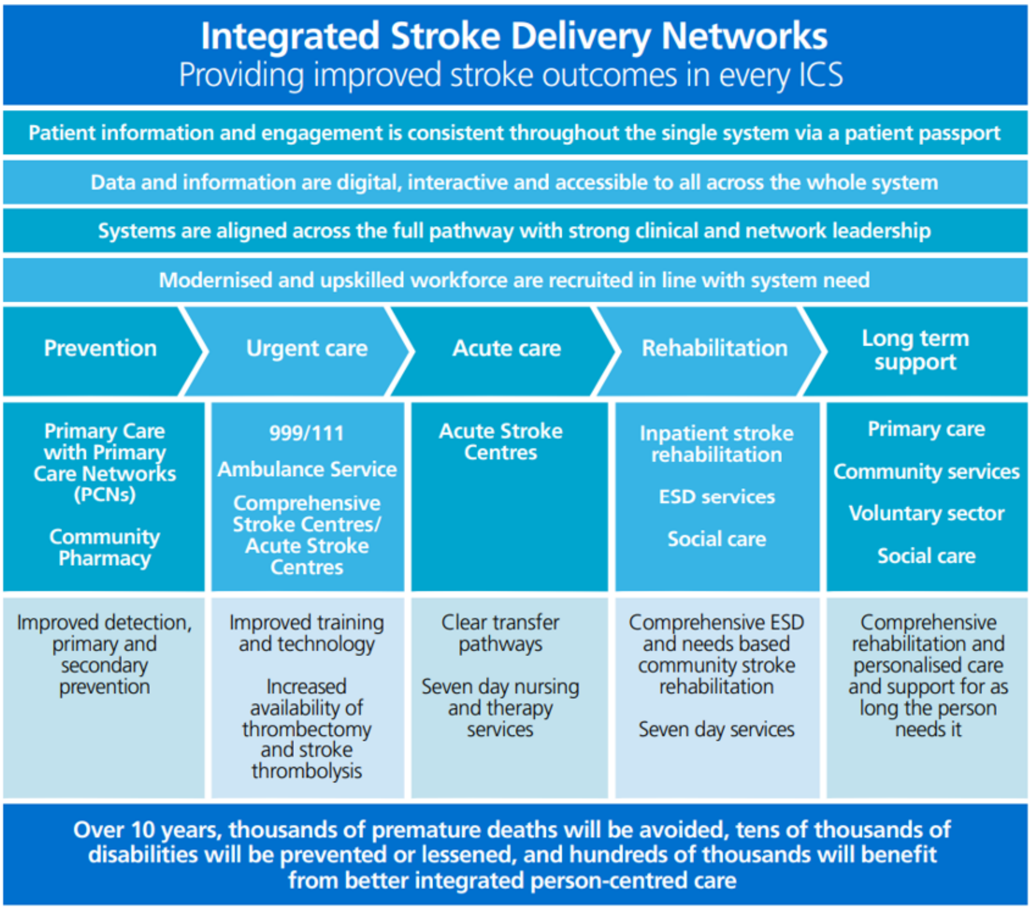

Figure 1.2. Integrated Stroke Delivery Network (ISDN) Infographic (NHS England, 2021)

1.7.2 Impact of COVID-19

The COVID-19 pandemic caused mass disruption and has had lasting effects on the delivery of services, including care after stroke, thereby impacting stroke survivors. During the pandemic, stroke services across the entire pathway were rapidly adapted and changed through necessity, with the introduction of new interventions and ways of working (Ford et al., 2020). A movement towards the use of technology, such as video consultations, remote or hybrid delivery of services, and telerehabilitation, were rolled out quickly (Ford et al., 2020). Some of these practices have been retained, or modified and implemented, resulting in permanent changes to ways of working. Within stroke care, examples of alternative models of delivery currently in use include virtual wards, telephone consultations at follow-up stroke clinics, and the NROL (Neuro-Rehab OnLine) service (Ackerley et al., 2023, Ford et al., 2020).

These changes have had both positive and negative consequences for stroke survivors. For some, the diversification of mode of delivery and use of technology has improved their access to services and support; yet for others, their lack of access to technology has widened the digital divide (Watts, 2020, Litchfield, Shukla and Greenfield, 2021). As well as the effects on stroke services, there is also evidence of a link between the COVID-19 virus and risk of associated stroke (Belani et al., 2020, Fifi and Mocco, 2020). This may have had an effect on incidence of stroke globally (Fifi and Mocco, 2020), and is likely to have increased the number of stroke survivors and thus the need for rehabilitation and secondary prevention interventions.

1.8 Secondary prevention

The risk factors for stroke can be categorised as modifiable, those which can be influenced by the person’s lifestyle, or non-modifiable, such as age or family history (Boehme, Esenwa and Elkind, 2017). The WHO advises tackling the effects of these diseases by targeting the modifiable risk factors (WHO, 2018). This involves strategies for adopting a healthy lifestyle including smoking cessation, consuming a healthy diet, reducing excessive alcohol intake, and undertaking regular physical activity.

1.8.1 Physical activity and exercise

Regular physical activity and/or exercise are recommended by the American College of Sports Medicine (ACSM) and come with a list of health benefits ranging from improvements in all-cause mortality and cardiorespiratory function to enhanced well-being and mental health, reduction in falls and risk of noncommunicable diseases (American College of Sports Medicine, 2018, Department of Health & Social Care, 2019, WHO, 2018). The terms ‘physical activity’ and ‘exercise’ are often used interchangeably, but they are different. Physical activity is defined as any movement of the body using skeletal muscle that involves energy expenditure, and may include occupational and leisure activities such as cleaning, walking, and sports (Caspersen, Powell and Christenson, 1985, American College of Sports Medicine, 2018). It can be carried out at a range of intensities, from light to very vigorous, which are estimated using a variety of methods such as heart rate and metabolic equivalents (American College of Sports Medicine, 2018). Physical activity guidelines in the UK recommend that adults should be physically activity every day and accumulate at least 150 minutes of moderate intensity activity, 75 minutes of vigorous intensity activity, or shorter periods of very vigorous intensity activity each week (Department of Health & Social Care, 2019). Adults aged 65+ are encouraged to include moderate aerobic activity as part of their physical activity to improve cardiovascular health (Department of Health & Social Care, 2019). Physical activity is also recommended after stroke as it reduces the risk of further stroke, improves blood pressure and cholesterol levels, and aids recovery after stroke (Fini et al.). Physical inactivity is defined as failing to meet the current recommendations for physical inactivity, which was estimated to be the case for over 25% of adults globally in 2016 (WHO, 2020). Furthermore, a Swedish study of patients with mild, moderate or severe stroke (n = 925) reported that 52% were physically inactive pre-stroke (Reinholdsson, Palstam and Sunnerhagen, 2018).

Exercise is a type of physical activity that is planned, regular, and structured, and is undertaken with the aim of improving or maintaining physical fitness (Caspersen, Powell and Christenson, 1985). Physical fitness is described as a set of health- and/or skill-related attributes that are linked to an individual's ability to carry out physical and daily activities (American College of Sports Medicine, 2018). The components of physical fitness are cardiorespiratory (endurance), musculoskeletal (strength and power), flexibility, balance, and body composition, although cardiorespiratory and musculoskeletal fitness have been described as the most important (Saunders et al., 2020). Low levels of cardiorespiratory and musculoskeletal fitness have been associated with loss of independence, decreased mobility, and reduced ability to carry out activities of daily living in older adults (McKinnon et al., 2017, Hasegawa et al., 2008, Shephard, 2009).

1.8.2 Cardiorespiratory fitness

Cardiorespiratory fitness is a health-related component of physical fitness and relates to the circulatory and respiratory systems' abilities to transport and use oxygen for physical work for a prolonged period of time (Liguori, 2020). It is important as reduced levels of cardiorespiratory fitness have been associated with increased risk of premature death, whereas high levels have been associated with both reduced death from all causes and increases in physical activity levels with the accompanying proven benefits to health (Liguori, 2020). Cardiorespiratory fitness can be reduced by stroke because of physiological changes to muscle fibre types and haemodynamic function (Billinger et al., 2012a). It has been reported that the level of cardiorespiratory fitness in those with mild stroke may be around 53% of healthy individuals (Smith, Saunders and Mead, 2012). Lower cardiorespiratory fitness levels, coupled with increased energy expenditure due to inefficient movement patterns post-stroke, can limit rehabilitation (Tang et al., 2009, Billinger et al., 2015). Furthermore, this is functionally significant for stroke survivors, as having a fitness level which is below that needed to carry out daily activities can result in further loss of independence (Saunders et al., 2020). The culmination of these issues has a negative impact on performance of the activities of daily living and quality of life for stroke survivors, as well as increased risk of a further cardiovascular event.

1.9 Aerobic exercise

Cardiorespiratory fitness is the ability of the respiratory and circulatory systems to transport and use oxygen for the purpose of performing physical work or activity for an extended period of time (Liguori, 2020). It can be improved by undertaking aerobic-type endurance exercise, with an emphasis on the intensity, frequency, and duration of the aerobic activity (Liguori, 2020). According to the American College of Sports Medicine, aerobic exercise is any planned activity that uses large muscle groups, is rhythmic, can be sustained continuously, and aims to improve the cardiorespiratory fitness of an individual (Liguori, 2020). Aerobic activities, such as swimming, dancing, walking or running, can contribute to meeting the recommended levels of physical activity without improving cardiorespiratory fitness, so the dose-response relationship is vital to achieve the purpose of increasing endurance and cardiorespiratory fitness, the difference between physical activity and aerobic exercise (Liguori, 2020, Saunders et al., 2020). Aerobic exercise is an evidence-based intervention that promotes cardiovascular health (Patel et al., 2017) and is recommended for both healthy populations (Garber et al., 2011) and those with specific conditions including stroke and coronary heart disease (Meneses-Echávez, González-Jiménez and Ramírez-Vélez, 2015, Thomas, Elliott and Naughton, 2006, Billinger et al., 2014, Gielen et al., 2015).

1.9.1 Aerobic exercise after stroke

Stroke survivors often experience reduced levels of cardiorespiratory fitness due to the physical, physiological, and metabolic effects of stroke (Ivey et al., 2005, Moncion et al., 2024, Welsh, 2020, Billinger et al., 2012a). Decreased cardiorespiratory fitness can limit rehabilitation, lead to difficulties with activities of daily living, and loss of independence (Tang et al., 2009, Saunders et al., 2020), so improving cardiorespiratory fitness post-stroke through participation in aerobic exercise is clearly beneficial. Increasing cardiorespiratory fitness also contributes to secondary prevention, not just for CVD, but also cancer, respiratory disease, and diabetes (WHO, 2018).

There is compelling evidence that aerobic exercise has a range of physical and psychosocial benefits post-stroke, with less, although growing, evidence for cognitive benefits. Improvements in mobility and walking speed (Kendall and Gothe, 2016, Quaney et al., 2009), balance (van Duijnhoven et al., 2016), and blood pressure (Wang et al., 2018, D'Isabella et al., 2017) amongst stroke survivors have been reported. Exercise promotes psychosocial wellbeing (van Nimwegen et al., 2023), with stroke survivors identifying this as a reason to attend exercise programmes (Poltawski et al., 2015). In comparison with the physical and psychological benefits of exercise after stroke, the cognitive benefits have been under-investigated to date (Saunders et al., 2020, Welsh, 2020). However, there is some research that suggests exercise is associated with improved cognitive function in people with chronic stroke (Liu-Ambrose et al., 2022, Swatridge et al., 2017), particularly around executive function (planning and problem-solving) (Deijle et al., 2024). Exercise-based interventions play an important role in secondary prevention (D'Isabella et al., 2017), reducing disability (Saunders et al., 2016), and improving ability to carry out daily activities (Billinger et al., 2014). Furthermore, exercise was identified as one of the top ten priorities for stroke research in the UK Stroke Priority Setting Partnership, meaning it is important both for people affected by stroke and the health and care professionals working within stroke care (James Lind Alliance, 2021).

1.10 Exercise prescription

Exercise prescription should be individualised for aerobic exercise to be effective, and can be guided by the ACSM FITT principles of frequency (F) in terms of how often to exercise, intensity (I) for how hard to exercise, time (T) for the duration of exercise, and type (T) for the kind of exercise (Liguori, 2020). The ACSM also provides general guidance on exercise prescription using the FITT principles following stroke, although the characteristics of the individual, such as comorbidities and stroke-related impairments, must always be taken into consideration so that appropriate adaptations can be made (Liguori, 2020). Aerobic exercise is beneficial during all phases of stroke recovery, from acute (Cumming et al., 2011), to subacute (Stoller et al., 2012) and chronic (Eng et al., 2003, Billinger et al., 2014), and should be included throughout stroke rehabilitation (Billinger et al., 2014). Research literature and current guidelines strongly support participation in aerobic exercise after stroke (Intercollegiate Stroke Working Party, 2023, Kleindorfer et al., 2021, Heart and Stroke Foundation Canadian Partnership for Stroke Recovery, 2019, Stroke Foundation, 2017). There is evidence to support the use of aerobic exercise for people who are non-ambulant as well as ambulant after stroke (Valkenborghs et al., 2019). In spite of this, a survey of USA-based physiotherapists found that, although almost 90% believed aerobic exercise should be part of rehabilitation after stroke, only 72% were able to prescribe aerobic exercise when it was indicated, and only 39% were confident in all aspects of exercise prescription (Boyne et al., 2017a). Furthermore, a similar survey of physiotherapists working in neurorehabilitation in Canada reported that 88% agreed it should be included in neurological rehabilitation, compared with 77% actually prescribing aerobic exercise in their practice (Doyle and MacKay-Lyons, 2013).

This lack of exercise prescription after stroke contrasts strongly with the routine inclusion of exercise as a component of cardiac rehabilitation (CR) (British Association for Cardiovascular Prevention and Rehabilitation, 2023), given that both stroke and coronary heart disease (CHD) are forms of CVD with similar risk factors and aetiology (WHO, 2021). CR is a multi-faceted intervention including education and exercise, which aims to address risk factors and encourage long-term change for secondary prevention (Dalal, Doherty and Taylor, 2015). In the UK, specific standards and guidelines for the process of referral, assessment, goal-setting, exercise prescription and delivery within CR have been published by the British Association for Cardiovascular Prevention and Rehabilitation (British Association for Cardiovascular Prevention and Rehabilitation, 2023) and the Association of Chartered Physiotherapists in Cardiovascular Rehabilitation (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). CR has been investigated as a model of delivery of aerobic exercise after stroke and proven to be feasible and effective, including within the UK

(Prior et al., 2017, Billinger et al., 2012b, Clague-Baker et al., 2022, Cuccurullo et al., 2022). However, implementation of adapted CR after stroke is challenging in terms of provision, referral, and uptake (Marzolini, 2020). Within the UK, people with cardiac conditions are prioritised for referral to CR due to local policy and resources (British Association for Cardiovascular Prevention and Rehabilitation, 2023), whereas those with a primary diagnosis of stroke are rarely eligible for CR. Currently, there is no equivalent to CR available after stroke in the UK.

1.11 Implementation

Implementation is defined simply as “the process of making something active or effective” (Merriam-Webster.com Dictionary, 2024). However, in reality, the process of implementing an evidence-based intervention involves a variety of factors and is highly complex in nature (van Gemert-Pijnen, 2022).

1.11.1 Implementation of aerobic exercise after stroke

In the UK, the clinical guidelines for stroke now recommend that all stroke survivors who are medically stable should be offered exercise which improves their cardiorespiratory fitness, and provide a recommended dose and type of exercise (Intercollegiate Stroke Working Party, 2023). This extra guidance and rationale for exercise is a vast improvement on the previous version of these guidelines (Royal College of Physicians Intercollegiate Stroke Working Party, 2016), but still does not address the challenge of how to actually implement aerobic exercise into practice. Indeed, to date, most research on exercise after stroke has tended to focus on the delivery of exercise programmes of various formats on patient outcomes (Boyne et al., 2017b, Biasin et al., 2014, Moncion et al., 2024, Tang et al., 2013). Examples include seated exercise versus standing (Barbosa, Santos and Martins, 2015), aerobic exercise (Biasin et al., 2014) (Mansfield et al., 2017), circuit classes and exercise intensity (Marsden et al., 2017, van de Port et al., 2012), different frequencies and durations of exercise (Billinger et al., 2015, Marsden et al., 2013), and inclusion of educational components and community-based group exercise (Cramp et al., 2010).

In contrast with the UK, the Canadian guidelines provide specific recommendations on the provision of aerobic exercise after stroke supported by an implementation strategy (MacKay-

Lyons et al., 2019). It was recognised that the guidelines alone were lacking in specific screening and exercise prescription protocols, resulting in limited implementation of the recommendations. Hence the Aerobic Exercise Recommendations to Optimize Best Practices In Care after Stroke (AEROBICS) project was undertaken (MacKay-Lyons et al., 2019). A structured approach was used to consolidate what is known about aerobic exercise for people after stroke or transient ischaemic attack into a concise and user-friendly set of recommendations for clinicians (Heart and Stroke Foundation Canadian Partnership for Stroke Recovery, 2013). Included within this clinician's guide were recommendations on pre-exercise screening, exercise prescription, the format of exercise sessions and outcome measures for all stages of stroke (Heart and Stroke Foundation Canadian Partnership for Stroke Recovery, 2013). However, in spite of these resources, the implementation of aerobic exercise after stroke in Canada still remains inconsistent and challenging, prompting researchers to continue to investigate the reasons for this, with the aim of developing effective strategies to improve clinical implementation (Inness et al., 2022). Studies around the barriers and facilitators to the implementation of exercise after stroke have tended to focus on physiotherapists' views, but exercise can be delivered by other professionals and in contexts other than a clinical healthcare setting (Condon and Guidon, 2018). Furthermore, a multitude of contextual factors, including individuals, can influence its implementation, such as policy and guidelines, organisations, managers, implementation leads, deliverers and recipients of the intervention (Damschroder et al., 2022).

1.11.2 Implementation science

Implementation science is defined as "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services" (Eccles and Mittman, 2006). It is known that implementing evidence into practice is a complex process with a cited gap of around 17 years between evidence generation and its implementation (Morris, Wooding and Grant, 2011). However, the speed at which changes to practice were implemented during the COVID-19 pandemic has raised questions around why the evidence-to-practice gap was previously so long. Implementation science, or implementation research, emerged in response to the growing realisation of this problem and the necessity for finding effective methods or strategies for promoting the uptake of evidence-based interventions into healthcare practices (Eccles and Mittman, 2006). Clearly, evidence-based practices are of limited use if they are not adopted successfully into practice.

There are certain elements which are important and should be considered in the implementation of any intervention; evidence, context, individuals, and change (Lynch et al., 2018). Firstly, the evidence behind the intervention needs to be robust. There is strong evidence in the form of published research and clinical guidelines worldwide supporting the benefits of aerobic exercise after stroke (D'Isabella et al., 2017, Kendall and Gothe, 2016, Intercollegiate Stroke Working Party, 2023). Secondly, the context in which it will be delivered will influence the effectiveness of the implementation (Waltz et al., 2019, Nilsen and Bernhardsson, 2019). In this case, the context will vary, due to both the diverse range of settings, such as public or private healthcare, or leisure centres, and the variations within those settings themselves. Thirdly, the individuals who are delivering or implementing this intervention often differ from one setting to another, as will the needs of the people who are the recipients of this intervention, meaning knowledge of workforce and local populations is essential for successful implementation. Finally, the process of change should be explored, so this can be made explicit and recorded for future learning and adaptation of the implementation (Lynch et al., 2018).

The aim of implementing evidence into practice is to improve patient care and the quality of healthcare services. Implementation research and the development of implementation strategies have previously been given little attention, meaning this is a relatively new scientific discipline in which interest has increased particularly since the 2000s (Nilsen and Birken, 2020). Understanding the factors that influence the implementation of aerobic exercise after stroke in the UK from different perspectives could facilitate the design of an effective implementation strategy to overcome this evidence-to-practice gap.

1.12 Positionality and reflexivity

Positionality influences a researcher's choice of research topic and methods, the lens through which they view the findings, and conclusions they reach (Malterud, 2001, Holmes, 2020). The author has been a physiotherapist for 27 years and has worked in both the NHS and private practice. At the time she commenced her MPhil (now PhD), she had been working in research part-time for three years. The author's interest in aerobic exercise after stroke stemmed from her previous clinical experience and expertise in CR and, to a lesser extent, experience within acute stroke rehabilitation in the NHS. Having one member of her PhD supervisory team who was an expert in stroke rehabilitation and stroke research therefore enabled constructive academic discussions around stroke, the research in this thesis, and the decisions made. The author knew that aerobic exercise was routinely offered as part of CR as she was delivering this as part of her clinical practice, and that there were specific guidelines and standards provided to guide clinicians in the assessment, prescription, and delivery of this intervention (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023, British Association for Cardiovascular Prevention and Rehabilitation, 2023). She realised that aerobic exercise was not used routinely within stroke rehabilitation, despite its benefits after stroke, and the fact that stroke and CHD are both CVDs. Her knowledge that aerobic exercise specifically improves cardiorespiratory (aerobic) fitness and contributes to secondary prevention influenced her decision to focus on, and use the term, 'aerobic exercise' for this thesis, rather than 'physical activity' which is not performed at sufficient intensity to increase cardiorespiratory fitness, or 'exercise', which includes strength, flexibility, and balance training as well as aerobic training.

Given the increasing prevalence of stroke and the significant impacts it can have on stroke survivors and their families, the author knew that it is vital that rehabilitation and leisure services offer opportunities such as participation in physical activity and exercise to improve the quality of life and daily functioning for stroke survivors. Whilst aerobic exercise is recommended globally in the literature and clinical guidelines for secondary prevention and to improve the quality of life for stroke survivors, there are substantial challenges around its implementation in the UK. Furthermore, there is limited understanding of the factors that influence the implementation of aerobic exercise after stroke, particularly from different perspectives. Therefore, the first step in addressing the challenge of implementation was to identify, from multiple perspectives, what these factors are. The work within this PhD addressed this first step, and it was hoped that this would be used to inform the development of effective implementation strategies in collaboration with stakeholders to increase the implementation of aerobic exercise after stroke.

The author recognised that being a physiotherapist with clinical and research experience was advantageous for this research in terms of the subject and context. However, she was acutely aware that her views and experiences were likely to differ from others, due particularly to the different perspectives being explored and changes to practice since she had last worked in the NHS. She also recognised that her professional and personal experiences could influence the direction of the research and her approach to the analysis and interpretation of the results (Creswell, 2014). She endeavoured to prevent her personal biases affecting the research and was supported in this by an experienced supervisory team from a range of professional backgrounds with clinical and research expertise that included stroke, cardiac rehabilitation, clinical psychology, and research design. The involvement of the public and those with lived experience of stroke at different points throughout the research provided alternative views to that of the author, which prompted reflection, and influenced the direction of the research at times. The discussions with the patient and public involvement group whilst developing the survey for the study 3 (chapter 5) provided some insight into the lives of stroke survivors and their participation in research, as well as cultural factors that needed to be considered when developing an implementation strategy. As the author recognised that she lacked recent clinical experience, she had informal conversations with colleagues currently in clinical practice, and later chose to conduct stakeholder engagement meetings with practicing stroke staff regarding the integrated findings.

1.13 Research question

The purpose of this thesis was to explore the research question:

What are the factors, from stakeholder perspectives, influencing implementation of aerobic exercise after stroke, and how can these inform implementation strategies to increase delivery of aerobic exercise in the UK?

Three studies were conducted to explore the stakeholder perspectives and thereby answer the following questions:

1. What is already known about the factors influencing delivery of aerobic exercise after stroke from a staff perspective?
2. What implementation factors can be learned from stroke survivors accessing cardiac

rehabilitation in the UK?

3. What are UK stroke survivors' views of aerobic exercise?

1.14 Aim of the thesis

The overall aim of this research was to determine the factors influencing the implementation of aerobic exercise after stroke in the UK from the perspectives of stroke survivors, staff, and a system.

1.15 Objectives of the thesis

There were four objectives for this thesis as follows:

- **Thesis Objective 1** – To conduct a systematic review of the literature to identify and collate existing evidence about the factors influencing the delivery of aerobic exercise after stroke from the perspectives of **staff** working within healthcare, exercise, or fitness settings.
- **Thesis Objective 2** – To conduct a retrospective observational study using **system**-level data of CR to explore the factors associated with the uptake and completion of CR by people with comorbid stroke in the UK.
- **Thesis Objective 3** – To conduct an online survey with **stroke survivors** in the UK to investigate their knowledge, perspectives, and experiences of aerobic exercise.
- **Thesis Objective 4** – To integrate and interpret the findings from the systematic review, observational study, and survey using a convergent mixed methods approach to generate a more complete understanding of the factors influencing the implementation of aerobic exercise after stroke in the UK from the perspectives of **staff, system, and stroke survivors**.

1.16 Structure of the thesis

The following chapters describe the research undertaken to explore the factors influencing the implementation of aerobic exercise after stroke in the UK. The research studies are presented in chronological order. Patient, carer, and public involvement (PCPI) and stakeholder engagement is described at appropriate points throughout the thesis. **Chapter 2** describes the ontological and epistemological stance of the author. It also justifies the chosen methodological approach of mixed methods, the rationale for the choice of design for each of the three studies undertaken to address the Thesis Objectives 1,2, and 3, and the implementation framework used to organise the integration of findings which addressed Objective 4. **Chapter 3** addresses Thesis Objective 1 and describes Study 1, a qualitative systematic review of the staff perspectives of the implementation of aerobic exercise after stroke. It includes justification of the methods, including the use of automated screening, and a discussion of those findings. **Chapter 4** reports on Study 2, a retrospective observational study of the factors associated with the uptake and completion of CR by people with comorbid stroke in the UK which addresses Thesis Objective 2. **Chapter 5** presents the rationale, methods and findings for Study 3, a survey of stroke survivor perspectives of aerobic exercise in the UK to meet Thesis Objective 3. **Chapter 6** describes the methods used to integrate the findings from all three studies and interprets the integrated findings as per the convergent mixed methods study design to generate a more complete understanding of the factors and fulfil Thesis Objective 4. In this chapter, contributions from stakeholder meetings about the integrated findings in the context of current practice are presented and discussed, and finally conclusions are drawn.

1.17 Chronology of this thesis

I undertook this PhD on a part-time basis over a period of 6 years, beginning in 2018, and both my perspectives and the landscape have changed during this time. My first study, the systematic review (Chapter 3), was completed and published in 2019. I acknowledge that, due to the part-time nature of the PhD, this was some time ago and that the results are from before the COVID-19 pandemic. As I was unable to conduct a formal update of the systematic review within the constraints of this PhD, I instead carried out a brief search of the literature in March 2024 and have provided a summary of relevant new publications in section 3.8.

My decision on the end-date of the data selection for the retrospective observational study (Chapter 4) was influenced by the COVID-19 pandemic. This was due to the pandemic's effects on CR service provision, restrictions on data collection for the National Audit of Cardiac Rehabilitation (NACR) during this time, and the ongoing effects on CR staffing, delivery and format during and since then (NACR, 2022a).

I designed my third study, the online survey of stroke survivors (Chapter 5), whilst the pandemic was ongoing and, as such, this had an impact on my decisions around its focus and the methods used. As a clinician, I was very aware of the demands placed on healthcare staff during the COVID-19 period and how resources had been redirected. I also realised that I should ideally seek the views of stroke survivors themselves about this intervention, given the challenges of implementation and the increasing emphasis on the importance of engaging service users in research about them. I therefore decided to explore stroke survivors' views of aerobic exercise rather than those of physiotherapists. Furthermore, I knew that people post-stroke had been identified as a vulnerable population and that the use of digital technology had increased during COVID-19, so I decided that the most appropriate design for this study at that time was an online survey.

I completed all data collection for this thesis before the new National Clinical Guidelines for Stroke for the UK and Ireland were published in 2023, which provide much greater detail around the delivery of exercise post-stroke than the previous version. I have discussed my findings in the context of these updated clinical guidelines. The new guidelines have generated an increased interest in aerobic exercise after stroke and I believe they are likely to have influenced stakeholder views and therefore my discussions with clinicians about my thesis findings in early 2024 (section 6.3).

1.18 Chapter summary

This chapter introduced the topic of stroke, its impacts, and the risk factors, specifically that of poor cardiorespiratory fitness and its effects. An overview of stroke care and the stroke pathway in the UK was described. The secondary prevention of stroke was discussed, with a focus on aerobic exercise and the challenges to implementing this intervention. The researcher's position was stated, and the thesis aims and objectives were defined.

CHAPTER 2 METHODOLOGY

2.1 Chapter overview

This chapter outlines the research approach to this thesis underpinned by the philosophical worldview of the author, and based on ontology, epistemology, and research design (methodology and methods). This is then discussed in the context of the research question, '*What influences the implementation of aerobic exercise after stroke in the UK?',* and the justification of the chosen methodological approach of a convergent mixed methods design. The theoretical framework used to guide the nature of the questions asked and answered in this thesis is also described.

2.2 Philosophical worldview

Each researcher brings a philosophical worldview, or set of beliefs which guides their actions, to a study. These are important as they influence the researcher's position in relation to their research, guiding their research plan. A worldview is built on three basic pillars; ontology, the study of the nature of reality; epistemology, the study of knowledge; and methodology, the study of how to investigate and validate new knowledge (O'Leary, 2007, Crotty, 1998, Creswell and Plano Clark, 2017). A worldview may also be called a paradigm (Creswell and Plano Clark, 2017), and within research there are two basic types of paradigm. The positivist paradigm believes there is a single reality and that phenomena can be objectively measured using the scientific method. Positivism is often associated with quantitative research studies and the generalisability of findings. Contrastingly, the interpretivist paradigm believes there are multiple realities and creates knowledge by interpreting people's experiences of events. As such, interpretivism usually holds with qualitative research studies and with results which are not generalisable.

There are also variations of both positivism and interpretivism, including constructivist, post-positivist, transformative, and pragmatist paradigms (Creswell and Creswell, 2017). The intention of constructivism, often combined with interpretivism, is to seek and interpret other people's meaning of the world by relying on the views of others, viewing reality as multiple. It is often an approach to qualitative research and is largely inductive (Creswell and Plano Clark, 2017). Post-positivism, often referred to as the 'scientific method', recognises that absolute truth cannot be found, thereby challenging the positivist view of the absolute truth of knowledge (Creswell and Creswell, 2017). It is generally associated with a quantitative approach to research, where being objective is essential (Creswell and Creswell, 2017), reality is singular, and study results are unbiased (Creswell and Plano Clark, 2017). The transformative paradigm disagrees with both constructivism and post-positivism. It focuses on the needs of groups that have been marginalized or oppressed, aiming for political and social transformative change using a collaborative approach to conducting research (Creswell and Plano Clark, 2017). The transformative paradigm usually uses qualitative methods (Creswell and Creswell, 2017) and assumes multiple realities. Pragmatism takes a pluralistic approach, but sees reality as both singular and multiple, whereby researchers may test hypotheses, but seek multiple views on the nature of the phenomenon (Creswell and Plano Clark, 2017). From an ontological and epistemological perspective, including the author's clinical experience as a physiotherapist within stroke and CR, pragmatism was identified as the research approach most aligned to the author's philosophical worldview and is therefore more fully explored in the following section.

2.2.1 Pragmatism

Pragmatism is a philosophical movement that emerged during the late 1800's and early 1900's in the works of American philosophers such as Charles S. Peirce, William James and John Dewey, who are regarded as the founding fathers of pragmatism (O'Leary, 2007, Kaushik and Walsh, 2019). It has also been discussed more recently by writers including Cherryholmes (1992) and Murphy and Murphy (1990). This philosophical movement stemmed from the early pragmatist leaders rejecting particular assumptions on the nature of knowledge, truth, and enquiry (Kaushik and Walsh, 2019). They rejected the either-or debate around choices of constructivism or post-positivism, believing that meaningful research focuses on the research problem and that pluralistic approaches could be used to obtain knowledge (Teddlie and Tashakkori, 2009). Pragmatist researchers can choose research methods and procedures that best meet the purpose and needs of their research question (Creswell, 2014). This may involve combining both qualitative and quantitative methods, leading to pragmatism as a philosophical underpinning for mixed methods research (Creswell and Plano Clark, 2017). However, Hampson and McKinley (2023) argue that this is an epistemological stance of convenience which could involve constructing a set of philosophical beliefs that permit the research that is of interest to the researcher, although they admit that this is unlikely to actually be the case. They also write that qualitative and quantitative methods can be used in postpositivist and constructivist paradigms (Hampson and McKinley, 2023). In contrast, others advocate that for mixed methods research, pragmatism is an important philosophical basis on which the what and how to research can be explored based on the intended consequences (Teddlie and Tashakkori, 2009, Creswell, 2014). As this worldview prioritises flexibility, practicality, and freedom of choice, it does not necessarily provide guidance to researchers on designing and conducting research, but focuses more on identifying ‘what works’ (Hampson and McKinley, 2023).

Pragmatism places an emphasis on the nature of experience, rather than the nature of reality (Morgan, 2014). Its epistemology is underpinned by the understanding that knowledge is based on experience, and each individual’s experiences are unique, thereby creating knowledge that is unique to each individual (Kaushik and Walsh, 2019). There is generally agreement amongst pragmatists that all knowledge is socially constructed (Kaushik and Walsh, 2019). Pragmatism acknowledges that people’s actions cannot be separated from their past experiences and the beliefs they have because of those experiences, so the meaning of actions and beliefs is tied to their consequences (Kaushik and Walsh, 2019). Essentially, people take actions based on the likely consequences of those actions and consider those resulting consequences when deciding on future actions (Morgan, 2014). For example, someone who begins to exercise regularly will *experience* the *consequences* of exercise (i.e., the benefits), which then influence their *beliefs* that this is something they should continue to *action*. Through *experience*, they know that the *consequences* of regular exercise are beneficial to them, and will consider these consequences in future decision-making about exercise (i.e., the *action*). Their views and actions will differ from those of the person who has never exercised, and therefore never experienced those beneficial ‘consequences’. According to John Dewey, beliefs that arise from repeatedly experiencing the consequences of repeated actions with predictable outcomes produce *warranted beliefs,* which are distinct from speculative beliefs about what may occur if one acted in a particular way (Morgan, 2014).

In contrast with the single reality of the post-positivist paradigm and the multiple realities of the constructivist paradigm, pragmatism holds that the link between actions and consequences is changeable, as no one can experience an identical situation twice, meaning that reality is open to change (Morgan, 2014). Additionally, the consequences of any action depend on the context within which it occurs. So, for the person who is exercising regularly, if they experience a *change* in health status, such as a stroke or cardiac event, the *beliefs* about the benefits (*consequences*) of exercise which they had established previously, based on their prior *experiences*, will influence their beliefs and subsequent *actions* following that change. However, their experience of exercise may change due to the effects of their stroke and a change in the context in which their exercise takes place, leading to changes in their beliefs and actions in relation to exercise, and also to that person's reality. Therefore, the pragmatic worldview provides a foundation for gaining knowledge around the phenomenon of aerobic exercise after stroke that is being explored in this thesis.

2.2.2 Research question and the research design

Dewey describes a five-step model of inquiry as a method to approach problem-solving, where inquiry is a form of experience that helps to resolve uncertainty (Morgan, 2014). This approach was used to identify the research question and research design for this thesis. In the model of inquiry, the problem is identified (first step), then reflected on using existing beliefs (second step) before a potential solution is devised (third step). Within pragmatism, considering the likely outcomes of a particular action is an example of abductive reasoning, which is essentially an 'if-then' method used to deduce that *if* one acts in a particular way, *then* specific outcomes are likely to result (Morgan, 2014). The potential solution devised in the third step is then reflected upon with regards to its success or creation of more problems (fourth step), and finally the action is taken with the new belief that this action will resolve the problem (fifth step). However, the new belief changes once the consequences of that action has been experienced, hence the changing reality. The research question for this thesis stemmed from the author's clinical experience as a physiotherapist within stroke and CR, and interest in the benefits of aerobic exercise for people with CVD. Reflection around how aerobic exercise is embedded within CR but not routinely offered as part of stroke rehabilitation in the UK, led to the question of why this beneficial intervention was not being implemented routinely following stroke. The nature of the question, together with the author's clinical experience, pointed to the possibility that the reasons, or influencing factors, for this lack of implementation may differ depending on perspective. Perspectives could include those participating in aerobic exercise (stroke survivors), those delivering aerobic exercise (staff) and the context in which it is being delivered (system). Another element of pragmatism is that actions cannot be separated from the context in which they occur (Morgan, 2014). Aerobic exercise after stroke is a complex intervention which is delivered within a range of contexts. Pragmatists examine shared beliefs, which also fits with the research question as it considers the perspectives of different groups, such as stroke survivors, staff, and the system.

The pragmatic worldview endorses flexibility, practicality and freedom of choice for individual researchers (Creswell, 2014), meaning the author could choose the research design and methods that best answered the research question. Pragmatism is also identified as an ideal worldview on which to mix quantitative and qualitative research methods (Creswell and Plano Clark, 2017). Once the research question had been identified, the author applied Dewey's five-step model of inquiry (Morgan, 2014) and reflected on the nature of the questions whilst seeking potential solutions and a potential research design. Due to the contrast noted regarding aerobic exercise as part of rehabilitation post-stroke and as part of rehabilitation post-cardiac event, the author, with support from a senior researcher, established a collaboration with an expert in the field of CR in the UK. Additional factors supporting this decision were the author's experience of people attending CR often having comorbidities, including stroke, and that stroke and CHD are CVD. As well as providing expertise in this area, this collaboration provided the opportunity to access a large UK database, the National Audit of Cardiac Rehabilitation (NACR), which is facilitated by researchers at the University of York. At this point, the author successfully applied to the Physiotherapy Research Foundation for a novice researcher fund, with an initial plan to conduct a systematic review of the literature around staff perspectives of aerobic exercise after stroke, followed by a survey of UK physiotherapists over the course of one year. The doctoral study, funded separately to the project, commenced one month after that project's start date, running concurrently for the first year of part-time study and continuing after the conclusion of the funding period. The work for this project and thesis evolved over time, both as the author's knowledge of the subject area developed and through discussion with the collaborative team and PhD supervisors. Hence, whilst the systematic review was completed as planned, a decision was taken that the next step would be to conduct an observational study using data selected from the NACR, in order to explore the factors from a system perspective. Once this had been completed, the effects of the COVID-19 pandemic on healthcare staff's capacity to participate in research, coupled with a lack of literature around UK stroke survivor perspectives of aerobic exercise, prompted the decision to investigate stroke survivor perspectives, rather than conduct a survey of physiotherapists. This led to the perspectives of stroke survivors, staff, and the system being explored to identify the factors influencing implementation.

2.3. Methodology

When reflecting on how to resolve a research question, the warranted beliefs of the likely consequences of using a particular research design are considered by the researcher. There are three main methodological approaches; quantitative, qualitative, and mixed methods. Quantitative research generally involves numbers, measurement, and closed-ended questions and responses, whereas qualitative research involves words, open-ended questions, and other data such as recordings or images (Tariq and Woodman, 2013). Mixed methods research uses a combination of quantitative and qualitative methods, and integrates both forms of data (Tashakkori and Creswell, 2007).

2.3.1 Mixed methods approach

The mixed methods approach is often linked with pragmatism (Tashakkori and Teddlie, 2010) due to its focus on the research question and consequences of the research, and pluralistic nature, using multiple methods of data collection (Creswell and Plano Clark, 2017). This provided further reasons for why this worldview and methodology were appropriate for answering this research question. Mixed methods research can involve both qualitative and quantitative methods, but may also include within-paradigm mixing, for example by using two methods of qualitative research (Walshe and Brearley, 2020). Combining forms of data can provide a more complete analysis of a complex problem, such as the implementation of aerobic exercise after stroke, whereby the whole is greater than the sum of the parts. To answer the research question, perspectives would be sought from both people and a system, so it followed that the type of data being analysed would be both qualitative and quantitative in nature. Mixing can be conducted at all stages of the research, or during data collection or analysis alone (Walshe and Brearley, 2020). There are five main purposes of mixed methods research: 1) triangulation looks for convergence or corroboration of the qualitative and quantitative data; 2) complementarity seeks to elaborate or enhance understanding of a phenomena by exploring different aspects; 3) development uses the results from one method to develop the other; 4) initiation seeks to discover paradox and contradiction; and 5) expansion uses different methods in order to extend breadth and range (Walshe and Brearley, 2020, Greene, Caracelli and Graham, 1989). For this research question, a variety of methods will be used to explore different perspectives on the implementation of aerobic exercise after stroke, in order to generate an elaborated understanding of the influencing factors. This intention holds with the purpose of complementarity.

There are three core mixed methods designs; explanatory sequential, exploratory sequential, and convergent (Creswell, 2014). Explanatory sequential design begins with the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data to expand on the quantitative findings (Creswell and Plano Clark, 2017). In contrast, exploratory sequential design begins with qualitative data collection and analysis, followed by the development of a quantitative feature based on those results, which is then tested quantitatively, and the findings interpreted (Creswell and Plano Clark, 2017). With a convergent design, the intent is to bring together the results of qualitative and quantitative analysis to compare or combine these in order to generate a more complete understanding of a problem or validate one set of findings with another (Creswell and Plano Clark, 2017).

The research question is of primary importance, and much consideration was given to which mixed methods design would be most appropriate to answer this, with the choice of method hinging on the intention of the thesis. It was decided that the best approach for exploring the perspectives of those who were participating in aerobic exercise, delivering aerobic exercise, and the context in which aerobic exercise was being delivered after stroke, would be to conduct three separate studies, and then integrate the findings from all of these using a convergent mixed methods design. These would consist of one study focussing on staff perspectives, another on stroke survivor perspectives, and the third on a system-level perspective. Each of these would explore the factors influencing the implementation of aerobic exercise after stroke, with the aim of providing different perspectives on the same research question.

2.3.2 Convergent mixed methods design

The convergent mixed methods approach consists of four main steps (Creswell and Plano Clark, 2017) which were utilised in this thesis. Firstly, quantitative and qualitative data was collected on the perspectives around aerobic exercise after stroke. Each type of data was considered of equal importance in answering the research question, as advocated by Creswell and Plano Clark (2017). Secondly, the qualitative and quantitative data sets were each analysed separately using appropriate procedures. Thirdly, the three sets of findings were integrated. The fourth, and final, step involved interpretation of the extent of convergence or divergence of the data which were combined to generate enhanced understanding of the factors influencing the implementation of aerobic exercise after stroke.

2.4 Methods of data collection

Pragmatists 'unite' research questions with research methods. Dewey's five-step model of inquiry was again used to guide the choice of method for each of the three studies, using the 'if-then' method (Morgan, 2014).

2.4.1 Determinant factors from the perspectives of staff

For the study around staff perspectives, an initial online search revealed that some literature had already been published on this subject. Additionally, the question was quite specific, seeking to explore the perspectives of healthcare, exercise and fitness professionals working within stroke or CR on the factors affecting the implementation of aerobic exercise after stroke. There exists a wide range of research methods to choose from. The traditional hierarchy of evidence 'pyramid' ranks healthcare research evidence on an effectiveness, appropriateness and feasibility basis (Evans, 2003). Systematic review, along with meta-analysis, is ranked as being at the top of the pyramid, followed by randomised controlled trials, cohort studies, case-control studies, and finally case series or report studies at the bottom. However, Murad et al. (2016) noted that the Grading of Recommendations Assessment, Development and Evaluation (GRADE) working group's approach to grading the quality of evidence involves assessment of factors, called domains, such as risk of bias and imprecision, rather than relying solely on the study design (Schünemann et al., 2023). In light of this, Murad et al. (2016) therefore proposed a change to this pyramid on the basis that methodological limitations can affect the reliability of a study, changing the straight lines between levels of the pyramid to wavy lines to indicate variability in the domains. Systematic review is a strong research method which follows a rigorous and transparent methodology. Therefore, *if* a systematic review of the literature was conducted around staff's perspectives of the barriers and facilitators to the implementation of aerobic exercise after stroke, *then* it would be possible to systematically synthesise the current published evidence on this subject. Completing a systematic review provided a robust evidence base of the existing factors from staff perspectives within the literature, and constituted part of the answer to the research question posed by addressing Objective 1. This study explored people's views of aerobic exercise, meaning the data collected was in the form of words and therefore qualitative in nature. The was the first time a systematic review had been conducted on staff perspectives of the factors influencing the implementation of aerobic exercise after stroke (Gaskins et al., 2019). This review has been cited in the National Clinical Guidelines for Stroke for the UK and Ireland (2023).

2.4.2 Determinant factors from a system perspective

The research question was considered from the perspective of the UK healthcare system. The 'if-then' method was again applied in relation to choosing an appropriate research method for this system-perspective study. Although the SSNAP (2023) in the UK collects data around the delivery of stroke care, this does not include data on the delivery of aerobic exercise following stroke. However, the NACR (2022c) collects a comprehensive set of data on the delivery of CR in the UK, and includes data around comorbidities. This dataset is described in greater detail in Chapter 4. *If* the research question was to be considered from a system perspective in a real-world setting, *then* real world data should be used to explore the factors influencing implementation. This 'real world' research question combined with the multimorbid profile of the target study population, indicated that an observational study design would be appropriate to explore the relationship among variables, such as whether people engaged with aerobic exercise or not.

Observational studies are used within epidemiology to collect data through observation without influencing the participants or surroundings in 'real-world' situations or settings (Anglemyer, Horvath and Bero, 2014). There are three main types of observational study; cross-sectional, cohort and case-control (Carlson and Morrison, 2009). These are non-experimental and can be applied to specific populations and used to investigate associations between characteristics and outcomes (Gallin and Ognibene, 2012). However, in the hierarchy of evidence pyramid, observational studies are ranked lower than randomised controlled trials (RCT) (Murad et al., 2016). Within health research and evidence-based medicine, RCTs are generally regarded as powerful, rigorous (and often costly) tools in the cause-effect relation between interventions and outcomes (Sibbald and Roland, 1998). It is important to note that necessary strict inclusion and exclusion criteria result in people with multiple morbidities such as diabetes and heart disease often being excluded from trials (Fortin et al., 2006). Populations in RCTs are usually less diverse, in terms of gender, age, and deprivation, in comparison with those for observational studies. RCT participants are randomly allocated to either a control group or an experimental group to test a specific intervention. The data collected is then analysed to identify any differences in the outcomes for each group and this information is used to assess the effectiveness of the intervention (Kendall, 2003). If well designed and conducted they can provide strong evidence for cause and effect, if any exist, of an intervention (Kendall, 2003). However, this thesis research question was not focussing on the effectiveness of an intervention on patient outcomes. Rather, it was seeking the determinant factors around uptake and completion of a currently offered intervention.

Although valuable, RCTs do have limitations, as mentioned previously. In contrast, observational studies are more representative of the routine population, for example, by including people with multi-morbidities (Fortin et al., 2006), and do not have the constraints of clinical trials where results can lack generalizability (Barnish and Turner, 2017). There is an argument that evidence from observational studies can complement that of RCTs (Barnish and Turner, 2017, Silverman, 2009) and make a valuable contribution towards informing healthcare practice. The National Institute for Health and Care Excellence (NICE) (2022) uses real-world data from observational studies to inform practice and decision making, which demonstrates widescale acknowledgment of the acceptance of this robust method.

Examples of other large databases used for retrospective observational studies in healthcare in the UK are the SSNAP (Lugo-Palacios et al., 2019) and the Hospital Episode Statistics (HES) (Bottle and Aylin, 2006, Zaccardi et al., 2016). Data available for research that has already been collected is called secondary, or retrospective, data (Johnston, 2017). The analysis of secondary data has obvious advantages, such as being cost-effective, convenient and time-saving (Johnston, 2017). However, it is necessary to select secondary data with care, ensuring that it is appropriate for answering the research question (Johnston, 2017). In this case, the population of interest were people with comorbid stroke who were potentially accessing aerobic exercise as part of CR within the real-world setting of the UK healthcare system, hence the NACR dataset was the most appropriate source of secondary data for the research question. Further details on the NACR dataset are provided in Chapter 4. The decision to use a retrospective observational study design, which was quantitative in nature, to explore a system view of the factors influencing implementation of aerobic exercise after stroke was therefore justified. This was the first time that this dataset had been explored with comorbid stroke as a primary focus, with the first part of the analysis published in 2020 (Harrison et al., 2020).

2.4.3 Determinant factors from the perspectives of stroke survivors

As per Dewey's five-step model of inquiry, the identified question of what stroke survivors' views of aerobic exercise were, and the most appropriate research method to answer this were considered. There was a dearth of evidence in the existing literature around this subject, particularly in relation to the views of stroke survivors living in the UK. To answer this question, participant views could have been sought via a qualitative study design, such as interviews or focus groups, using words or images, which would have provided a greater breadth/depth of data, but from fewer people (Gill et al., 2008, Teddlie and Tashakkori, 2009, Paradis et al., 2016). In contrast, quantitative research designs, such as surveys and questionnaires, can be used to collect data from a greater number of people, with the purpose of describing a population's attitudes or opinions by studying a sample of that population (Creswell, 2014). Interviews and questionnaires do also share some similarities in that they aim to determine participants' beliefs and views of a topic, involve self-reporting, and can generate quantitative, qualitative, and mixed methods data (Teddlie and Tashakkori, 2009). Traditionally, surveys have used closed-ended question formats but can include open-ended to collect qualitative data, whereas interviews have used open-ended formats (Creswell, 2014, Paradis et al., 2016). Interviews can be more cost- and resource-intensive to conduct and analyse than surveys or questionnaires (Jones, Baxter and Khanduja, 2013, Paradis et al., 2016), which was another consideration within the context of this doctoral study.

The contexts and settings in which aerobic exercise may be implemented can be varied and complex, so it was deemed important to plan to gather perspectives from a large number of stroke survivors across the UK. Furthermore, the breadth of information being sought for this study would have been too great to obtain with interviews or focus groups. The author was also aware that the findings from a survey could subsequently be used as a basis for interviews or focus groups to collect richer data and explain the survey findings in the future (Creswell and Plano Clark, 2017). The conclusion was that a mixed method self-administered questionnaire was an appropriate research method to fulfil these criteria. Online surveys are a cost- and time-effective method of data collection, but do require careful planning to ensure the data collected is meaningful (Jones, Baxter and Khanduja, 2013). This questionnaire was predominantly quantitative by design with multiple choice questions to facilitate completion by stroke survivors given the potential effects of their stroke, but also contained free text options which were qualitative in nature, as advised by the patient and public involvement group. Further details on how patient and public involvement shaped this survey is provided in Chapter 5. The decision to disseminate the survey electronically was influenced by several factors. These included the health risks to vulnerable populations, restriction in data collection methods, and increase in the use of technology for communication during the COVID-19 pandemic, as well as low cost and ease of completion (de Koning et al., 2021). To the best of the author's knowledge, this was the first time that UK stroke survivors' perspectives of aerobic exercise had been explored using an online survey.

2.4.4. Integration of determinant factors from staff, system, and stroke survivor views

To answer the thesis research question and address the objectives, a convergent mixed methods research design was chosen with the intention of generating a more complete understanding of aerobic exercise after stroke (*Figure 2.1*). The topic, implementation of aerobic exercise after stroke, was the same across all three studies, but the influencing factors were explored from different perspectives, those of staff, system, and stroke survivor. *Table 2.1* shows a summary of the research question, objectives and methods used for this thesis.

Table 2.1. Overview of research methods and intended outputs

Thesis Objectives	Method	Output
Thesis Objective 1 - To conduct a systematic review of the literature to identify and collate existing evidence about the factors influencing the delivery of aerobic exercise after stroke from the perspectives of staff working within healthcare, exercise, or fitness settings.	Qualitative – Systematic review of the literature to identify barriers and facilitators to implementation from staff perspectives.	Factors perceived by staff worldwide.
Thesis Objective 2 - To conduct a retrospective observational study using system-level data of CR to explore the factors associated with the uptake and completion of CR by people with comorbid stroke in the UK.	Quantitative – Retrospective observational study using data selected from the UK NACR about people with comorbid stroke.	Factors associated with uptake and completion of CR by people with comorbid stroke in the UK.
Thesis Objective 3 - To conduct an online survey with stroke survivors in the UK to investigate their knowledge, perspectives, and experiences of aerobic exercise.	Mixed method – Online survey of UK adult stroke survivors on their perspectives of aerobic exercise.	Factors influencing participation in aerobic exercise perceived by stroke survivors in the UK.
Thesis Objective 4 - To integrate and interpret the findings from the systematic review, observational study, and survey using a convergent mixed methods approach to generate a more complete understanding of the factors influencing the implementation of aerobic exercise after stroke in the UK from the perspectives of staff, system, and stroke survivors.	Convergent design data analysis and interpretation – Integration of findings from all three using a joint display, and interpret the overall thesis findings.	Identification of modifiable and unmodifiable factors influencing the implementation of aerobic exercise after stroke in the UK from three perspectives.

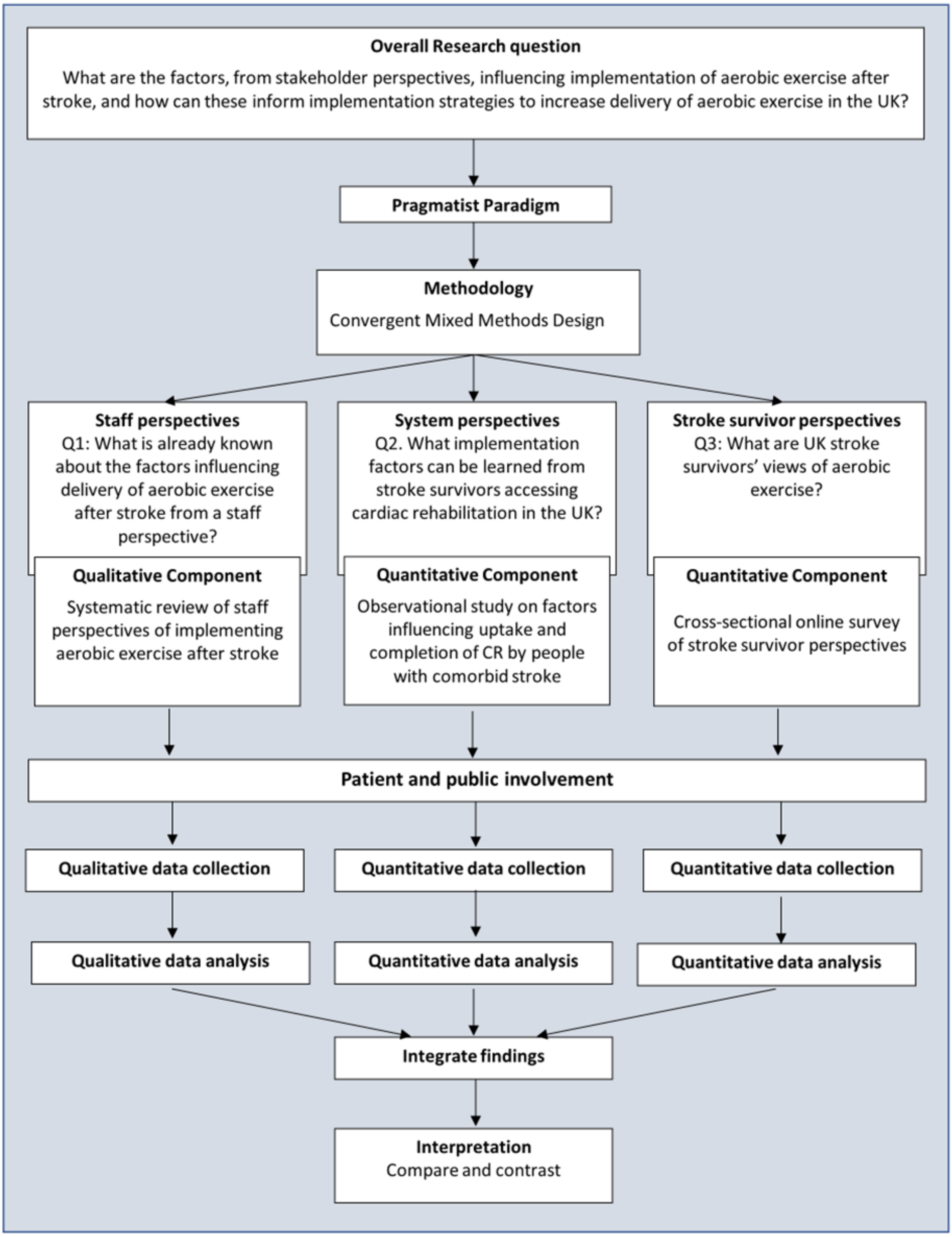

Figure 2.1. Flow chart presenting convergent mixed methods design adopted in this thesis

2.5 Theoretical framework

As described in Chapter 1, implementation is the process of putting a proven intervention into practice. Implementation science is research which investigates how best to promote and support effective implementation, and what mechanisms or strategies facilitate successful implementation in order to improve healthcare quality and effectiveness (Lynch et al., 2018, Eccles and Mittman, 2006, Nilsen, 2015, Bauer et al., 2015).

2.5.1 Theories, models, and frameworks

A theory, model or framework can be applied to a mixed methods study to predict and shape the direction of a study (Creswell and Plano Clark, 2017). The terms theories, models and frameworks are often used interchangeably but there are distinct typologies for each (Carpiano and Daley, 2006, Tabak et al., 2012) and a need to differentiate between them. Within implementation science, the three main aims of theories, models and frameworks are to describe the process of moving research into practice, explain what influences the outcomes, and evaluate the implementation (Nilsen, 2015). Essentially, these are tools that can be used by researchers and implementers to guide and support this process (Lynch et al., 2018).

A theory is defined as a set of analytical propositions or statements which clearly explain how and why certain relationships lead to certain events (Nilsen, 2015, Wacker, 1998). Wacker (1998) proposed that theory consists of definitions of variables, a phenomenon where the theory applies, relationships between the variables and specific predictions about the phenomenon. Theories can be used within all phases of research (Birken et al., 2017). Establishing a good theoretical basis or underpinning for implementation activities is valuable in understanding why and how implementation activities either succeed or fail (Nilsen, 2015). In turn, this knowledge enables identification of the factors which influence the likelihood of success and informs the development of strategies for successful implementation (Nilsen, 2015).

A model is a deliberately simplified explanation of a phenomenon or a particular aspect of a phenomenon (Nilsen, 2015). It does not need to be a completely accurate representation of reality to have value (Nilsen, 2015). Models are closely related to theories and may be based on one or more theories (Carpiano and Daley, 2006). Also, the differences between a model and theory may not be clearly defined (Nilsen, 2015). A diagrammatical representation of a model can be a useful visual aid for understanding the proposed links between the variables defined in a theory (Carpiano and Daley, 2006). In comparison with theories and frameworks, models have the narrowest focus but the greatest specificity (Carpiano and Daley, 2006). In the context of implementation science, models describe or guide the process of implementation (Nilsen, 2020), whereas theories describe and explain the causes of success or failure (Frankfort-Nachmias and Nachmias, 1996).

A framework is defined as a structure, overview, system or outline consisting of various categories, domains or constructs, and the relations between them which are presumed to account for the phenomena (Nilsen, 2015). Within implementation science, frameworks generally indicate the factors that may influence the outcomes of implementation (Nilsen, 2020). Frameworks describe but do not explain (Nilsen, 2015).

There are five categories of theories, models and frameworks used within implementation science according to Nilsen (2015). These are; 1) process models, which describe and/or guide the process of moving evidence into practice; 2) determinant frameworks, consisting of categories of determinants (barriers/facilitators) which influence the outcomes of implementation; 3) classic theories, taken from fields such as psychology or sociology; 4) implementation theories, adapted specifically for use in implementation; and 5) evaluation frameworks, which provide a structure for evaluation of implementation activities (Nilsen, 2015).

2.5.2 Choosing an appropriate implementation theory, model, or framework

An array of theories, models and frameworks now exist, so it can be challenging to identify the most appropriate one for a particular context (Birken et al., 2017, Lynch et al., 2018). There is no 'one size fits all' where implementation is concerned, so the researcher is required to select and apply a relevant approach from an extensive menu of potential appropriate options (Nilsen, 2015). Lynch et al. (2018) noted that there are similarities across all implementation theories, models and frameworks including the evidence, context, deliverers or implementers, and the process of change. Indeed, Nilsen and Bernhardsson

(2019) note the particular importance of context in relation to determinant frameworks, and how it is included, either directly or using other terms for the same concept, within many theoretical approaches. Nilsen (2015) writes that it is important to understand the three main aims and five categories of theories, models, and frameworks when seeking to identify an appropriate theoretical approach for implementation research. Lynch et al. (2018) recommend taking a pragmatic approach to this decision, by considering the aims of the research study and goodness-of-fit of the selected approach. The author of this thesis decided to combine her understanding of theoretical approaches with this pragmatic approach, using the *if-then* method to select an appropriate useable theory, model, or framework. This thesis aimed to determine the factors, from stakeholder perspectives, influencing the implementation of aerobic exercise after stroke in the UK. Hence it sought to understand the barriers and facilitators that influenced implementation outcomes, which is the second aim of theoretical approaches within implementation science described by Nilsen (2015). Three theoretical approaches are recommended to address this aim; determinant frameworks, classic theories, and implementation theories (Nilsen, 2015).

Determinant frameworks describe types of determinants, consisting of barriers and/or facilitators, that influence implementation and are useful for informing the design of implementation strategies, but they do not explain how change take place (Nilsen, 2015). They often identify determinants at multiple levels, from individual deliverer or recipient, through to an organisational level, and acknowledge that relationships exist within and between the levels and determinants (Nilsen, 2015). Examples of determinant frameworks include the PARIHS (Promoting Action on Research Implementation in Health Services) (Rycroft-Malone and Bucknall, 2010), the Theoretical Domains Framework (Cane, O'Connor and Michie, 2012), and the Understanding-User-Context Framework (Jacobson, Butterill and Goering, 2003).

Classic theories have been taken from fields such as sociology and psychology, describing mechanisms of change and explaining how change occurs without trying to bring about change (Nilsen, 2015). There are different types of classic theories that are concerned with studying a range of areas such as psychological behaviour change, communities of practice, relationships between individuals, and, in particular, organisations, due to the acknowledgement of the importance of context within implementation outcomes (Nilsen, 2015). Classic theories include the Cognitive Continuum Theory (Hammond, 1981) used to analyse cognitive processes in clinical decision-making and implementation of evidence-based practice, and the Situated Change Theory (Orlikowski, 1994) used to increase understanding of organisations.

Implementation theories have been developed, or adapted from existing theories, to improve understanding and explanation of particular elements of implementation (Nilsen, 2015). Adapting particular elements of a theory allow prioritisation of issues that are regarded as most relevant or important for implementation (Nilsen, 2015). For example, Normalization Process Theory (May and Finch, 2009) was originally a model that was later developed into a theory to improve understanding of how new health technologies or complex interventions are embedded in daily practice (Nilsen, 2015).

The author considered choosing either a classic or implementation theory for this thesis, such as the COM-B (Capability, Opportunity, Motivation - Behaviour) (Michie, van Stralen and West, 2011) or a social cognitive theory. However, if this approach was to be used, then it would have been necessary to use two or more theories to generate a complete understanding, as a single theory generally focuses on one element and this thesis was concerned with factors from different perspectives at different levels. In contrast, one determinant framework could identify factors at multiple levels (Nilsen, 2015), meaning this approach was potentially more appropriate for addressing the thesis research question and objectives. Lynch et al.'s (2018) summary of the most commonly used theories, models or frameworks within implementation science was also consulted. Their recommendations were intended to guide clinical researchers in the design and conduct of implementation projects, based on their purpose and context (Lynch et al., 2018). Several of these identified approaches were dismissed based on their focus, for example, the RE-AIM framework (Glasgow, Vogt and Boles, 1999) focuses on public health, and Theoretical Domains Framework (TDF) (Cane, O'Connor and Michie, 2012) on behaviour change. However, two frameworks were identified as being potentially appropriate for use in this thesis, the Promoting Action on Research Implementation in Health Services (PARIHS) (Rycroft-Malone, 2004) and the Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2009, Damschroder et al., 2022).

2.5.2.1 Promoting Action on Research Implementation in Health Services (PARIHS)

The PARIHS framework considers the interaction of three domains, evidence, context, and facilitation, in determining successful implementation (Rycroft-Malone, 2004, Kitson, Harvey and McCormack, 1998). It proposes that the presence of robust evidence, with a receptive context, and an internal or external facilitator to implement the change(s), influence the implementation outcome. However, this model lacks a domain relating to the characteristics of individuals, which was an important aspect of this thesis. Furthermore, the role of a facilitator to aid implementation was not a focus in any of the three planned studies for the thesis. For these reasons, the PARIHS framework was not selected.

2.5.2.2 Consolidated Framework for Implementation Research (CFIR)

The CFIR was first developed in 2009, through the identification of constructs which were common across published implementation theories (Damschroder et al., 2009) *(Appendix 3.4)*, and was subsequently updated in 2022 based on user feedback (Damschroder et al., 2022) *(Appendix 2.1)*. The authors recognised that there was both overlap, and omission, of key constructs in individual theories, and wanted to create a comprehensive structured list of constructs using consistent terminology and definitions, which could be used as a guide through all stages of the implementation process (Damschroder et al., 2009). For the original development of this framework, Damschroder et al. (2009) searched for and reviewed published theories, frameworks and models used to facilitate the movement of research findings into healthcare practice. The PARIHS framework was included, as was Greenhalgh et al.'s (2004) 'Conceptual Model for Considering the Determinants of Diffusion, Dissemination, and Implementation of Innovations in Health Service Delivery and Organization'. This resulted in a comprehensive overarching framework compiled from a robust review of existing published theories, which was applicable to a variety of settings and contexts. A revision of the existing CFIR domains and constructs was conducted in 2022, with constructs added, removed or relocated, and the inclusion of guidance on how to use the framework and define each of the domains (Damschroder et al., 2022). Examples of these changes were that the *Intervention Characteristics* domain became the *Innovation* domain, and the *Cosmopolitanism* construct became *Partnerships & Connections. Figure 2.2* shows a diagrammatic representation of the revised CFIR as adapted by the Center for Implementation (2023). These revisions widened its applicability to a greater range of interventions and settings.

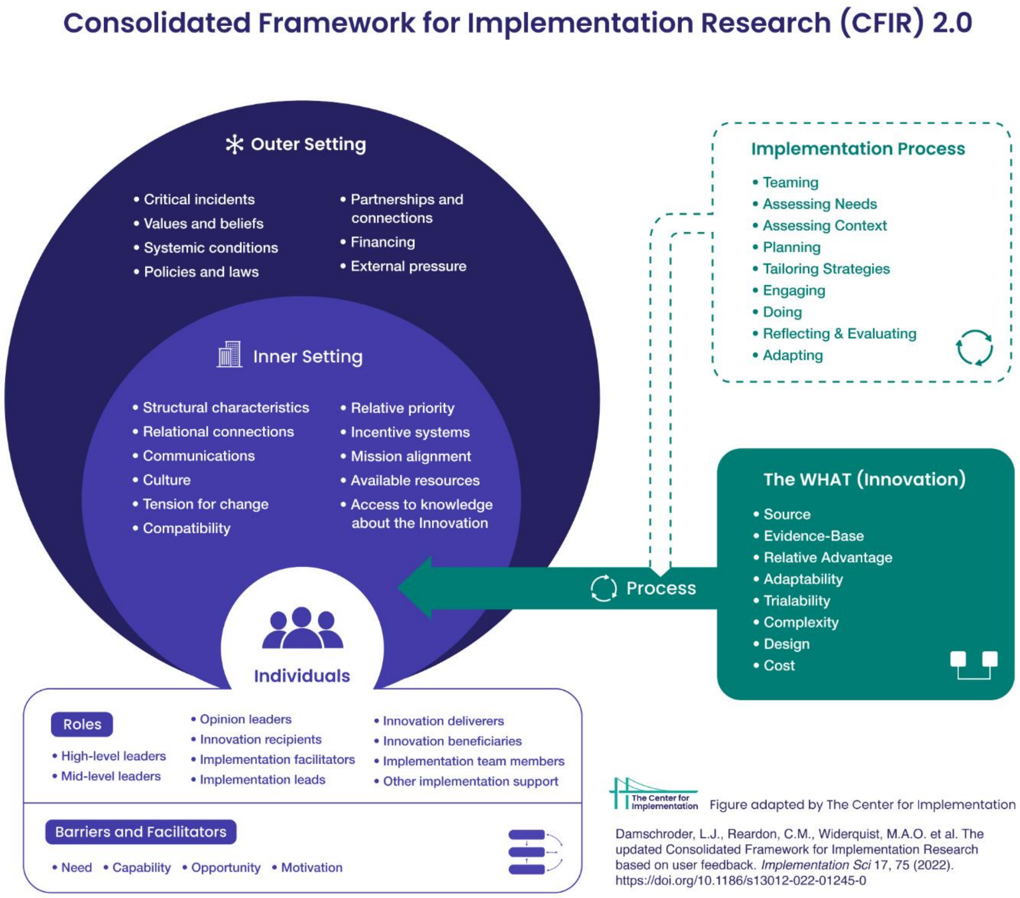

Figure 2.2. The Consolidated Framework for Implementation Research (CFIR) 2.0. Adapted from Damschroder, L. J., Reardon, C. M., Widerquist, M. A. O., et al. (2022). The updated consolidated framework for implementation research based on user feedback. Implementation Science, 17, 75. https://doi.org/10.1186/s13012-022-01245-0. Image adapted by The Center for Implementation, © 2022. Version: V2024.01. https://thecenterforimplementation.com/toolbox/cfir.

Damschroder et al. (2009) encourage the use of the CFIR throughout the process of implementation but note that the CFIR does not indicate how the constructs interact with each other. Advantages of using the CFIR prior to the implementation of the intervention include the identification of potential barriers, appropriate selection of implementation strategy, and adaptation of the strategy to maximise likelihood of success (Kirk et al., 2016).

During implementation it can be used to monitor for unexpected factors which are influencing the implementation and finally, post-implementation use may include investigation of the effects of factors on the implementation (Damschroder et al., 2009). The CFIR is a comprehensive determinant framework based on existing published theories that includes multiple levels of influence, and, for these reasons, was identified as an appropriate approach to understanding and organising the factors influencing the implementation of aerobic exercise after stroke in this thesis.

2.5.3 Application of the CFIR to this thesis

The updated determinant framework consists of five domains, which are subdivided into constructs (Damschroder et al., 2022), and will now be described briefly in the context of the focus of this thesis, together with a definition of the subject of each domain (*Appendix 2.1)*.

- First domain – The *Innovation*, or intervention, which is being implemented, defined as aerobic exercise after stroke. For the purpose of this thesis, the term 'aerobic exercise' is broad and includes any form of exercise which is aerobic in nature as well as the processes involved in the delivery of exercise following stroke. This process could include initial referral, screening, assessment, exercise prescription, delivery, and participation in aerobic exercise, as well as onward referral to, and/or discharge from, a service delivering aerobic exercise. This definition reflects the understanding that the term 'aerobic exercise' has different meanings for different people. For example, stroke survivors may consider their participation in particular modes of aerobic exercise, whereas staff may consider the process of how to screen and assess a stroke survivor for participation in aerobic exercise. Constructs in this domain include the evidence base for the intervention, adaptability, complexity, design, and cost.
- Second domain – The *Outer setting* domain can be comprised of multiple levels. In this thesis, the outer setting is defined as the political context, relevant guidelines and policies, the COVID-19 pandemic, economic conditions, and funding and commissioning of services at one level. The UK healthcare system and community exercise settings are included at the next level in this domain, although there is some overlap with the *Inner setting*. Local attitudes, partnerships and connections, policies,

and financing are some of the constructs within this domain.

- Third domain – The *Inner setting* is the setting within which the intervention is implemented and exists within the *Outer setting*. In the context of this thesis, NHS services, leisure centres, gyms, and other community exercise providers are defined as the *Inner setting*. The constructs of this domain focus on structural characteristics, relational connections and communications within this setting, culture, compatibility of the implementation within workflows, relative priority, and resources.
- Fourth domain - The roles and characteristics of individuals comprise the fourth domain, *Individuals.* This can include leaders, implementers, deliverers, and recipients of the intervention. Individuals' characteristics are based on Michie, Atkins and West's (2014) behaviour change model of capability, opportunity and motivation. The two obvious roles applicable to the thesis research question were staff (deliverers) and stroke survivors (recipients), with the potential for leaders and managers to be included if identified in the findings.
- Fifth domain - The *Implementation Process* domain relates to how aerobic exercise after stroke as an intervention will be implemented and the actions or strategies used to do this. The subject of this domain is usual practice within healthcare and/or exercise settings within the UK. Constructs such as assessing the needs of deliverers and recipients, context-specific barriers and facilitators to implementation, step-by-step planning, engagement, and evaluation are listed under this domain.

In addition to being used as a comprehensive structure to integrate the thesis findings, this framework was also chosen for use in the data analysis and discussion phases of the systematic review of staff perspectives, to identify and organise the factors influencing implementation. The original version of the CFIR (2009) was used for data extraction and synthesis in the systematic review (Study 1) as the updated version of the CFIR (2022) did not exist at the time this was completed. However, as the determinant factors identified in the three studies were integrated in 2024, the updated CFIR (Damschroder et al., 2022) was used to structure this.

2.6 Patient, public and stakeholder involvement

Patients, carers, and members of the public can make valuable contributions to research due to their lived experiences of health conditions and the health service. The National Institute for Health Research (NIHR) defines public involvement as research carried out 'with' or 'by' the public rather than 'to', 'about' or 'for' them (National Institute for Health and Care Research, 2021). This can include identifying research priorities, partaking in project steering groups and contributing to the development of research materials (National Institute for Health and Care Research, 2020). PCPI is encouraged at all stages of research and can include many different types of activity (Staley, 2015), although it is underreported (Price et al., 2018), including within doctoral research (Coupe and Mathieson, 2020).

Consultation, which is one of the four approaches to PCPI described by the NIHR (National Institute for Health and Care Research, 2021), was undertaken after the systematic review of staff perspectives, described in Chapter 3, for the stroke survivor study in Chapter 5, and following the integration of findings from all three studies in Chapter 6. The purpose of 'consultation' is to seek views from people with lived experience of stroke, and other stakeholders such as those delivering an intervention, on several stages of the research process. PCPI involvement in the NACR dataset is described in Chapter 4, although this was not conducted by the author. Further consultation in relation to the thesis findings was conducted with stroke and neurological rehabilitation staff and is reported in Chapter 7.

2.7 Ethics

Research ethics should be considered, and appropriate guidelines adhered to, for all research projects in order to protect both the participants and the researcher (Universities UK, 2019). The retrospective observational study of system view of the factors influencing implementation of aerobic exercise after stroke utilised secondary data from the NACR. The NACR has approval to collect confidential patient information in England and Wales without consent from individual patients under section 251 of the NHS Act 2006 (NACR, 2020). Further details on this are provided in Chapter 4. For the stroke survivor survey, ethical approval was obtained from the Health Ethics Review Panel at the University of Central Lancashire (Reference HEALTH 0310) (*Appendix 2.2*). Further details on consent and data management for this survey are provided in Chapter 5.

2.8 Chapter summary

This chapter has described the overall methodology for this thesis. The choice of a pragmatic approach using a mixed methods study design to explore the factors influencing implementation of aerobic exercise after stroke from the perspectives of stroke survivors, staff and a system has been explained. The next three chapters will each report one study, beginning with the systematic review of staff perspectives, followed by the retrospective observational study of a system perspective, and finally the study on stroke survivor perspectives.

CHAPTER 3 STAFF PERSPECTIVES OF THE FACTORS INFLUENCING IMPLEMENTATION OF AEROBIC EXERCISE AFTER STROKE: A SYSTEMATIC REVIEW

3.1 Chapter overview

Study 1 was conducted on staff perspectives of the implementation of aerobic exercise after stroke to address **Thesis Objective 1**. Chronologically, this was the first study conducted for this thesis and was completed in 2019, prior to the update to the Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2022) in 2022 (section 2.5.2.2). Hence, the original (first) version of the CFIR is used in this study (Damschroder et al., 2009). This chapter will describe the background and objectives of the study, followed by the methods, results, discussion of the findings and the conclusions reached. The chapter concludes with a section around the patient and public involvement aspect of this study, and a short update to the systematic review.

3.1.1 Original contribution to knowledge

The systematic review presented in this chapter has been published as a peer-reviewed academic paper in Disability and Rehabilitation (Gaskins et al., 2019). The work has been cited 21 times to date, including within the National Clinical Guidelines for Stroke for the UK and Ireland (2023) to support recommendations around cardiorespiratory fitness and raise issues around lack of resources identified by staff. This highlights how this work has contributed to the literature and to clinical practice. Furthermore, citations indicate a contribution to research around the implementation of interventions within stroke, mental health, and telerehabilitation, as well as the use of automated screening software in systematic reviews. This systematic review has also been presented as a poster at the National Physiotherapy UK Conference 2019, the Society for Research in Rehabilitation Winter Conference 2019, and the Research @ UCLan Event in 2020 (*Appendix 3.1*).

3.2 Introduction

It has been recognised in the literature for many years that staff's knowledge and beliefs influence their implementation of guidelines and interventions into practice, including within stroke rehabilitation (Huijg et al., 2014, McCluskey, Vratsistas-Curto and Schurr, 2013, Munce et al., 2017, Connell et al., 2014b). McCluskey et al. (2013) interviewed healthcare professionals about the factors influencing their implementation of stroke guideline recommendations in Australia. Amongst the key barriers and facilitators identified were their beliefs about their clinical capability to deliver interventions, their levels of knowledge and skill about the interventions, and their motivation for delivery (McCluskey, Vratsistas-Curto and Schurr, 2013). A 2019 scoping review of the barriers and facilitators to the implementation of research into stroke practice by occupational therapists reported that lack of knowledge of interventions, and lack of confidence in using new interventions, were barriers to implementation (Juckett et al., 2019). Holding negative views of a new intervention despite strong evidence of effectiveness was also a barrier (Juckett et al., 2019). Conversely, having knowledge of, and agreeing with, stroke rehabilitation guidelines facilitated their implementation in a RCT involving healthcare professionals (Munce et al., 2017).

Factors other than knowledge and beliefs have also been identified by staff as impacting intervention implementation (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Prout et al., 2016). These relate to stroke survivors themselves (Boyne et al., 2017a), the availability of resources such as time and equipment (Doyle and MacKay-Lyons, 2013, McCluskey, Vratsistas-Curto and Schurr, 2013), managerial support (Prout et al., 2016) and availability of clinical guidelines (Van Kessel, Hillier and English, 2017).

The delivery of aerobic exercise after stroke is another area that has been considered in the literature (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Prout et al., 2016). Although a survey of 16 physiotherapists working in inpatient stroke rehabilitation in Canada did not report knowledge or beliefs as key factors influencing implementation, it did identify a willingness amongst participants to upskill to be able to include aerobic exercise in their clinical practice (Prout et al., 2016). Instead, stroke survivor characteristics such as physical and cognitive impairments, risk of cardiovascular events, and fatigue were cited as barriers to implementing aerobic exercise by physiotherapists (Prout et al., 2016). These stroke survivor-related factors were also reported in a considerably larger Canadian study of physiotherapists working in neurological rehabilitation (n=155), although other important barriers to using aerobic exercise in practice were also identified, such as lack of resources including staff, time, and screening tools (Doyle and MacKay-Lyons, 2013). In America, physiotherapists (n=568) who participated in Boyne et al. (2017a) online survey indicated a lack of familiarity with the American College of Sports Medicine guidelines for exercise testing and prescription (American College of Sports Medicine, 2018), and the American Heart Association recommendations on physical activity and exercise for stroke survivors (Billinger et al., 2014). Within acute care, as well as stroke survivor-related factors, they also identified lack of equipment, lack of time, and short length of hospital stay as barriers, similar to those reported by Doyle and MacKay-Lyons (2013). Furthermore, of the physiotherapists working in outpatients, 53.7% (n=103) were not aware of community-based exercise programmes that stroke survivors could attend (Boyne et al., 2017a). This is significant in terms of facilitating long-term adherence to aerobic exercise post-stroke, which is important for secondary prevention.

Staff are the deliverers of aerobic exercise interventions and therefore their perspectives form a valuable part of the picture around what influences its implementation post-stroke. Deliverers of the intervention are identified as one of the roles within the *Individuals Domain* of the updated CFIR (Damschroder et al., 2022), and the *Characteristics of Individuals* domain of the original CFIR (Damschroder et al., 2009). The research question around staff's views of the implementation of aerobic exercise after stroke was very specific, meaning that a systematic review was an appropriate choice of method to fulfil the Thesis Objective 1. The perspectives of interest were those of staff whose roles were within healthcare, exercise or fitness settings, as aerobic exercise post-stroke can be delivered in a variety of settings.

At the time that this systematic review was conducted, no other review existed which collated the existing evidence around staff's perspectives of factors influencing implementation of aerobic exercise after stroke. Since its publication in 2019 (Gaskins et al., 2019), a scoping review on the barriers and facilitators to implementing aerobic exercise in stroke rehabilitation has been published, but this was solely from the perspectives of physiotherapists (Moncion et al., 2020).

3.3 Objectives

Thesis Objective 1. To conduct a systematic review of the literature to identify and synthesise existing evidence about the factors influencing the delivery of aerobic exercise after stroke from the perspectives of staff working within healthcare, exercise, or fitness settings.

- **Study Objective 1a.** To systematically identify relevant literature on the factors influencing the implementation of aerobic exercise after stroke from the perspectives of staff whose roles were within healthcare, exercise, or fitness settings.
- **Study Objective 1b**. To synthesise the findings from the identified literature using the CFIR.

3.4 Methods

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009). The PRISMA aims to improve the reporting of systematic reviews and promote transparency. It consists of an evidence-based 27-item checklist and a flow diagram statement (Moher et al., 2009). A PRISMA checklist is presented in *Appendix 3.2*. This review was registered with PROSPERO, an international prospective register of systematic reviews (Registration Number CRD42018099579). Registration helps to avoid the duplication of reviews and allows the completed review to be compared with the protocol to reduce the likelihood of reported bias.

3.4.1 Search strategy

The SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research type) search tool was specifically adapted from the PICO (Population/Problem, Intervention/Exposure, Comparison, and Outcome) tool for use in qualitative research (Cooke, Smith and Booth, 2012). As it was anticipated that most of the data would be qualitative in nature, this tool was chosen to develop an effective search strategy. Using the SPIDER search strategy (Cooke, Smith and Booth, 2012), three domains were identified to include within the search strategy; the sample (patients with stroke), the phenomenon of interest (aerobic exercise) and evaluation (of the barriers and facilitators from a healthcare, exercise, and fitness professional's service perspective). The American College of Sports Medicine (ACSM) defines aerobic exercise as any planned activity that uses large muscle groups, is rhythmic and can be sustained continuously, which can be prescribed and undertaken guided by the FITT components of Frequency, Intensity, Time and Type (American College of Sports Medicine, 2018). The search strategy was developed using previous similar searches (Craig et al., 2016), using synonyms of each domain as shown in *Appendix 3.3*. The synonyms of the sample domain (stroke) were collated with assistance from an information specialist whereas the synonyms for the phenomenon of interest were compiled from previous Cochrane reviews (Bidonde et al., 2017, Voet et al., 2013, Andriolo et al., 2010, Hassett, Moseley and Harmer, 2017) and for the evaluation from a previous similar search (Nathan et al., 2018). Key authors' publications together with reference lists of included and related articles were scanned to identify any further potential studies ("snowballing") (Greenhalgh and Peacock, 2005). In the case of abstracts identified as potentially relevant, authors were contacted where possible. Databases were chosen to ensure a comprehensive identification of articles. The following electronic databases were chosen with searches conducted up to December 2018:

- OVID SP MEDLINE
- OVID SP Excerpta Medica Database (EMBASE)
- Cumulative Index to Nursing and Allied Health Literature (CINAHL)

No start date was applied, and articles were limited to the English language as resources were not available for foreign language translation. Where applicable, Boolean operators AND, OR and truncation codes (*) were used. Search hits from all databases were imported into EndNote where duplicates were removed.

3.4.2 Selection criteria

3.4.2.1 Inclusion criteria

As per the SPIDER search tool domains, studies were included if they involved the exploration of factors from the perspectives of staff (evaluation domain) affecting the implementation of aerobic exercise (phenomenon of interest domain) after stroke (sample domain). No restrictions were imposed based on age, stroke characteristics, or time since stroke. A scoping exercise was carried out which indicated that, due to issues with reporting and defining of interventions, the definition of 'aerobic exercise' needed to be comprehensive. Therefore, any exercise interventions which were potentially aerobic in nature but did not use the term 'aerobic exercise' were included, for example, 'exercise after stroke', 'community-based exercise', and 'treadmill training'. Studies within stroke rehabilitation and community settings were included with no restrictions on the types of study design eligible for inclusion.

3.4.2.2 Exclusion criteria

The SPIDER domains of sample, phenomenon of interest, and evaluation, were used to guide decisions around the exclusion criteria. Studies were excluded if:

- They did not involve stroke (sample domain)
- The intervention was not aerobic exercise as per the broad definition used in this review (phenomenon of interest)
- There was a sole focus on patients' perspectives of participation in aerobic exercise, or they did not explore barriers or facilitators to implementation from a staff perspective as a formal study objective, for example, studies with a focus on clinical outcomes, economic evaluations or "normal practice" (evaluation domain)
- Other – Reviews were also excluded.

3.4.2.3 Population

The study population were staff working within stroke-related healthcare, exercise, or fitness settings, with no restrictions based on qualifications or experience. This included, but was not limited to, physiotherapists, rehabilitation assistants, managers, and health, exercise, and fitness staff.

3.4.3 Screening

A single reviewer (NG) screened the titles of retrieved references to exclude obviously irrelevant studies. This reviewer then carried out abstract screening. In the absence of availability of full texts for any abstracts, every attempt was made to contact authors through ResearchGate and email to obtain further information or any published full texts about their research. The remaining articles were each read in full and independently screened by two of the three reviewers (NG, LC, or EB). Uncertainty was resolved by discussions, and if consensus could not be reached, arbitration was carried out by the third reviewer. Reasons for exclusion at the full text screening stage were documented.

3.4.4 Post-protocol automated screening

Following data analysis, a post-protocol adaptation was made to enhance single screening in the form of retrospective automated screening. Due to limited resources the initial screening had been carried out by a single screener, the author of the thesis. An alternative to dual screening, which has been shown to be as accurate, is automated screening (Olofsson et al., 2017). This can reduce the burden on the screener by reducing the number of citations which need to be screened (Wallace et al., 2010). The automated screening software used was Rayyan (Ouzzani et al., 2016). This gives a hierarchical recommendation for title and abstract screening. This was recommended as the most appropriate software for use in optimising the results of the screening process, as evidence has shown that Rayyan resulted in time-saving of up to 50% when compared with other screening tools (Ouzzani et al., 2016). It was developed as a semi-automated aid to title and abstract screening with features which enable the user to include or exclude studies and add reasons for the decisions in the form of labelling (Ouzzani et al., 2016). It also facilitates collaboration on reviews with the option to 'hide' the decisions of other collaborators during screening. Rayyan has been tested on two published Cochrane reviews by uploading the original searches (Ouzzani et al., 2016). The original search records for this review were uploaded to Rayyan with the included and excluded studies indicated. The software then calculated and rated how likely the excluded studies were to be related to the included studies. The 200 most relevant studies were then re-screened again by NG and four additional studies identified through this process were added for data analysis and synthesis.

3.4.5 Data extraction and synthesis

Following Cochrane guidance (Noyes et al., 2018a), contextual and methodological information was extracted from each study and organised in Microsoft Excel, including study aims, study context, participants, methods of data collection and analysis, and key findings. In order to choose an appropriate synthesis method, the Integrated Health Technology

Assessment for Evaluating Complex Technologies (INTEGRATE-HTA) (Booth et al., 2016) document was consulted. This provides non-prescriptive guidance, organised as a five-item framework, on what to consider when seeking a method of qualitative evidence synthesis. This framework has since been expanded as the RETREAT (Review Question – Epistemology – Time/Timescale – Resources – Expertise – Audience and Purpose – Type of Data) mnemonic (Booth et al., 2018) with seven criteria, and is suitable for use for stand-alone methodologies and when amalgamating quantitative and qualitative data. To use this framework, consideration should be given to what is already known about the subject. Initially this may include the research question being asked, the evidence base, study designs, and type of data required (Booth et al., 2016) . Next, it is advised to consider the resources, time, and expertise allocated for the review, followed by the audience and review purpose, ending with any other specific methodological characteristics (Booth et al., 2016). Following the INTEGRATE-HTA guidance, it was decided that the most appropriate method for this systematic review would be a framework synthesis approach. The rationale behind this decision was that the review question was fixed, with low epistemological dependence and was intended as a rapid process in a short timeframe requiring a low level of qualitative researcher expertise alongside a broad target audience of policymakers, practitioners, intervention designers, and academics.

In framework synthesis, an *a priori* framework is used to structure and organise the data extraction and synthesis meaning that this approach is primarily deductive in nature (Barnett-Page and Thomas, 2009). Within implementation research many frameworks, theories, and models have been described which aim to facilitate the uptake of research into healthcare practice. Examples of these include *The Practical, Robust Implementation and Sustainability Model (PRISM)* (Feldstein and Glasgow, 2008), *Normalisation Process Theory (NPT)* (Murray et al., 2010)*,* and *PARIHS* (Moullin et al., 2015). These have been applied within a variety of healthcare contexts and settings. Choosing an appropriate method can be challenging for researchers and clinicians as there is no one method to suit all. Lynch et al. (2018) actively encourage consideration of the intervention, context, and setting when choosing an approach.

The original CFIR (first version) is a deductive framework synthesis approach which was developed in response to the variation in constructs and terminology used in individual frameworks, theories, and models (Damschroder et al., 2009). It is a pragmatic taxonomy of the factors that influence implementation consisting of constructs amalgamated from a synthesis of published literature. The literature it is compiled from included a synthesis of 500 published sources (Greenhalgh et al., 2004) and 18 individual models. The CFIR can be used as a 'menu' with researchers free to choose the constructs which are most relevant to the setting and context of their research (Damschroder et al., 2009). The CFIR has 37 constructs across the five domains of characteristics of the intervention, inner setting, outer setting, characteristics of individuals, and process (*Appendix 3.4*). The framework can be used to guide assessments of implementation, evaluate implementation progress, and explain findings in research studies, and has been used previously by the research team to explore implementation issues within stroke rehabilitation (Connell et al., 2018, Connell et al., 2014a). Information was extracted from the results section in each of the included studies as this comprised the primary data and mapped to the appropriate domains from the original CFIR (Damschroder et al., 2009). Due to the nature of the framework, it was anticipated that most of the data extraction would be qualitative in nature. The nature of the intervention (aerobic exercise after stroke), context (staff's perception of the factors affecting implementation), and setting (healthcare and leisure), together with a need to organise and structure the primary data, led to the decision to use the CFIR for data synthesis in this review.

In the context of a qualitative evidence synthesis there are three classifications of data – participant quotes are categorised as first order constructs, explanations and recommendations of the author as second order interpretations, and new understandings resulting from the data synthesis as third order interpretations (Noyes et al., 2018a). Another noteworthy point applicable to any method of qualitative data extraction, analysis, and synthesis is that this is not a rigid ordered process but involves movement between these three stages of review (Noyes et al., 2018a). Regular team meetings focusing on discussion of the evidence were carried out to facilitate a shared understanding as recommended in the Cochrane guidance (Noyes et al., 2018a). Care was taken during data analysis and synthesis to refer back to the primary data to ensure that there was no loss of context or misinterpretation of results (Noyes et al., 2018a).

For data extraction, all identified texts were imported as Microsoft Word documents into NVivo 12, a computer software package for qualitative data analysis. Nodes for data extraction were as per the original CFIR (Damschroder et al., 2009) with extra nodes created as deemed appropriate by each reviewer. Data extraction was completed independently by three reviewers (LC, EB, and NG) with each document being reviewed by two of the three reviewers. Texts were allocated randomly to two reviewers (LC and EB) with the third reviewer (NG) reviewing all texts. One study was coded by all three reviewers followed by a discussion amongst the reviewers to ensure that similar decisions had been made on how to interpret the framework. Results were then synthesised using a framework synthesis approach (Booth et al., 2016). Regular team meetings focusing on discussion of the evidence were carried out to facilitate a shared understanding as recommended in the Cochrane guidance (Noyes et al., 2018a).

3.4.6 Quality assessment and sensitivity analysis

Quality Assessment

A quality assessment, via a critical appraisal tool, of the included studies was considered for this review, but excluding studies risks the loss of valuable data and the contribution of individual studies may only become apparent during data synthesis (Hannes, 2011). Hence no studies were excluded on the basis of quality, but elements of the GRADE (Grading of Recommendations Assessment, Development and Evaluation) CERQual (Confidence in Evidence from Reviews of Qualitative research) (Lewin et al., 2018) method around coherence and relevance were considered. This is further discussed in section 3.6.2.

Sensitivity Analysis

A sensitivity analysis was conducted with the aim of establishing whether inclusion of any abstract-only texts affected the review findings, and therefore whether these should be included in the data analysis and synthesis. All studies which met the review inclusion criteria were included for data extraction and initial synthesis, with a sensitivity analysis conducted post-synthesis to ensure that valuable contributions from individual studies were included (Hannes, 2011). Two of the researchers (NG and LC) extracted, examined, and compared the data from each individual abstract-only text with the data from the full text papers to assess the effect of the data from each abstract on the overall results and conclusions of the review, thereby establishing whether the abstracts should be included or omitted from the synthesis and final data analysis. This decision is further discussed in section 3.6.2.

3.5 Results

3.5.1 Study identification

A total of 11,611 hits were identified through the search strategy (11,449 from initial search process to June 2018 and 162 from the update to December 2018) of which 62 progressed to full text review. A total of 20 studies were included in the review which comprised of eleven full text articles and nine conference abstracts for which no full texts were available (*Figure 3.1*). Three of these texts were identified for inclusion through the automated screening.

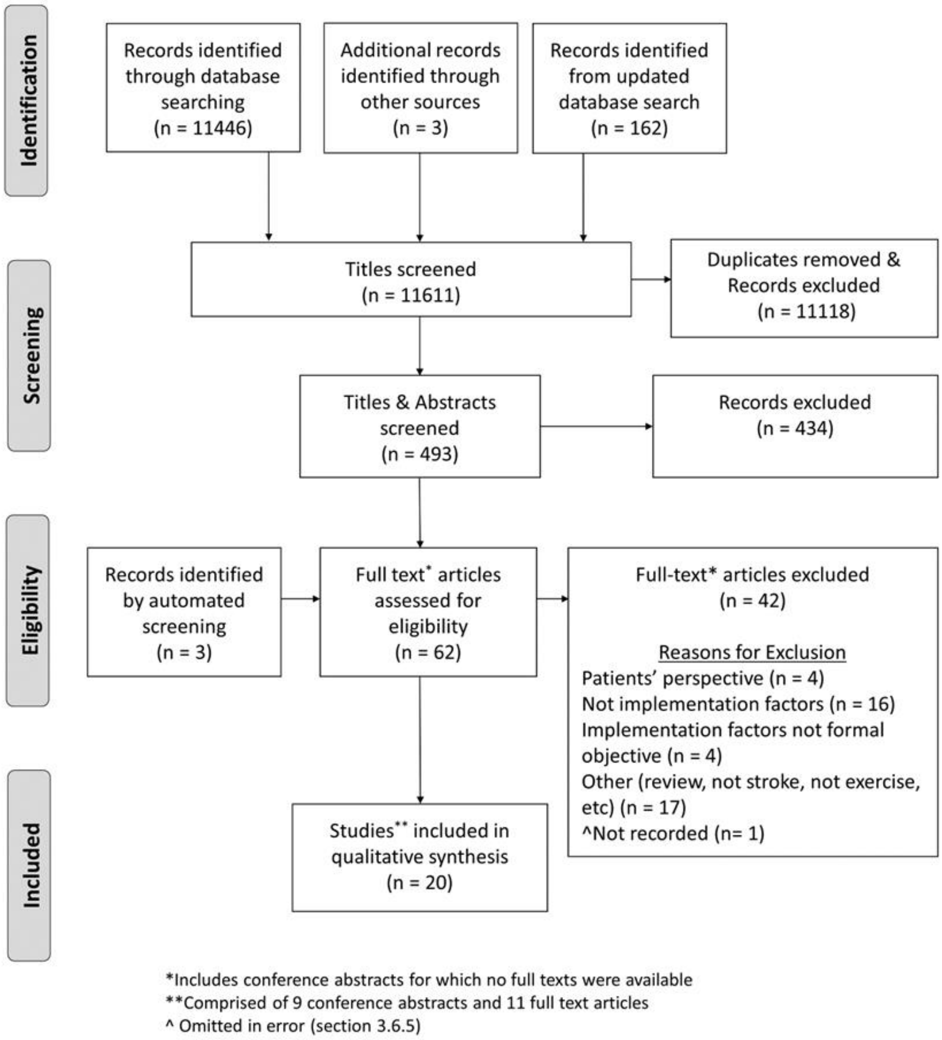

Figure 3.1. PRISMA flow chart of search strategy and screening results

Table 3.1. Summary of included studies

Author (year) Country	**Design**	**Setting**	**Population and participant characteristics**	**Methods**	**Results**
*Ali et al. (2018) United Kingdom	Workshops	Not reported	30-40 stakeholders including stroke survivors, carers, therapists, exercise professionals, doctors, social services, commissioners, the voluntary and private sector.	Double diamond approach for two workshops co-facilitated by a multidisciplinary team and two designers aiming to promote exercise post-stroke. Data analysed thematically.	Key themes identified: • a variation in information exchange amongst patients & clinicians • a need to integrate exercise & rehabilitation and for support to access services 3 main barriers: • lack of access to information, accessibility, and infrastructure
*Axelson et al. (2014) Canada	Included a literature review	Neuro-rehabilitation unit	People post-stroke and clinicians delivering aerobic exercise to this population. Number of participants not stated.	Development of an Aerobic Fitness Programme for subacute post-stroke rehabilitation guided by a literature review and based on 'The Aerobic Exercise Recommendations to Optimize Best Practices Care after Stroke' (Mackay-Lyons et al., 2013).	Challenges: • patients' cognitive & physical abilities, comorbidities • exercise testing and intensity monitoring • incorporation into schedules
Best et al. (2012) United Kingdom (Scotland)	Scoping study – internet survey & interviews	Health service, leisure services, and stroke charities	Service providers: • 45 health boards • 61 local authorities • 105 private gyms • 19 charities	Survey on models of community-based exercise after stroke services & how these meet needs of people post-stroke. Interviews conducted to complete data.	230 survey responses plus 14 interviews. 14 Exercise After Stroke services identified: • 12 stroke-specific services run by health services, leisure centres & charities • Two multipathology services: by collaboration between health and leisure services. Service capacity in terms of safety, effectiveness, and sustainability.

Boyne et al. (2017a) United States of America	Cross-sectional web-based survey study	Primary practice settings of acute care, home health, inpatient rehabilitation, extended care, or outpatient rehabilitation in 5 US states	1212 physiotherapists (actively licensed), including a subset of 568 currently working in clinical practice and stroke rehabilitation whose responses were focused upon in the analysis.	Survey to assess aerobic exercise prescription for people post-stroke was emailed to physical therapists.	Aerobic exercise important post-stroke & majority able to prescribe. Barriers: • patients' physical & cognitive abilities, motivation • knowledge about exercise intensity • confidence • safety – screening, adverse effects • short length of stay • lack of equipment & time
*Clague-Baker (2015) United Kingdom	Qualitative interpretive with focus groups	CR and stroke rehabilitation	CR and stroke teams – number of participants not given.	Investigated attitudes of CR & stroke teams to people post-stroke participating in CR. Conducted seven focus groups prior to stroke patients participating in CR & five focus groups after participation. Data analysed thematically.	Four main themes identified as factors affecting implementation of CR post-stroke: • confidence in delivering the service • stroke and exercise • lack of knowledge • cardiac adaptations
Condon and Guidon (2018) Ireland	Cross-sectional descriptive study using an online survey.	Community – various	87 exercise professionals (EPs) (31% response rate) registered with the register of exercise professionals (REPs) in Ireland. • median of 5 years' experience, n=19 had experience with people post-stroke • 40% based in gyms, 36% in for-profit exercise facilities • 25% received training on stroke as part of EP training with 17%	Researcher-designed survey used to investigate the opinions of EPs on working with people post-stroke. Included rating barriers and facilitators, quantifying experience & skills and exploring how training related to the barriers and facilitators. Survey link emailed to eligible REPs members. Calculation of descriptive statistics using SPSS.	Most were interested in working with people post-stroke. Barriers: • training, equipment, safety, and cost of staffing Facilitators: • training, professional certification and funding for this • equipment, environment • liaison between physiotherapists and EPs

			completing CPD on stroke post-qualification		
Desveaux et al. (2016) Canada	Quantitative study using a cross-sectional design using a patient-barriers questionnaire	Hospital-based rehabilitation facilities	35 healthcare professionals (HCPs): • 19 physiotherapists • 10 kinesiologists • 6 physicians 83 patients with multi-morbidities including stroke	Barriers to physical activity post-rehabilitation explored via modified version of the Cardiac Rehabilitation Barriers Scale (CRBS) completed by patients with heart failure, stroke, diabetes & COPD and by HCPs working with these populations. Questionnaires delivered via one-to-one interviews, face-to-face apart from five via phone. Perceived barriers to participation in community-based exercise were evaluated quantitively.	Barriers perceived by HCPs: • travel time • lack of motivation • cost • severity of symptoms Facilitators: • referral from HCP • facilitated transition to the programme Suggested solutions: • reduced rehabilitation-to-community transition time • transportation strategy • accessible and supportive community environment
*Diehl D (2017) United States of America	Pilot, non-experimental descriptive study using anonymous surveys	Healthcare – setting not specified	31 Indiana-based physiotherapists with 50% practice time spent with people with sub-acute CVA	To explore the familiarity with and understanding of the use of high intensity interval training (HIIT) in CVA rehabilitation and barriers to implementation of HIIT	16.1% reported using HIIT in practice. Barriers: • 51.8% inadequate understanding of HIIT • 48.1% patient comorbidities • 77.8% unable to perform exercise testing • 48.1% lack of access to support personnel
Doyle and MacKay-Lyons (2013) Canada	Quantitative cross-sectional web-based survey study	• Rehabilitation centres Public/private outpatient clinic • Community/home Stroke unit • General hospital ward	155 physiotherapists practicing adult neurorehabilitation (response rate 36%)	Electronically distributed survey regarding use of aerobic exercise (AEx) in clinical practice for neurological populations including stroke. Closed questions	Most agreed AEx should be part of treatment programs for neurological population & prescribed AEx in their practice.

				(profile, screening, prescription, and implementation AEx).	Barriers: • safety, patients' inability to participate • resources (staffing, training, screening tools, knowledge), • role of AEx in neurorehabilitation. • lack of availability of exercise stress test but few said test was essential for safety
*Eng et al. (2015) Australia	Pilot study – one-to-one interviews and focus groups	Tertiary metropolitan hospital	• 20 clinical staff (professions not stated) • seven people post-stroke who were inpatients • six main carers	Explored factors affecting people post-stroke performing inpatient independent therapeutic practice outside therapy time. Interviews with people post-stroke & their main carer. Two focus groups with clinical staff. Data analysed thematically.	Barriers: • majority of time outside therapy spent dealing with loss caused by stroke • differences in patient and staff perceptions of key motivation for rehabilitation Facilitators: • accessible exercise equipment • private space for structured therapy homework • simulated real world engagement
Fullerton et al. (2008) Canada	Descriptive cross-sectional study with survey/ questionnaire	Fitness facilities (community-based) in Greater Toronto Area	213 analysed after exclusions. 105/213 were from for-profit organizations, 56/213 from government-sponsored agencies, 44/213 from non-profit and 8/213 did not identify funding model. Range of HCPs employed.	Exploration of characteristics & availability of fitness programmes for people post-stroke via questionnaire with 5 subcategories: facilities' background, program availability and barriers, characteristics, physical and educational components & demand for fitness programmes for people after stroke. Completed by staff member most qualified to answer. Excluded facilities with mainly CR or hospital outpatient rehabilitation (different to community-based fitness	Response rate 42%. Of the 213 facilities, 62 had specific programmes for people with chronic disabilities and of these and 26 had fitness programmes for people post-stroke. Facilities with stroke-specific programmes only: • all delivered aerobic exercise • 85% had specific acceptance criteria • 35% were fixed lengths with 1:7 instructor-client ratio • Barriers to implementation – cost, lack of qualified staff & time

				facilities); home-exercise program provision only: education-only programmes specialising in a specific skill, e.g., dance or Tae Kwon Do.	Facilities without stroke-specific programmes: • Barriers to offering – lack of qualified staff, low demand & cost
*Miller et al. (2017) United States of America	Explorative qualitative study with focus groups and interviews	Healthcare – setting not specified	Stroke survivors, caregivers, rehabilitation clinicians, nurse practitioners and physicians. Number of participants not given.	Development of a stroke-specific CR programme using stakeholder input via separate focus groups with stroke survivors, caregivers, rehabilitation clinicians, nurse practitioners and interviews with physicians. Analysis of resulting themes, patterns, and issues.	4 main themes: • safety • individual prescription of programme • return to function & maximise potential • long-term maintenance of activity Main components: • individualised education for stroke survivors • exercise testing pre-exercise • timely implementation (needs, resources, benefits), individualisation • staff training/education • interdisciplinary approach • onward referral to community/home programmes
Otterman et al. (2012) Netherlands	Descriptive survey using web-based questionnaire	Hospitals with inpatient neurological department	91 physiotherapists practicing in acute stroke rehabilitation	Four-part web-based survey used to examine physiotherapists' current practice and adherence to clinical practice guidelines for patients with stroke at acute hospital stroke units. Included questions on barriers and facilitators for start of mobilisation and time dedicated to exercise therapy.	95% response rate. Barriers to adherence to guidelines: • time • cooperation by colleagues • professional characteristics • flexibility • applicability • belief Barriers for early mobilisation and exercise therapy: • patients' health status

					• policy & funding of the organisation
Prout et al. (2016) Canada	Prospective cross-sectional study with survey and literature review	Three hospital-based rehabilitation centres – with and without structured aerobic exercise programme as part of inpatient stroke rehabilitation	16 physiotherapists actively practising in inpatient acute stroke rehabilitation	A questionnaire to identify physiotherapists' perceptions of people post-stroke, the practice environment, and training on aerobic exercise post-stroke administered via face-to-face interview by member of research team. A literature review was conducted on potential barriers to physical activity and aerobic exercise for healthcare providers and people post-stroke. Comparisons made between rehabilitation centre with aerobic exercise program and the two without.	Most agreed aerobic exercise is essential part of inpatient stroke rehabilitation. All willing to upskill to incorporate aerobic exercise into their practice. Site with aerobic exercise programme had more equipment available for equipment for exercise testing & training, screening & monitoring. Main barriers at facilities with aerobic exercise programmes: • cardiovascular risk and cognitive impairment • lack of time in the session • fatigue Main barriers at facilities without aerobic exercise programmes: • physical impairment, • lack of necessary resources • lack of support staff • fatigue
Salbach et al. (2018) Canada	Mixed methods including a 1-day stakeholder meeting and online survey	Academic, healthcare and recreation centre settings	53 multidisciplinary and multi-professional participants working within academia, healthcare, and recreation: • 40 (7 healthcare professionals, 9 healthcare system representatives, 11 fitness instructors,9 recreation managers, 3 researchers, 1 ex	1-day meeting with community-based exercise programme ("Together in Movement and Exercise") stakeholders. Subsequent completion of online survey to identify challenges and solutions to implementation of this programme model.	Challenges – seven themes: • resources (staff, space, equipment, training) • marketing of programme to ↑ uptake • transportation to programme (cost) • accessibility (availability, appropriateness) • maintenance of programme integrity • sustaining communication & collaboration between organisations & services • funding (staff, equipment, training)

			participant) discussed challenges/solutions • 42 rated priorities • 17 completed online questionnaire		
*Stewart et al. (2017) Australia	Qualitative study using focus groups	Rehabilitation unit	Multidisciplinary: • 11 nurses • 8 AHPs • 2 medical staff	5 multidisciplinary focus groups explored factors influencing implementation of practice books & nurse-led weekend classes which aimed to increase practice by inpatient stroke patients. Analysed using framework analysis and the Theoretical Domains Framework. Barriers mapped to behaviour change interventions using Behaviour Change Wheel framework.	Barriers: • staff beliefs about patient motivation to participate in rehabilitation, • ward environment • resources • ability of staff to motivate & supervise active practice
Tang et al. (2009) Canada	Survey via email, phone, fax, or post. Retrospective database review.	CR programme facilities	40 CR programmes	Two-part study to identify the potential opportunity and effectiveness of CR for people post-stroke using: 1) Questionnaire/survey containing multiple choice questions (on programme use) and open-ended questions (barriers to enrolment), 2) Retrospective database review to compare effects of CR for people with primary diagnoses of TIA/stroke, secondary diagnoses TIA/stroke, and cardiac diagnoses only.	40 responses analysed: • 24 accepting people post-stroke • of these, 14 had no specific stroke-related restrictions to program eligibility • remaining 10 facilities accepted people with a diagnosis of stroke and/or those with mild or moderate impairments only Reasons for exclusion from programs: • impaired walking • cognitive or communication ability 16 facilities provided some adaptation to accommodate people post-stroke (equipment, staffing, individual exercise prescription)

*Waters et al. (2014) Australia	Qualitative study using semi-structured interviews and focus groups	Rehabilitation facilities • one rehabilitation • one acute care	14 physiotherapists: • eight at rehabilitation facility • six at acute care facility	Focus groups (using semi-structured questions) conducted to explore perceptions about treadmill training during inpatient stroke rehabilitation. Recorded, transcribed, coded, and analysed thematically.	Themes: • treadmill training potentially beneficial for function & early walking practice • mixed perceptions on walking quality/normal gait pattern Factors influencing use of treadmill: • patient comorbidities & ability • safety & resources • culture & organisation • access to training • encouragement
Wiles et al. (2008) United Kingdom	Qualitative methodology using focus groups and interviews	Exercise on Prescription (EoP) schemes in leisure centres in urban, rural, and suburban areas	• nine people post-stroke participating in EoP schemes • six fitness instructors running the schemes including one scheme coordinator • 15 physiotherapists who can refer patients to these schemes	Fitness instructors,' physiotherapists' and patients' perspectives about EoP schemes for people post-stroke explored through interviews with the stroke patients, fitness instructors and two of the physiotherapists, and focus groups with 13 of the physiotherapists. Thematically analysed.	Most patients referred to EoP were men. Patients' perceptions compared with physiotherapist and fitness instructor perceptions Main themes: • method of continuing with physiotherapy post-discharge from NHS • safety (knowledge, training about stroke, equipment, patient ability) • supervision, support, and interaction during participation • collaboration between fitness instructors and physiotherapists Barrier: • training and funding
*Zinger et al. (2011) Netherlands	Questionnaire	Rehabilitation facilities • hospitals • rehabilitation centres	186 team members of the rehabilitation facilities	Exercise guide to increase exercise intensity for people post-stroke was developed with	Decision to create two versions: 1) ready-to-use version categorising exercise levels for hospital use

		• nursing homes		therapists and rehabilitation facility team members regarding content, format, and implementation.	2) customisable version for individual exercise prescription for use in nursing homes and rehabilitation centres

**abstract only*

Following the results of the sensitivity analysis, the relevant abstracts (n=9) as well as the full text articles (n=11) were included for data synthesis to avoid excluding any valuable insights (Noyes et al., 2018a). A summary of the included studies is shown in *Table 3.1* as recommended by the Cochrane Qualitative and Implementation Methods Group (Noyes et al., 2018a), with a full narrative summary given below.

3.5.2 Sensitivity analysis

The sensitivity analysis conducted on the conference abstracts (n=9) revealed that they had less methodological detail. This may be due to word restrictions meaning that many aspects regarding methods are not reported. However, the sensitivity analysis also revealed that the data from the abstracts either confirmed or added depth to the findings and added valuable insight. For example, confirming the need for specialist staff to help implement the intervention post-stroke into an existing model (in this case, CR) (Clague-Baker, 2015) and the challenge of integrating exercise testing and prescription into patient and clinician schedules (Axelson et al., 2014). Therefore, the abstracts were retained as part of the final analysis and review findings.

3.5.3 Description of included studies

3.5.3.1 Study location

The 20 studies included were from six countries and utilised a variety of methodologies, study settings, participants, and interventions. Seven were conducted in Canada, four in the UK, three in Australia, three in the USA, two in the Netherlands, and one in Ireland. Studies were published between 2007 and 2018 with most studies published between 2012 and 2018 (n=16, 80%). The larger studies were generally from North America and the Netherlands. The four studies which expressly investigated the implementation of aerobic exercise after stroke were conducted in North America (three Canadian and one American).

3.5.3.2 Study setting

All studies were set within either healthcare, exercise, or fitness settings ranging from hospital-based to primary practice to leisure services and charities. Most studies focused on one setting although a number (n=4) had multiple settings (Best et al., 2012, Boyne et al., 2017a, Zinger et al., 2011, Doyle and MacKay-Lyons, 2013). The UK studies (n=4) were predominantly within leisure and fitness settings (Best et al., 2012, Wiles et al., 2008), with one study additionally including health services and charities (Best et al., 2012). Another study was set solely within cardiac and stroke rehabilitation in the UK's NHS (Clague-Baker, 2015) as confirmed through correspondence with the author, and the fourth did not specify a setting (Ali et al., 2018).

3.5.3.3 Intervention type

Four of the North American studies (Axelson et al., 2014, Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Prout et al., 2016) provided data on the factors perceived by physiotherapists (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Prout et al., 2016) and clinicians (specific profession not given) (Axelson et al., 2014) to influence implementation of aerobic exercise after stroke. These fitted specifically within the review question as they included staff perspectives on factors affecting implementation of aerobic exercise after stroke. Doyle and MacKay-Lyons (2013) examined factors around utilisation, screening, and implementation of aerobic exercise in neurological populations including stroke from a physiotherapist's perspective (n=155). A larger study by Boyne et al. (2017a) assessed prescription of aerobic exercise in stroke rehabilitation and the factors affecting this, again from a physiotherapist's viewpoint (n=1,212). An exploration of 16 physiotherapists' perspectives on the prescription and implementation of aerobic exercise was conducted by (Prout et al., 2016). The challenges relating to the development and implementation of an aerobic fitness programme for subacute stroke rehabilitation were studied by (Axelson et al., 2014).

The remaining sixteen studies were included under this review's broad definition of 'aerobic exercise' as their exercise interventions were potentially aerobic in nature despite not explicitly using the term 'aerobic exercise' *per se* in their reports. This inclusion aimed to avoid the possibility of excluding valuable data, as was also the case with inclusion of the abstracts (n=9). These sixteen studies reported on the barriers and/or facilitators to participation in, or implementation of, an exercise intervention after stroke from the perspectives of staff. Examples of these interventions were 'exercise programme' (Condon and Guidon, 2018), 'community-based exercise' (Desveaux et al., 2016, Salbach et al., 2018), 'high intensity interval training' (Diehl D, 2017) and 'fitness programmes' (Fullerton et al., 2008). Included within these 16 studies, one targeted service providers in the UK (Best et al., 2012), another fitness facilities in Toronto in Canada (Fullerton et al., 2008), and a third CR programme facilities in Canada (Tang et al., 2009). Their focus was on the provision of exercise services for people post-stroke (Best et al., 2012, Fullerton et al., 2008) and, in the case of (Tang et al., 2009), the clinical effectiveness of this. These three studies contributed data relating to patient needs, available resources, and characteristics of exercise professionals to the review. The remaining 13 studies encompassed a range of exercise interventions including, but not limited to, community-based exercise (Desveaux et al., 2016), exercise on prescription schemes (Wiles et al., 2008), high intensity interval training (Diehl D, 2017), CR (Clague-Baker, 2015), amount of practice post-stroke (Eng et al., 2015) and the implementation of treadmill training (Waters et al., 2014).

3.5.3.4 Staff type

A range of staff were involved in the twenty studies. These included healthcare professionals (Desveaux et al., 2016, Eng et al., 2015, Stewart et al., 2017, Zinger et al., 2011, Miller et al., 2017, Salbach et al., 2018, Ali et al., 2018), physiotherapists (Otterman et al., 2012, Waters et al., 2014, Diehl D, 2017), fitness instructors (Wiles et al., 2008, Salbach et al., 2018), cardiac and stroke rehabilitation teams (Clague-Baker, 2015), exercise professionals (Condon and Guidon, 2018, Ali et al., 2018), and others (Best et al., 2012, Fullerton et al., 2008, Tang et al., 2009, Salbach et al., 2018, Ali et al., 2018). The views of physiotherapists (n=909) were predominant with a lesser number of exercise professionals (n=114), medical staff (n=8), and nurses (=11) represented. The number and/or specific profession of participants were not reported in six of the abstracts (Axelson et al., 2014, Clague-Baker, 2015, Eng et al., 2015, Zinger et al., 2011, Miller et al., 2017, Ali et al., 2018).

3.5.3.5 Methodological approaches

Several different methodological approaches were used in these studies. The most utilised methods were surveys or questionnaires with twelve studies selecting these for part (Best et al., 2012, Prout et al., 2016, Tang et al., 2009, Salbach et al., 2018) or all (Boyne et al., 2017a, Condon and Guidon, 2018, Desveaux et al., 2016, Doyle and MacKay-Lyons, 2013, Fullerton et al., 2008, Otterman et al., 2012, Zinger et al., 2011, Diehl D, 2017) of their data collection. Focus groups alone were the choice of two further studies (Clague-Baker, 2015, Stewart et al., 2017), with another four combining focus groups with interviews (Waters et al., 2014, Miller et al., 2017, Wiles et al., 2008, Eng et al., 2015). The remaining two studies used workshops for a co-production event (Ali et al., 2018), and a literature review to guide development and implementation of an exercise programme (Axelson et al., 2014). The majority of studies included qualitative data which related to the barriers and facilitators to implementation.

3.5.3.6 Analysis techniques

Data analysis techniques were not reported in all studies, but in those that did a range of techniques were utilised. Thematic analysis (Clague-Baker, 2015, Eng et al., 2015, Waters et al., 2014, Wiles et al., 2008, Miller et al., 2017, Ali et al., 2018, Salbach et al., 2018) and framework analysis (Stewart et al., 2017) were adopted by over a third of the studies. Quantitative analysis was primarily descriptive statistics to describe the participants and the level of agreements or importance of barriers and facilitators and was used in a fifth of studies (Prout et al., 2016, Otterman et al., 2012, Condon and Guidon, 2018, Fullerton et al., 2008). Statistical analysis was carried out by Desveaux et al. (2016) and Doyle and MacKay-Lyons (2013) using the Statistical Package for the Social Sciences (SPSS).

3.5.4 Factors influencing implementation

All the included studies contained data relating to the factors (i.e., barriers and/or facilitators) influencing implementation of their chosen exercise-related intervention. Factors influencing implementation were derived from the original version of the CFIR (Damschroder et al., 2009) as this systematic review was completed prior to the CFIR update when existing domains and constructs were revised, with some added, removed, or relocated (Damschroder et al., 2022). For example, the *Intervention Characteristics* domain in the original CFIR became the *Innovation* domain in the update, and the *Patient Needs & Resources* construct in the original was separated and relocated to the *Roles Subdomain*, *Characteristics Subdomain,* and *Inner Setting* Domain (section 2.5.2.2). The domains coded in this review were *Intervention Characteristics*, *Outer Setting* (e.g., patients' needs and external policy factors), *Inner setting* (e.g., setting/service), and *Characteristics of Individuals* (e.g., health, exercise, and fitness professionals). *Table 3.2* provides a summarised description of the findings coded under each domain with the source references identified.

Table 3.2. Factors influencing the implementation of aerobic exercise in stroke according to the CFIR domains (Damschroder et al., 2009)

Intervention Characteristics	
Adaptability	• Exercise can be adapted for stroke patients needs through equipment, changing the environment, and presence of specialist or additional staff (Axelson et al., 2014, Clague-Baker, 2015, Condon and Guidon, 2018, Miller et al., 2017, Otterman et al., 2012, Tang et al., 2009, Salbach et al., 2018, Zinger et al., 2011)
Complexity	• The steps required prior to implementation (screening) (Clague-Baker, 2015, Diehl D, 2017, Doyle and MacKay-Lyons, 2013, Miller et al., 2017, Otterman et al., 2012) • The number of (potential) professionals involve (Clague-Baker, 2015, Desveaux et al., 2016, Doyle and MacKay-Lyons, 2013, Fullerton et al., 2008, Miller et al., 2017)
Design Quality & Packaging	• Prescriptiveness and format of the aerobic exercise influences if and how it is implemented (Otterman et al., 2012, Zinger et al., 2011)
Cost	• Costs for implementation includes staff, training, equipment, and environment (Ali et al., 2018, Condon and Guidon, 2018, Fullerton et al., 2008, Salbach et al., 2018, Wiles et al., 2008)
Outer Setting	
Patient Needs & Resources	• Physical and cognitive needs, safety and perceived risk to the patient (Axelson et al., 2014, Clague-Baker, 2015, Condon and Guidon, 2018, Best et al., 2012, Desveaux et al., 2016, Doyle and MacKay-Lyons, 2013, Boyne et al., 2017a, Eng et al., 2015, Diehl D, 2017, Fullerton et al., 2008, Otterman et al., 2012, Prout et al., 2016, Stewart et al., 2017, Tang et al., 2009, Waters et al., 2014, Wiles et al., 2008, Zinger et al., 2011) • Social and cultural factors (Clague-Baker, 2015, Doyle and MacKay-Lyons, 2013) • Accessibility of services (Best et al., 2012, Desveaux et al., 2016, Boyne et al., 2017a, Fullerton et al., 2008, Salbach et al., 2018, Ali et al., 2018)
Cosmopolitanism	• Networking and skill-sharing between organisations, such as between physiotherapists and fitness instructors (Condon and Guidon, 2018, Salbach et al., 2018, Wiles et al., 2008)
Inner Setting	
Structural Characteristics	• Service organisation and staffing (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Fullerton et al., 2008, Miller et al., 2017, Salbach et al., 2018, Waters et al., 2014) • Geographical coverage of services (Best et al., 2012, Desveaux et al., 2016) • Funding models (Fullerton et al., 2008, Otterman et al., 2012) • Service provision for the stroke population (Best et al., 2012, Fullerton et al., 2008, Otterman et al., 2012, Tang et al., 2009)

Networks & Communications	• Communication and collaboration between professionals within organisations (Best et al., 2012, Salbach et al., 2018, Otterman et al., 2012)
Compatibility	• How implementation fits within the individuals' role, responsibilities and workflow and the method for onward referral to other services or professionals (Axelson et al., 2014, Boyne et al., 2017a, Clague-Baker, 2015, Condon and Guidon, 2018, Doyle and MacKay-Lyons, 2013, Otterman et al., 2012, Salbach et al., 2018, Wiles et al., 2008)
Relative Priority	• Perceived as desirable with an identified willingness to facilitate through training(Fullerton et al., 2008, Wiles et al., 2008), e.g., physiotherapists providing training on stroke to fitness instructors in the Exercise on Prescription setting
Organizational Incentives & Rewards	• Provision of funding for training and professional certification in the area of stroke for exercise professionals would be an incentive. (Condon and Guidon, 2018, Otterman et al., 2012, Wiles et al., 2008)
Available Resources	• Available resources included staff, training, equipment, physical space, accessibility to screening and exercise testing and funding for these.(Axelson et al., 2014, Boyne et al., 2017a, Clague-Baker, 2015, Condon and Guidon, 2018, Doyle and MacKay-Lyons, 2013, Otterman et al., 2012, Salbach et al., 2018, Wiles et al., 2008, Desveaux et al., 2016, Fullerton et al., 2008, Prout et al., 2016, Miller et al., 2017, Stewart et al., 2017, Eng et al., 2015, Tang et al., 2009, Ali et al., 2018, Best et al., 2012)
Access to Knowledge & Information	• Communication within organisations and knowledge-sharing between both professionals and services. (Clague-Baker, 2015, Best et al., 2012, Boyne et al., 2017a, Condon and Guidon, 2018, Diehl D, 2017, Waters et al., 2014)
Characteristics of Individuals	
Knowledge & Beliefs about the Intervention	• Generally agreed that aerobic exercise was important and should be prescribed post-stroke (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Prout et al., 2016, Stewart et al., 2017, Tang et al., 2009, Waters et al., 2014, Wiles et al., 2008) • Not all staff possessed factual knowledge about the intervention. (Boyne et al., 2017a, Condon and Guidon, 2018, Diehl D, 2017, Prout et al., 2016, Tang et al., 2009, Wiles et al., 2008) • Concerns about their patients' ability and motivation to participate in aerobic exercise (Boyne et al., 2017a, Desveaux et al., 2016, Doyle and MacKay-Lyons, 2013, Eng et al., 2015, Stewart et al., 2017, Wiles et al., 2008, Zinger et al., 2011)
Self-efficacy	• Individuals' confidence in their abilities to prescribe aerobic exercise to people post-stroke varied (Best et al., 2012, Boyne et al., 2017a, Clague-Baker, 2015, Condon and Guidon, 2018, Prout et al., 2016, Stewart et al., 2017, Wiles et al., 2008) • Some fears of liability or making the patient worse. (Condon and Guidon, 2018, Waters et al., 2014)
Other Personal Attributes	• Individuals displayed an interest and willingness to upskill in order to implement aerobic exercise for this population (Best et al., 2012, Clague-

	Baker, 2015, Condon and Guidon, 2018, Fullerton et al., 2008, Prout et al., 2016, Wiles et al., 2008)

3.5.4.1 Intervention Characteristics

This domain relates to the attributes of the intervention which have been shown to influence the effectiveness of implementation. The importance of being able to adapt the intervention for stroke patients, the format and prescriptiveness of the intervention as well as the number of steps and cost required to implement were the main *Intervention Characteristics* perceived by staff within healthcare, exercise, and fitness settings.

Adapting exercise interventions by having access to suitable adaptive equipment for screening for safety, and for individual exercise prescription was a need identified by clinicians, physiotherapists, and exercise professionals (Condon and Guidon, 2018, Axelson et al., 2014, Doyle and MacKay-Lyons, 2013, Miller et al., 2017, Tang et al., 2009). Examples of these are body weight supported treadmills and cycle ergometers. Use of standard exercise equipment may be challenging for some people after stroke depending on physical and cognitive abilities (Wiles et al., 2008). A suitable accessible physical space and appropriate environment were factors reported by exercise and healthcare professionals (Condon and Guidon, 2018, Salbach et al., 2018).

The potential number of professionals involved in implementation added to the complexity (Doyle and MacKay-Lyons, 2013, Miller et al., 2017), with Miller et al. (2017) advocating an interdisciplinary approach to ensure success. Depending on patients' physical and cognitive abilities and on the level of supervision required by individual patients, specialist stroke or additional staff may also be required during the delivery of the intervention (Clague-Baker, 2015, Tang et al., 2009). Screening to determine whether aerobic exercise should be prescribed to an individual and its required resources also added to the complexity (Doyle and MacKay-Lyons, 2013).

The potential cost involved in providing these extra resources was also identified as a factor. In one study, self-employed fitness instructors expressed a willingness to undertake training in exercise for stroke but were concerned about the provision of funding for that training (Wiles et al., 2008, Condon and Guidon, 2018). In another, concerns were expressed about funds required to sustain a community-based exercise programme which is a healthcare-recreation collaboration in Canada (Salbach et al., 2018).

3.5.4.2 Outer Setting

This domain relates to external influences such as economic or social contexts which may affect the implementation. The needs of the patients and networking between organisations were factors in the *Outer Setting*.

Concerns about the varied physical and cognitive needs and comorbidities of the patients, and the impact of this on the patient's ability to participate in aerobic exercise were reported by physiotherapists (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Diehl D, 2017, Prout et al., 2016). To maintain patient safety, exercise professionals perceived that greater levels of supervision were potentially required as well as adapted equipment (Wiles et al., 2008, Miller et al., 2017, Condon and Guidon, 2018). Physiotherapists perceived that the patient may be at risk of a cardiac event during the intervention (Prout et al., 2016, Doyle and MacKay-Lyons, 2013), and, amongst exercise professionals, there was a fear of making the patient worse (Condon and Guidon, 2018). Accessibility to and inclusivity of services varied depending in part on how ambulatory the patient was and how complex their needs were (Salbach et al., 2018, Best et al., 2012). An example of this was in exercise after stroke services in Scotland, where there was a greater provision for ambulatory stroke survivors rather than those with complex disabilities (Best et al., 2012). The social and cultural barriers were noted in one UK study (Clague-Baker, 2015), although the details of these were not reported, whilst language skills were noted as a barrier by healthcare professionals in Canada (Desveaux et al., 2016).

The rehabilitation goals and motivation of the patients were found to be an area of conflicting opinion. Physiotherapists reported that aerobic fitness was not identified as a patient goal (Boyne et al., 2017a) and some healthcare professionals (physiotherapists, kinesiologists, physicians and nurses) (Desveaux et al., 2016, Stewart et al., 2017) reported that patients were perceived to have a lack of motivation, whereas conversely, CR and stroke teams reported that patients were generally motivated after stroke (Clague-Baker, 2015).

The development of networking and skill-sharing between organisations can facilitate implementation. Examples of this include liaison between physiotherapists and fitness instructors during patients' transition from the health service to exercise on prescription in leisure centres in the UK (Wiles et al., 2008, Condon and Guidon, 2018) and in a healthcare-recreation partnership involving delivery of exercise programmes in community centres in Canada (Salbach et al., 2018). In contrast, American outpatient physiotherapists reported a lack of knowledge regarding suitable community-based exercise programmes for people post-stroke (Boyne et al., 2017a).

3.5.4.3 Inner Setting

This domain includes features within the structural, cultural, and political contexts of the organisation. Staff recognised that there is a definite need for sufficient resources including staff, training, equipment, and space as well as accessibility to appropriate screening and exercise testing to implement aerobic exercise within the stroke population. A culture of communication and collaboration within organisations would aid the sharing of knowledge between professions and services, facilitate methods of onward referral to other services, and work to ascertain how the intervention would fit into the individuals' role and responsibilities. The "Together in Movement and Exercise" (University Health Network, 2024) collaboration is an example of knowledge-sharing between physiotherapists and fitness instructors which facilitates implementation of exercise programmes but which still faces challenges to sustaining collaboration and communication between the organisations involved (Salbach et al., 2018).

There was an acknowledgement amongst physiotherapists (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013) that aerobic exercise after stroke is desirable, even amongst those who were not currently providing this (Fullerton et al., 2008). Exercise professionals (Condon and Guidon, 2018), physiotherapists (Prout et al., 2016) and CR and stroke rehabilitation teams (Clague-Baker, 2015) displayed a willingness to engage with the intervention through training. One reported example involved physiotherapists providing training on stroke to fitness instructors within the Exercise on Prescription setting (Wiles et al., 2008).

The perceived need for further information, knowledge and training about stroke was strongly expressed by physiotherapists, exercise professionals, rehabilitation clinicians and fitness instructors (Clague-Baker, 2015, Condon and Guidon, 2018, Waters et al., 2014, Best et al., 2012, Prout et al., 2016, Wiles et al., 2008, Miller et al., 2017). Exercise professionals were interested in training on safety, the physical and cognitive aspects of stroke, adaptive exercise and equipment and communication (Condon and Guidon, 2018), and physiotherapists wanted to improve their skills to incorporate aerobic exercise into stroke rehabilitation (Prout et al., 2016). The need for suitable equipment was a recurring factor amongst these same staff groups; one study noted that standard exercise equipment may not be appropriate for some patients and led to physiotherapists referring only more able patients to gyms (Wiles et al., 2008). A lack of time to incorporate the intervention into their practice was cited by physiotherapists (Boyne et al., 2017a, Prout et al., 2016) and exercise professionals (Condon and Guidon, 2018).

The structural characteristics of the organisation referred to in the literature included the organisation of the service and staffing as well as service provision for people post-stroke and the geographical areas covered by these services. For example, in Scotland the reported number of exercise after stroke services only equates to less than one per 7000 stroke survivors (Best et al., 2012). Provision of funding for specialist training and professional certification was an identified incentive to implement the intervention. Another factor was funding models which influenced organisations' service provision (Otterman et al., 2012, Fullerton et al., 2008).

3.5.4.4 Characteristics of Individuals

In the context of this review, this domain relates to the staff involved in implementation of the intervention. The individuals' knowledge and beliefs about the intervention played an important role in implementation. Their self-efficacy (a person's belief in their own ability to carry out courses of action to achieve goals) and other personal attributes influenced how likely they were to prescribe aerobic exercise. It was generally agreed by physiotherapists that aerobic exercise was important and should be prescribed post-stroke (Prout et al., 2016, Doyle and MacKay-Lyons, 2013, Boyne et al., 2017a). However, not all exercise professionals

(Wiles et al., 2008) or physiotherapists (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013) possessed factual knowledge about the intervention in relation to screening, prescription and guidelines. A fear of liability and of making the patients worse was identified as a barrier amongst some exercise professionals, especially those who lacked training on stroke (Condon and Guidon, 2018), whereas potential cardiovascular risk to the patient was a barrier for physiotherapists in two Canadian studies (Doyle and MacKay-Lyons, 2013, Prout et al., 2016). Concerns about the ability (Doyle and MacKay-Lyons, 2013) and motivation (Stewart et al., 2017) of their patients to participate in aerobic exercise after stroke were raised by physiotherapists, and nurses, allied health professionals and medical staff respectively. Some physiotherapists and exercise professionals expressed confidence in their own ability to prescribe the intervention for people post-stroke whilst others did not (Clague-Baker, 2015, Boyne et al., 2017a).

Physiotherapists and exercise professionals displayed a willingness and interest in learning and in improving their skills to facilitate implementation (Condon and Guidon, 2018, Prout et al., 2016). For example, exercise professionals identified a need for training on psychological problems post-stroke (Condon and Guidon, 2018). They also agreed that stroke-specific training would lead to improvements in safety (Condon and Guidon, 2018) and even those with experience of working with people with stroke reported that further training would be of benefit (Wiles et al., 2008).

3.5.4.5 Non-CFIR nodes

The researchers reflected on the non-CFIR nodes created during data extraction and decided that these were descriptors of the included studies rather than findings. Examples of these nodes were '*characteristics of the rehabilitation service or exercise class'* and '*content of aerobic exercise'*.

3.5.4.6 Overall interpretation

There were only a small number of studies (n=20, including nine conference abstracts), which presented mainly North American and healthcare professionals' perspectives, despite the researchers necessarily embracing a broad definition of aerobic exercise. Studies predominantly included qualitative data with the abstracts providing a valuable, albeit more limited, contribution to the data. Four studies specifically explored the factors around implementation of aerobic exercise after stroke with the remaining sixteen studies involving a range of general exercise interventions after stroke. These were included as the descriptions of their interventions were not comprehensive but potentially aerobic in nature and this was an inclusive review. Only one of the four UK-based studies was conducted solely within the NHS (Clague-Baker, 2015), with one other surveying NHS-funded community-based services as part of their study (Best et al., 2012).

The key factors influencing implementation of aerobic exercise post-stroke were staff self-efficacy and their beliefs about the intervention as they considered the needs of their patients in addition to system-level factors regarding staffing and access to resources, such as suitable equipment for screening and exercise delivery, and training and information. Across all studies, regardless of country, setting or profession, intervention or methodology, the primary data confirmed the barriers and facilitators identified in the evidence synthesis. These are the factors which require consideration when developing a strategy to resolve the lack of implementation of this valuable intervention for people post-stroke in the UK. This review highlights the need to develop theoretically underpinned implementation strategies to overcome these challenges.

3.5.5 Reflexivity

The process of reflexivity involves proactive critical examination of how the personal and professional experiences, assumptions, and values of the researcher influence the process and outcome of the conducted research (Alley, Jackson and Shakya, 2015, Berger, 2015). It forms an important part of qualitative research due to the potential for enhancing the credibility of the research through self-monitoring of the effects of the researcher's positions on all phases of the research process (Berger, 2015).

This review was set within both healthcare and exercise. As the six members of the review team generally have a background within health rather than exercise, the researchers were aware of potential issues which may influence the outcomes of the review. The lead researcher (NG) is a physiotherapist with clinical experience in both stroke and, more extensively, CR. Three other members of the team also have a background in physiotherapy:

LC is a clinician-scientist specialising in implementation research and stroke rehabilitation, PD has over 20 years of working experience as a clinical academic in CR and Director of the NACR, and JH is a senior fellow in evidence synthesis with experience of systematic reviewing and automated screening. The final two members of the team are a chartered psychologist (EB) with an interest in health interventions and experience of designing and conducting NHS-based health interventions, and a health services researcher (AH) specialising in modes of delivery in CR. To reduce associated bias, data extraction was completed independently by three team members (NG, LC, and EB) with each document reviewed by two of these three researchers. Any disparities were discussed within the team, and consensus reached.

3.6 Discussion

This systematic review of the literature showed that the main factors perceived by staff as influencing the implementation of aerobic exercise post-stroke were staff self-efficacy, their beliefs about the intervention and their patients' needs, and system-level issues relating to staffing, resources, knowledge, and training.

3.6.1 Systematic review

Systematic reviews aim to identify, select, and analyse the available evidence on a particular topic by following a specific methodology, and can be qualitative or quantitative (Stern, Jordan and McArthur, 2014, Sataloff et al., 2021). Quantitative systematic reviews are more traditional and focus on the evidence for the effectiveness of an intervention using numerical data and statistical analysis (Tufanaru et al., 2024). Qualitative systematic reviews focus on participant views of an intervention and can explore why an effective intervention is not implemented (Stern, Jordan and McArthur, 2014). A clear review question is important as it guides the researcher on how to carry out the review (Butler, Hall and Copnell, 2016). In the case of this systematic review, the question and the aim focused clearly on identifying the factors that influenced the implementation of aerobic exercise specifically from staff perspectives. Due to the focus on participant views, it was anticipated that the primary data for this review would be qualitative in nature, leading to the decision to use a search tool developed for use in qualitative research to guide the search strategy, the SPIDER tool (section 3.4.1). This tool also informed the development of the inclusion and exclusion criteria for the selection of studies.

Following study selection, qualitative data were extracted from a range of studies that used different designs, including interviews, focus groups, surveys, and questionnaires. Due to the variety in study design, some primary data were qualitative in nature, some were quantitative, and some studies had both qualitative and quantitative data. However, as the focus of this review was the perspectives of individuals about a phenomenon, the implementation of aerobic exercise after stroke, the data extraction process used was qualitative and the output was descriptive. Based on the mixture of quantitative and qualitative data in the primary studies, it could be argued that a mixed method systematic review may have been a more appropriate method to provide a comprehensive evidence synthesis. However, the aim of mixed methods reviews is to collate evidence of the effectiveness of an intervention and people's experience of the intervention (Lizarondo et al., 2024), and intervention effectiveness was not included within the aim of this review. Furthermore, neither study design nor type of study data collected were specified within the inclusion or exclusion criteria for this review. As the aim of the review, to generate a comprehensive understanding of the factors from staff perspectives, was qualitative, this was described as a qualitative systematic review, with data extracted from all eligible studies.

3.6.2 Data quality and assessment

Ongoing debate exists over the assessment of quality of qualitative research and what actually constitutes 'good' qualitative research. This is in contrast with quantitative research where clear guidelines exist for assessing quality (Critical Appraisal Skills Programme, 2019, Blobaum, 2006). It is challenging to measure quality in qualitative research due to reflexivity and subjectivity. The drive towards evidence-based healthcare and subsequent increase in qualitative research has led to a demand for the quality assurance of this (Reynolds et al., 2011).

The quality of a review relies on the data reported within the primary studies (Charrois, 2015). A lack of comprehensibility in the exercise intervention descriptions in sixteen of the included studies led to difficulties in ascertaining whether aerobic exercise was included. Improved reporting which clarified the intervention would have eliminated the need to adopt a broad definition of aerobic exercise for this review (Yamato et al., 2016). Similar reporting challenges were found with respect to detail regarding staff and setting. Initiatives such as the Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann et al., 2014), which has been developed as a template for intervention description and replication in response to the poor quality in reporting of interventions, may help overcome some of these issues for future reviews.

Critical appraisal can be used to assess primary research in terms of its reliability and validity (Carroll and Booth, 2015) and critical appraisal tools such as the Critical Appraisal Skills Programme (CASP) (Critical Appraisal Skills Programme, 2019) have been developed. However, there is still an argument that excluding studies risks the loss of valuable data and that the contribution of individual studies may only become apparent during data synthesis (Hannes, 2011). A single study finding may serve to confirm or contradict the findings of other studies and as such is valuable. Conducting a quality assessment of the studies identified for this review may have resulted in the removal of studies, and choosing not to use a critical appraisal tool could be viewed as a limitation to this review. However, it is difficult to speculate if this would have impacted the results significantly, with the presence of multiple sources for many of the factors. In the case of this review, the decision was made to retain all studies for data extraction and synthesis thereby retaining all valuable insights and to then conduct a sensitivity analysis on the abstracts.

A series of decisions are taken during the process of conducting a systematic review, some of which may initiate a need for a sensitivity analysis (Deeks et al., 2024). This can be conducted as part of quality control and to assess the robustness of a systematic review (Higgins JPT, 2011), although the strategy used is at the discretion of the researchers (Bown and Sutton, 2010). One question that may require a sensitivity analysis is whether abstracts whose findings have not been published in a full text publication should be included (Deeks et al., 2024). The aim of the sensitivity analysis conducted for this review was to establish whether inclusion of the abstract-only texts (n=9) affected the review findings and whether they should continue to be included in the data analysis and synthesis along with the full-texts (n=11). The result of this sensitivity analysis was that the data from the abstracts either confirmed or added depth to the findings and provided valuable insights. Neither inclusion nor exclusion of the abstracts affected the overall results and conclusions of this review indicating a higher degree of robustness (Deeks et al., 2024). Therefore, the sensitivity analysis carried out on the included abstracts post-synthesis corroborated the earlier decision to retain all eligible studies (n=20) for this review. In future reviews, it would be wise to investigate current best practice for assessing quality assurance of primary data. An informed decision regarding quality assessment should be then made prior to conducting the review.

3.6.3 CERQual

When considering quality assessment for this review, the use of GRADE (Grading of Recommendations Assessment, Development and Evaluation) CERQual (Confidence in Evidence from Reviews of Qualitative research) (Lewin et al., 2018) was investigated as a possible method. GRADE-CERQual is a method of assessing confidence in a qualitative review to establish the degree to which each review finding represents the subject of interest (Lewin et al., 2018). It was developed in response to a need to bring structure to, and facilitate transparency in, an otherwise informal process of qualitative evidence syntheses-based decision-making (Lewin et al., 2018).

GRADE-CERQual is comprised of four components which are; methodological limitations (Munthe-Kaas et al., 2018), coherence (Colvin et al., 2018), adequacy of data (Glenton et al., 2018), and relevance (Noyes et al., 2018b). These are used collectively to inform the assessment and produce a summary of qualitative findings table (Lewin et al., 2018). It can be conducted either during a review process by the authors or applied retrospectively to a review carried out by others (Noyes et al., 2018b). The decision was made not to use GRADE-CERQual for the reasons described in relation to each of these four components as follows:

- For GRADE-CERQual, the **methodological approaches** used within the primary studies included in a review are assessed as any limitations can impact on the confidence in those study findings (Munthe-Kaas et al., 2018). Interestingly, there is no consensus on the most appropriate approach for assessing the quality of qualitative methodologies (Munthe-Kaas et al., 2018). In order to carry out this component of the assessment reviewers are required to have chosen a critical appraisal tool to inform the methodological limitation assessment component (Munthe-Kaas et al., 2018). Choosing not to use a critical appraisal tool for quality assessment of the studies included in this review precluded the use of this component of the assessment.

- **Coherence** is the assessment of the extent to which the primary data agrees with the synthesised review findings (Colvin et al., 2018). As documented in the methods section of this systematic review, the primary data was referred back to frequently during data synthesis to ensure that there was no loss of context or misinterpretation of the individual study results.
- **Adequacy of data** is defined as the measure of the degree of richness and quantity of data that supports a finding although the assessment only seeks grounds for concern rather than achievement of adequacy (Glenton et al., 2018). What represents acceptable or adequate levels of degree of richness and quantity of data is debated and remains a contentious issue. This uncertainty influenced our decision-making regarding the use of GRADE-CERQual due to its subjectivity.
- In the context of GRADE-CERQual, **relevance** is described as the degree to which the data from the included primary studies supporting a review finding fits within the context of the research question (Noyes et al., 2018b). Relevant data should surely always be sought for any review although it should be acknowledged that this assessment is a means of formalising the process. The authors of this review believe that it has been carried out robustly through adherence to the inclusion and exclusion criteria during the screening process, the addition of retrospective automated screening to enhance single screening and rigorous revisitation of the primary data during data synthesis. These steps ensured that only data from studies relevant to the context of the research question were included in the findings.

It can be argued that the elements of the GRADE-CERQual assessment have either been considered or carried out during the process of this review, although the assessment has not been formally conducted. A noteworthy point is that conducting a quality assessment does not guarantee accuracy as the findings of any synthesis are dependent on the quality and transparency of the primary research reports.

3.6.4 Automated screening using Rayyan

In this study, single screening was carried out due to resource limitations. Previous research has demonstrated that single screening is less accurate than dual screening due to the possible reduction in the recall of relevant studies (Edwards et al., 2002). With hindsight, it was concluded that the process for this review could have been made more robust through the addition of another screener, but this had not been possible within existing resources. The benefits of applying automated screening as an enhancement to the screening component of this review process were twofold. Firstly, it increased the recall and identified four extra texts for inclusion in the review, thereby strengthening the review. Secondly, it reduced the workload, by effectively eliminating the need for a second screener, had resources been available for one. Rayyan proved to be accurate, efficient, and user-friendly with the benefit of free availability. The efficiency of this system led to its use within the available resources in this case. On reflection, had the reviewers been aware of automated screening prior to commencement of the systematic review, it could have been used to expedite the title and abstract screening. In future, the option of using automated screening as a tool for enhancing the screening process during systematic reviewing should definitely be considered.

3.6.5 PRISMA diagram amendment and full text eligibility assessment

The PRISMA diagram in the published systematic review paper does not present the reasons for the exclusion of full texts at the eligibility assessment stage. These reasons have been added to the PRISMA diagram in this thesis, with the exception of one text for which the reason was not recorded *(Figure 3.1).* Hence, although reasons for exclusion at the full text stage were recorded at the time the review was conducted, these were not recorded sufficiently. In future systematic reviews, use of a more rigorous approach to recording the reasons for excluding records and articles will be ensured.

3.6.6 Framework

A framework synthesis approach was chosen as the most appropriate qualitative evidence synthesis method for this review using the INTEGRATE-HTA (Booth et al., 2016) document as guidance. The *a priori* framework used to guide the synthesis was the CFIR. The CFIR had been used successfully and meaningfully in other areas (Kirk et al., 2016), but not in the context of exercise implementation within stroke services. Implementation is a complex process, and there is no simple algorithm for choosing an appropriate framework for implementation. Kirk et al. (2016) encouraged consideration of the aim, context, setting, and intervention to be implemented to inform choice and application of an approach. They emphasize that there is no right or wrong method of selection. The CFIR was chosen as it was developed through the identification of constructs which were common across published implementation theories. The review authors believed that this was a comprehensive system for identifying and organising the factors affecting implementation in this review. Damschroder et al. (2009) recognised that there was both overlap and omission of key constructs in individual theories. They wanted to create a comprehensive structured list of constructs using consistent terminology and definitions which could be used as a guide through all stages of the implementation process. To develop this framework, they searched for and reviewed published theories, frameworks and models used to facilitate the movement of research findings into healthcare practice. The PARIHS framework with its three domains of evidence, context, and facilitation, was included, as was Greenhalgh et al.'s (2004) 'Conceptual Model for Considering the Determinants of Diffusion, Dissemination, and Implementation of Innovations in Health Service Delivery and Organization'. The availability of an overarching framework compiled from a robust review of existing published theories which is applicable to a variety of settings and contexts was appealing. The PARIHS framework lacks constructs relating to characteristics of individuals, which were an important aspect of this review. PARIHS also advocates the role of a facilitator to aid implementation which wasn't explicitly part of our search strategy. The advantages of using the CFIR prior to intervention implementation include the identification of potential barriers, appropriate selection of implementation strategy, and adaptation of the strategy to maximise likelihood of success (Kirk et al., 2016). During implementation it can be used to monitor for unexpected factors which are influencing the implementation and finally, post-implementation use may include investigation of the effects of factors on the implementation (Damschroder et al., 2009). The CFIR however, does not indicate how these constructs interact with each other.

A systematic review of use of the CFIR in 26 studies reported that it was utilised for a wide variety of objectives and settings and that most studies used either mixed or qualitative methods (Kirk et al., 2016). Kirk et al (2016) noted that the CFIR has mostly been used retrospectively in the post-implementation phase, despite Damschroder et al. (2009) describing how it can be used before, during, and after implementation. Interestingly, a review of studies using the PARIHS framework identified that it hadn't been used prospectively in designing implementation strategies (Helfrich et al., 2010). As our systematic review was conducted pre-implementation, the information identified regarding the barriers to implementing aerobic exercise after stroke can be used to inform the direction of future research and facilitate successful implementation. The structure of the CFIR and 'permission' to choose appropriate constructs facilitated the data extraction and synthesis as carried out by a lesser experienced researcher, albeit with support. It also provided a logical structure for reporting the findings and identifying the factors. Selected constructs from four of the five original CFIR domains were used in this review. The fifth and last domain in the original CFIR, *Process*, deals specifically with the planning, engaging, executing, and evaluation of the process of implementation. This review did not aim to develop an implementation plan, but to explore the perceptions of staff about the influencing factors and collate existing information to contribute to future planning. The *Process* domain could be considered in the development of an implementation strategy.

3.6.7 Factors

The factors identified in this review are not unique to the context of implementation of aerobic exercise after stroke (Kalkan et al., 2014, Ilott et al., 2013, Cilenti et al., 2012, Damschroder and Lowery, 2013). Similar factors have been identified within rheumatology, intensive rehabilitation after stroke, weight management, and implementation of evidence-based practices in healthcare (Kalkan et al., 2014, Cilenti et al., 2012, Damschroder and Lowery, 2013, Connell et al., 2018). The repetition of these factors within research indicates their importance in intervention implementation in a variety of settings. If one or more of these factors are modified successfully within a setting, it is possible that these results could be applicable to implementation of interventions in similar healthcare settings and health populations. These may include long-term and multiple conditions.

Factors such as staffing, equipment, training, and staff self-efficacy are potentially modifiable depending on the specific individual settings, staffing profiles, knowledge, experience, and support within the broad range of staff groups. Criteria such as APEASE (Acceptability, Practicability, Effectiveness/Cost-effectiveness, Affordability, Safety/Side-effects, Equity) (Michie, Atkins and West, 2014), which were developed for use with behaviour change interventions, may provide a starting point for prioritising which modifiable factor(s) to target. These criteria indicate that factors around affordability, practicability, effectiveness and cost-effectiveness, acceptability, side-effects/safety, and equity should be considered when designing or evaluation interventions. Aerobic exercise is a proven effective intervention after stroke; however, its effectiveness is irrelevant if it cannot be afforded, implemented as designed or by the appropriate professionals, or if it is not accepted by staff and people post-stroke.

Successful implementation may require changes in staff beliefs. Although this can be challenging, the importance of behaviour change in the implementation of evidence-based practice has been acknowledged in the literature. Research has been conducted around behaviour change interventions, one example of which is the Behaviour Change Wheel (Michie et al., 2008). This framework is a 'behaviour system' in which capability, opportunity, and motivation interact to generate behaviour (COM-B), which in turn influences the three components (Michie, van Stralen and West, 2011). Nineteen behaviour change frameworks were synthesised to form one framework (Michie, van Stralen and West, 2011), which has now been published as a practical guide for designing behaviour change interventions (Michie, Atkins and West, 2014). Knowledge and skills are included within the capability component highlighting the importance of training. However, despite research which confirms that staff beliefs and behaviour change have an important influence on implementation, it remains unclear whether it is possible to change these within the context of aerobic exercise after stroke and if so, what process should be used for successful sustainable change (Stokke et al., 2014).

Physiotherapists and exercise professionals in this review reported a need for knowledge and training on stroke and appropriate exercise interventions. There are links between staff beliefs and knowledge, which have a subsequent influence on implementation (Stokke et al., 2014, Van Kessel, Hillier and English, 2017). Van Kessel, Hillier and English (2017) found that physiotherapists' knowledge and beliefs influenced their implementation of circuit classes and seven-day therapy in stroke rehabilitation. Provision of appropriate training tailored to staff groups and settings may positively influence staffs' beliefs about the intervention and therefore aid implementation. This could be provided within organisations through internal training or externally by educational institutions or a collaboration between providers and local educational institutions. However, changing behaviour is complex and it should be noted that education in isolation is likely to be ineffective (Bird et al., 2019). Other strategies must therefore be considered, such as provision of support for staff through facilitation, tailoring of strategies to staff groups and settings, and use of care pathways or a combination of these (Bird et al., 2019).

Bridging the evidence-practice gap and changing clinical practice is challenging. Successful implementation requires sufficient resources to address the needs of the population (Cilenti et al., 2012), but current systems often lack these resources. Many staff recognise the importance of aerobic exercise for people post-stroke and are willing to upskill to enable incorporation of this intervention into their clinical practice. However, the barrier created by limited resources is difficult to surmount for some staff without support from funding bodies or management. This is particularly true for the self-employed. Again, research is needed to identify if and how these staff and system-level factors can be changed within a variety of settings. The question of what factors require little or no increase in resources to be modified needs to be explored. These could include changing the perceptions of staff regarding the intervention and evidence-base and developing new ways of working. Increasing demands on resources within current systems mean that alternative mechanisms of delivery of interventions need to be explored. This could include, for example, resource reallocation or skill-sharing amongst colleagues both within and between organisations. Linking up professionals would enable them to bring their individual skills together and enhance interprofessional working to transform practice. This would clearly require improvements in communication between professions and organisations. Maximising the effectiveness and potential of available technologies already embraced within healthcare is another avenue for working within existing resources. Part of the UK's NHS Long Term Plan involves investment in a programme for the digital transformation of health and social care (NHSX, 2019). This aims to increase productivity and improve delivery of care and communication between health and care professionals(NHS England, 2019).

It may also be necessary to modify how interventions are implemented in light of the increasing limitations on resources and the changing population. We are faced with an aging population who are increasingly presenting with multiple conditions. In order to provide true patient-centred care should this type of intervention be delivered as person-specific or impairment-specific taking account of individuals' personal exercise preference rather than continuing as a condition-specific intervention? A means of approaching this question may be through evidence-based co-design. This is a process in which staff and patients work together to reflect on their experiences, identify an improvement plan, and then implement changes to a service thereby improving healthcare (Donetto et al., 2015). For the resulting implementation to be successful and sustainable in the longer-term, it also requires the support and commitment of those in leadership and management roles.

There is also a lack of clarity as to whose role it is to initiate and implement change. Changes are often led by clinicians, due to their knowledge of evidence-based practice (Ilott et al., 2013, Lynch et al., 2018), and as previously mentioned, there is evidence that middle management (Birken et al., 2018a), leadership engagement, and collaboration between organisations are important for successful implementation (Cilenti et al., 2012). In view of this, it is imperative that staff are involved in the implementation process with support from their managers. One possible means of facilitating this process is via co-production where stakeholders work collaboratively to facilitate service re-design (Ali et al., 2018). However, according to Loeffler and Bovaird (2016), co-production generally incurs set-up costs and though it may improve service outcomes, it may not be feasible without increasing costs (Loeffler and Bovaird, 2016). A description of what these costs may include and the degree to which they may be increased is not given. It should be noted that there is a lack of evidence with regards to both co-design, as mentioned previously, and co-production.

Evidence demonstrates that implementation of research into practice is more successful when a small number of practice changes are made at a time and when these are adapted to suit each setting (Bird et al., 2019). The studies included in this review encompassed a wide range of settings. Adapting one intervention to different settings would require reflection and evaluation before, during, and after implementation for it to be successful. A one-size-fits-all approach will clearly not work in this context (Boaz et al., 2024).

Successful implementation of evidence-based interventions can be facilitated through the application of an appropriate theory-based strategy. Recent research aiming to assist with appropriate selection of theories and frameworks to plan and guide implementation is available (Birken et al., 2018b, Birken et al., 2017, Lynch et al., 2018). Lynch et al. (2018) have produced one such guide aimed at both clinicians and clinical researchers which presents ten different commonly used theoretical approaches. They noted that clinicians often have knowledge of evidence-based interventions but know little about how best to implement these into clinical practice. This guide provides a logical approach to the task of selecting a strategy facilitated by provision of appropriate questions to ask and a concise summary of each of the ten theoretical approaches. As was the case with the CFIR, Lynch et al. (2018) found that these approaches had generally been used retrospectively in the post-implementation phase rather than before or during implementation. They suggested that this resulted in a potentially missed opportunity to gather information which could have been used to inform and adapt the intervention, and have led to an increased likelihood of success. Despite these studies, evidence is still lacking with some empirical testing reporting that a theory-based strategy showed no significant changes (Seers et al., 2018). An international cluster RCT tested two different strategies for implementation of research evidence regarding urinary continence recommendations in twenty-four long-term nursing care sites (Seers et al., 2018). The authors concluded that there were no significant differences in the main outcome between any of the three groups.

Within the literature included in this review, several possible solutions for facilitating implementation of aerobic exercise post-stroke in specific settings were suggested. There was recognition of the need to develop practical ways to implement this intervention (Axelson et al., 2014). Fitness instructors indicated that a greater collaboration with physiotherapists during transition from NHS to non-NHS community-based exercise facilities would be beneficial, even suggesting that physiotherapy posts be created with leisure centres to facilitate mutual learning and improve patient care (Wiles et al., 2008). The provision of training, specifically around psychological issues after stroke, and suitable equipment were highlighted by exercise professionals in Ireland (Condon and Guidon, 2018). The pooling of skills between CR and stroke rehabilitation teams could increase the feasibility of including stroke patients in CR sessions and give staff the confidence to deliver the intervention (Clague-Baker, 2015).

To continue the process of facilitating the implementation of this intervention after stroke, further research is needed. Firstly, to establish which of these identified staff and system-level issues should be prioritised for modification in a variety of settings, and secondly, to identify who should be involved in leading and implementing any changes to systems and practices. This information can then be used to inform the selection and adaptation of an implementation strategy to maximise the likelihood of successful implementation.

3.6.8 Strengths and limitations

The use of automated screening with the Rayyan app (Ouzzani et al., 2016) enhanced the screening process. This efficient, accurate, user-friendly addition to manual screening, which could be used as an alternative to this, also has the benefit of free availability. In future, the option of using automated screening as a tool for enhanced screening during systematic reviewing should be considered. A strength of this review involved the use of an implementation framework, the CFIR. This ensured a comprehensive, structured, and consistent approach to considering the factors influencing implementation.

There were several limitations to this review including the low number of full-text studies (n=11), which highlighted the shortfall in research in this area, and the decision not to use a quality assessment tool which may have changed the level of confidence in the review findings. However, elements of the GRADE-CERQual approach were considered as described in Section 3.6.2. The predominance of healthcare professionals' views, geographical coverage limited to the three continents of North America, Europe, and Australia, and limiting the language to articles in English potentially limit the generalisability of the findings.

Aerobic exercise was expressly reported as the intervention in just four studies, all of which were North American. The lack of comprehensibility in the description of the exercise intervention in sixteen of the studies made it difficult to ascertain whether aerobic exercise was included. Improved reporting to clarify the intervention would have eliminated the need to adopt a broad of definition of aerobic exercise for this review (Yamato et al., 2016). Three of the studies which focused on aerobic exercise after stroke were from Canada. This is the only country which has produced detailed guidelines for clinicians to facilitate the implementation of aerobic exercise after stroke. Therefore, this could have introduced bias. The systematic review was conducted using standardised methods as outlined in the PRISMA statement, to produce a comprehensive qualitative synthesis of factors influencing aerobic exercise from staff perspectives.

3.7 Update to this systematic review

This review was conducted in 2018 and published in 2019, during the early stages of this part-time PhD, so inevitably there have been changes within the literature since it was completed. A formal update was not possible within the constraints of this PhD, but a brief search of the literature in March 2024 has identified three new studies, all from Canada, which fit with the question answered by this systematic review. A summary of each study is presented in and a descriptions of how the results are positioned within the existing systematic review findings has been provided below.

Table 3.3. Summary of relevant studies published since the systematic review was conducted

Author (year) Country	Design	Setting	Population and participant characteristics	Methods	Results
Inness et al. (2022) Canada	Theory-informed qualitative descriptive study using focus groups and interviews	Stroke rehabilitation settings – inpatient and outpatient care	24 physiotherapists (5 managers, 19 delivering direct care), 5 rehabilitation assistants, 1 nurse (manager), 1 occupational therapist (manager), 1 physician	6 focus groups (with healthcare professionals (HCP)), 8 interviews (with managers & physician), HCP data mapped to theoretical domains framework (TDF), manager data mapped to CFIR	Five themes: • interventions targeting function were prioritised over aerobic exercise (AEx) • team approach to implementation • HCP confidence and capability • access to, and support from, experts • developing implementation processes
Legasto-Mulvale, Inness and Salbach (2024) Canada	Cross-sectional web-based survey	Inpatient stroke rehabilitation settings	37 physiotherapists in inpatient rehabilitation treating stroke patients	Questionnaire on AEx testing practices and factors influencing testing, guided by the TDF	41% conducted AEx testing with stroke patients and most used field tests Barriers: • low priority of AEx testing • lack of knowledge, skills & confidence • lack of resources including time 92% wanted to increase knowledge & skills on AEx testing
Barzideh et al. (2023) Canada (*preprint*)	Qualitative descriptive study using interviews	4 urban rehabilitation hospitals, 3 with inpatient & outpatient stroke rehabilitation, 1 with outpatient rehabilitation only; all sites offered, and had resources for, aerobic exercise programmes from a previous research study	10 physiotherapists trained in aerobic exercise testing and exercise prescription post-stroke	Thematic analysis informed by the COM-B and TDF	Three themes: • participant views and practices of aerobic exercise • stroke survivor characteristics, goals, and exercise preferences • healthcare priorities, rehabilitation policies and available resources

Inness et al. (2022) investigated the barriers and facilitators to the implementation of aerobic exercise after stroke from the perspectives of healthcare professionals and managers. Their aim was to use the study findings to inform the development of a toolkit (currently ongoing), which will support the implementation of aerobic exercise in stroke rehabilitation (Inness, [In progress]). Data collected from those delivering care were analysed using the Theoretical Domains Framework (TDF), and data from managers and leaders were analysed using the CFIR, before overarching themes were identified and interpreted.

Overall, the study findings corroborated the factors identified in the systematic review. Participants believed the intervention was important and beneficial, but said they needed to prioritise function over aerobic exercise due to lack of resources and for reasons of cost-effectiveness. This fits within the systematic review findings around knowledge and beliefs about the interventions, and available resources. Staff were concerned about the safety of delivering aerobic exercise for people with cardiovascular risk, when patients had language or communication impairments, and where exercise monitoring equipment was unreliable, particularly in the absence of exercise stress testing. However, staff were willing to improve their skills and capability through education and clinical experience, which included educating physicians around cardiopulmonary exercise testing for the purpose of exercise prescription rather than diagnosis of CVD. They also believed that implementing aerobic exercise was a complex process, which involved a number of professionals as well as substantial planning for screening, exercise testing and exercise training within existing therapies.

Communication and collaboration with staff experienced in aerobic exercise improved participants' self-efficacy, one example of which was connecting with CR settings for support. This collaborative approach is advocated in the UK Clinical Guidelines for Stroke (Intercollegiate Stroke Working Party, 2023). The staff participants in this study described some practical methods for supporting the process of implementation which required collaborative working within and between teams (Inness et al., 2022). This included timetabling for sharing equipment and therapy assistant time, development of forms and processes for screening and referral, and the inclusion of aerobic exercise on admission, transfer, and discharge forms. The establishment of processes for onward referral to community services, such as exercise programmes, was reported as supporting participation in aerobic exercise post-discharge. From a managerial perspective, assessing barriers and facilitators to implementation via a readiness checklist, and evaluating the cost-effectiveness of implementation of the intervention were identified as important. The participants were aware that local context needed to be considered when implementing new practices.

The study by Legasto-Mulvale, Inness and Salbach (2024) identified the barriers and facilitators to aerobic exercise testing from physiotherapists' perspectives (n=37). The authors aimed to describe physiotherapists' current practice of testing, including field, submaximal and maximal tests, and the factors influencing its implementation in these settings. Their findings agreed with those of the systematic review, reporting a range of barriers to conducting aerobic exercise testing. These included lack of knowledge, skills, and confidence, as well as resources such as equipment and guidelines. Only a third of participants had access to documents for recording aerobic exercise training in their organisations. This suggests that aerobic exercise testing is not routinely recorded in practice. Less than half of participants agreed that physiotherapists had expertise in aerobic exercise testing post-stroke, which fits with the systematic review factor around how implementation fits with the staff's role and responsibilities. Furthermore, in terms of the systematic review finding of "safety and perceived risk to the patient" within the outer setting domain, almost three-quarters of participants in Legasto-Mulvale, Inness and Salbach (2024) believed that aerobic exercise testing after stroke was safe, and less that one quarter said they were concerned about the patient experiencing an adverse event during testing. This was a more positive finding than that in the systematic review, where a fear of risk and causing harm to the patient during aerobic exercise participation was identified. However, just 56% expressed confidence in identifying whether a stroke survivor was appropriate for exercise testing which again highlights a lack of knowledge and skills amongst staff.

The third study, currently available as a preprint, explored physiotherapists' use of aerobic exercise during stroke rehabilitation (Barzideh et al., 2023). The context for this study was slightly different, as the participants had previously received training in aerobic exercise testing and prescription, and the sites had been provided with the resources needed to provide aerobic exercise programmes for stroke survivors, as part of a prior research study (Mansfield et al., 2017). However, the study findings still agreed with those of the systematic review. Contrary to the authors' expectations, lack of time and the need to share resources were expressed as barriers to exercise prescription. However, some participants also reported that their decisions around including aerobic exercise as part of treatment were influenced by the exercise resources and facilities that would be available to the stroke survivor post-discharge. Inter- and intra- professional collaboration and support were facilitators for aerobic exercise prescription. Stroke survivors' characteristics, such as age and comorbidities, their views and knowledge of exercise, functional level, and motivation, were also factors. Their goals, and the priority of these goals, were also considered during treatment planning by the physiotherapists.

Overall, the findings of these three studies support the factors influencing implementation identified in the systematic review. They suggest that staff perspectives of the barriers and facilitators remain largely unchanged since 2018.

3.8 Conclusion

At the time it was conducted, this was the first systematic review to explore the factors that influence the implementation of aerobic exercise after stroke from the perspectives of staff working within healthcare, exercise, and fitness settings. The inclusion of perspectives from a range of staff roles within a range of delivery settings has captured a broader perspective of the determinant factors than would have been possible had the focus been a single role type or single setting. It also draws attention to the range of settings in which aerobic exercise is being delivered after stroke which is important given the emphasis on context and settings within the implementation literature (Lynch et al., 2018, Waltz et al., 2019). Characteristics of staff (self-efficacy, beliefs about the intervention and their patients' needs) and system-level issues (staffing, resources, and training) were identified as key factors. These are not unique to this intervention as they have been reported within other areas of healthcare. Factors such as knowledge, training and beliefs are modifiable, depending on the setting. From this review there are clearly several potential avenues for future research. Due to the complexity of the process of implementation, further research is needed to investigate factor modifiability and strategies for implementation of this intervention. The cost of modification and methods of sustaining these changes should also be investigated due to the overlap between health and leisure organisations and the varying states of flux of health and political systems around the world. Overcoming the challenges to successful implementation is likely to involve resources and cost. However, any future evidence which informs implementation of this intervention could potentially be applicable to the implementation of interventions within other clinical areas. This would increase the value of this research and serve to bridge the evidence-practice gap.

3.9 Patient, carer, and public involvement

3.9.1 Introduction and aims

Following completion of the systematic review of staff perspectives of factors influencing the implementation of aerobic exercise after stroke, two separate, local PCPI events took place. One involved people who had lived experience of stroke as stroke survivors or carers, whilst the other involved individuals undertaking CR who had lived experience of a cardiac condition. The CR group was consulted as both stroke and CHD are CVDs, meaning that some stroke survivors in the UK may be accessing aerobic exercise through CR following a cardiac event. The aims of these two PCPI sessions were to disseminate findings from the systematic review and discuss peoples' views regarding aerobic exercise and the direction of future research.

3.9.2 Methods

These events took place within established settings. The first was a community stroke support group run by volunteers and the second a local CR phase 3 programme organised and staffed by the acute hospitals NHS Trust. Contact was made with the coordinators of each group to introduce the researcher and outline the aims and plan for the event. Permission to attend each group was granted and a mutually suitable date for each visit arranged. At each event, the researcher introduced herself and explained her interest in aerobic exercise after stroke. She informally provided a plain English description of aerobic exercise and summary of the systematic review findings. The opportunity to ask questions was then given to the attendees and a discussion around the subject of aerobic exercise after stroke was initiated.

3.9.3 Outcomes and discussions

3.9.3.1 CR phase 3 group

Seven male patients who were currently enrolled and attending CR were present. One female was enrolled on the programme, but was not in attendance for that session. The group was generally positive about the benefits of aerobic exercise and research in this area. One person gave the example of a relative who had had a stroke and needed guidance on exercise and lifestyle post-stroke. Three of the group described a comorbidity they had, chronic obstructive pulmonary disease and arthritis, and the benefits of exercise for this as well as their heart condition. Concern was expressed about the lack of resources available within the NHS in terms of waiting times, although they were full of praise for the staff delivering the programme. The group agreed that training for staff would help to increase confidence for providing aerobic exercise after stroke.

The three staff members present who were taking the group, an experienced physiotherapist, occupational therapist, and nurse, offered to share their views on exercise for those with vascular conditions including stroke. Their discussions can be divided into the following three categories, training, service redesign and managerial support. The staff stated that training was needed to increase staff confidence to treat other conditions, although they themselves were comfortable with having stroke survivors in the programme. They had previous experience of people with comorbid stroke as well as musculoskeletal and respiratory conditions taking part in their programme. The staff identified that providing exercise classes with low, medium, and high levels of exercise which were less condition-specific and more function- or patient- specific would not need much in the way of extra resources to implement and enable inclusion of patients with a wider range of conditions and comorbidities. They had identified potential ways to improve the service which would include the use of web-based apps, webinars, home exercise and collaboration with community services or leisure centres. They had already had conversations with a stroke consultant within their NHS Trust. However, they mentioned a lack of resources available for service redesign and challenges relating to finance and funding in terms of staffing, some of which are legacy issues. The staff said that managers needed to be supportive and 'on board' with making changes and that CR is delivered differently across the multiple sites in their NHS Trust. However, it is a struggle to make changes without managerial support and staff themselves lack the time to conduct audit or research, or to create a business plan. They also indicated that managers lacked understanding of clinical work and the training and experience required for these roles. The staff had made changes to the programme within existing resources in an attempt to address the waiting times for CR. This had the positive effect of reducing anxiety amongst patients but hadn't, by the time of this event, affected the waiting list. The staff were clearly committed to providing the best possible care for the patients. They were continually thinking and planning about how to improve the service further but struggled to do this without the support of managers and extra resources.

3.9.3.2 Community stroke support group

Four female and three male stroke survivors, and three carers plus one stroke discharge co-ordinator from the Stroke Association were present. The researcher initiated the discussions by asking if any of the group had had any advice or attended exercise sessions after their stroke. One person had attended a phase 4 CR group in the past, but had to have a carer accompany them due to communication difficulties. No one else reported being provided with information about aerobic exercise after stroke. During the discussion, the challenges around transport needed to attend any exercise sessions were raised. This included the difficulties in obtaining a bus pass for both the person and their carer where their assistance was required. Within the group there was a suggestion that it would be best to begin with a one-to-one exercise session followed by group exercise to facilitate motivation and build confidence. One person from the group emailed the researcher later to describe in more detail their opinions on the factors affecting uptake of aerobic exercise amongst stroke survivors. These included transport difficulties, fear, cost of attending, a lack of knowledge, existing medical problems, fatigue, their home situation, and a perception that exercise is boring.

3.9.4 Reflections

3.9.4.1 CR phase 3 group

The patients were generally positive about the benefits of exercise after their event and after stroke. They appeared to enjoy each other's company. They were concerned about a lack of resources in the NHS and duration of the waiting time they had experienced before being offered CR. On reflection the author wondered if they would be concerned about waiting times increasing further if people with stroke were also offered CR. It was interesting that there was only one female enrolled on the programme as this reflects the predominance of male over female attendees at CR programmes across the UK. The presence of comorbidities was evident even amongst this small group of people and discussions with the staff revealed how these were taken into consideration with adaptations made to accommodate resulting differences in ability.

3.9.4.2 Community stroke support group

This group were interested in the benefits of aerobic exercise after stroke but displayed a lack of knowledge about it. They highlighted practical difficulties, such as transport issues, with accessing exercise. Their varied views on exercise format reinforced that there is no 'one size fits all' in terms of delivery of aerobic exercise and that flexibility within the intervention may be important for uptake. This group highlighted an existing need for provision of information regarding aerobic exercise after stroke or on how and where to access this information for themselves. Potential avenues include the inpatient or outpatient setting, perhaps with family present, or within community or leisure centres, or as web-based support. Issues such as transport and home situation should be given consideration in terms of access. The group didn't identify any real direction for further research. Their discussions indicated that they had insufficient access to information about aerobic exercise leading to a decreased awareness of the benefits which may have been the reason they were unable to make suggestions about future research. It should be noted that this was one stroke support group in one part of the UK so their feedback may not be generalisable to the rest of the UK's stroke population. However, their feedback provided useful insight into stroke survivors' perspectives of aerobic exercise.

3.9.5 Conclusion

These PCPI activities provided valuable insight into the perceptions and views of those with both cardiac and stroke diagnoses in regard to aerobic exercise. It highlighted a lack of knowledge amongst some people post-stroke around this intervention and also their willingness to learn more. The positive views of exercise held by those attending CR was also apparent.

3.10 Chapter summary

This chapter has described the systematic review conducted in response to the Thesis Objective 1, which was to establish what is already known about the factors influencing delivery of aerobic exercise after stroke from a staff perspective. The twenty studies included in the review identified a range of patient- and service- level factors influencing the implementation of aerobic exercise in countries across the world including the UK.

CHAPTER 4 FACTORS ASSOCIATED WITH THE UPTAKE AND COMPLETION OF CARDIAC REHABILITATION BY PEOPLE WITH COMORBID STROKE FROM A SYSTEM PERSPECTIVE: AN OBSERVATIONAL STUDY

4.1 Chapter overview

In Chapter 3, staff perspectives of the factors influencing the implementation of aerobic exercise post-stroke were explored. Chapter 4 describes **Study 2** which explored a system perspective, the UK CR system, of the implementation of aerobic exercise after stroke to address **Thesis Objective 2**. An overview of CR service provision in the UK is provided, followed by a description of the study methods and results, which are then discussed in the context of current literature.

4.1.1 Original contribution to knowledge

This work is the first time the National Audit of Cardiac Rehabilitation (NACR) dataset has been utilised to explore the factors associated with the uptake or completion of CR by people with comorbid stroke as a primary focus. The findings on the factors associated with uptake of CR were disseminated via peer-reviewed publication in 2020 as '*Factors influencing the uptake of cardiac rehabilitation by cardiac patients with a comorbidity of stroke'* (Harrison et al., 2020) in the International Journal of Cardiology, Heart and Vasculature, which has been cited eight times to date. Additionally, this study was shared as an oral presentation at the ACPIN Online Conference in 2021, and as an oral presentation at the Physiotherapy Research Society Conference in 2023.

4.2 Introduction

As explained previously in Chapter 1, stroke is a CVD which shares similar aetiology and modifiable risk factors with CHD (British Heart Foundation, 2018, Lennon and Blake, 2009, Prior et al., 2011). Having a stroke is also linked to a subsequent increased risk of a major adverse cardiac event such as a myocardial infarction (Sposato et al., 2020). Following a cardiac event, people are eligible for referral to CR, which is a comprehensive complex intervention. A proportion of those referred to CR also have comorbid stroke (NACR, 2022a).

The British Association for Cardiovascular Prevention and Rehabilitation (BACPR) defines CR as "*the coordinated sum of activities required to influence favourably the underlying cause of cardiovascular disease, as well as to provide the best possible physical, mental and social conditions, so that the patients may, by their own efforts, preserve or resume optimal functioning in their community and through improved health behaviour, slow or reverse progression of disease*" (British Association for Cardiovascular Prevention and Rehabilitation, 2023). The '*coordinated sum of activities'* refers to five patient-focused core components for prevention and rehabilitation. These are changing health behaviour, managing lifestyle risk factors (physical activity and exercise, diet and smoking cessation), psychosocial health, medication management, and long-term management strategies (British Association for Cardiovascular Prevention and Rehabilitation, 2023). This structured cardiovascular prevention and rehabilitation programme should be individually tailored and aims to improve physical health and quality of life as well as develop skills for self-management through education and exercise (British Association for Cardiovascular Prevention and Rehabilitation, 2023). CR is an effective comprehensive intervention for people with CVD.

Aerobic exercise is a routinely delivered component which aims to improve physical fitness (British Association for Cardiovascular Prevention and Rehabilitation, 2023). Comprehensive standards and guidelines for the assessment, prescription and delivery of exercise in the cardiovascular population in the UK have been produced by the BACPR (British Association for Cardiovascular Prevention and Rehabilitation, 2017, British Association for Cardiovascular Prevention and Rehabilitation, 2023) and the Association of Chartered Physiotherapists in Cardiovascular Rehabilitation (ACPICR) (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). CR spans inpatient care through to long-term management in the community. Early CR involves acute pre-discharge care, when the patient is provided with appropriate tailored advice on physical activity and cardiac risk factors, and the period following discharge from hospital when they continue to follow the advice regarding making lifestyle changes that was provided on discharge. Following this, they attend an initial assessment for core CR (also known as phase 3) where appropriate rehabilitation options are discussed, and goals and plans agreed. If appropriate, they may then commence a structured comprehensive outpatient CR programme consisting of exercise and educational components. Following completion of core CR, they may be signposted to a community-based long-term management phase 4 programme where they can continue to maintain and benefit from their achieved lifestyle and activity changes.

A 2020 position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventative Cardiology included core CR components and recommendations for people who have had a stroke or TIA as part of secondary prevention of cardiovascular conditions (Ambrosetti et al., 2021). However, within the UK, CR is routinely offered to priority groups, such as those with myocardial infarction, acute coronary syndrome, coronary revascularisation, or heart failure (British Association for Cardiovascular Prevention and Rehabilitation, 2017, NACR, 2020, British Association for Cardiovascular Prevention and Rehabilitation, 2023). The BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation 2023 acknowledge that people with presentations of CVD other than CHD conditions may also benefit from a cardiovascular prevention and rehabilitation programme (British Association for Cardiovascular Prevention and Rehabilitation, 2023). The 2017 BACPR standards state that people who have had a cerebrovascular event should also be offered a programme but recognise that it may be necessary to initially target priority patient groups whose primary diagnosis is cardiac in nature (British Association for Cardiovascular Prevention and Rehabilitation, 2017). This is corroborated by the NACR, which reported in 2020 that referrals to CR are generally made following a cardiac event (NACR, 2020) with no indication that any referrals were made based on a cerebrovascular event. This is despite the fact that following a stroke, people often suffer from poor cardiovascular health and may have physical, cognitive, and psychosocial impairments (Stroke Association, 2024a, Baert et al., 2012).

There is emerging evidence that CR is both feasible and beneficial for people post-stroke (Tang et al., 2010, Tang et al., 2009, Prior et al., 2011, Regan et al., 2021a, Regan et al., 2021b, Marzolini et al., 2020, Kirk et al., 2014), and the components of CR can address the same risk factors for stroke as they do for CHD, including those of physical activity and exercise (Lennon et al., 2020, Orme et al., 2020, Regan et al., 2021b). CR modified for delivery post-stroke has been shown to improve both cardiovascular health and function (Cuccurullo et al., 2019, Regan et al., 2021b, Regan et al., 2019), reduce all-cause mortality (Cuccurullo et al., 2022), and may also help with depression (Lennon et al., 2008). Even in countries such as Canada where CR is advocated for people post-stroke (Marzolini, 2018), it is potentially underused for this population (Tang et al., 2010, Marzolini et al., 2020, Howes, Mahenderan and Freene, 2020, Toma et al., 2020). This is unsurprising given the low overall general rates of participation in CR. For example, in the UK, the rate of uptake of CR for those eligible is only around 50% (NACR, 2018), significantly below the NHS Long Term Plan target of 85% (NHS, 2019) and only 70% of those who start CR go on to complete it (NACR, 2019). This issue is not unique to the UK with low rates of participation and adherence reported across the world (Ades et al., 2022, Driscoll et al., 2020, Sumner, Grace and Doherty, 2016, Samayoa et al., 2014, Ambrosetti et al., 2021, NACR, 2018).

The NACR collects data on the comorbidity profiles of people accessing CR in the UK. A comorbidity is a medical condition which someone has in addition to another chronic health problem (Feinstein, 1970, Academy of Medical Sciences, 2018). The incidence of multi-morbidities, having two or more chronic conditions (Barnett et al., 2012), is becoming more prevalent globally (Academy of Medical Sciences, 2018), and links between stroke and CHD have been identified in literature (Boulanger et al., 2018, Sposato et al., 2020, Gunnoo et al., 2016). There is an increased likelihood of a further cardiovascular event for those who have had a stroke (Sposato et al., 2020) and the inverse is also true, with people twice as likely to have a stroke if they have CHD or have had a myocardial infarction (British Heart Foundation, 2018), so stroke can present as a comorbidity. This is one of the comorbidities recorded by the NACR (NACR, 2018). In 2018, 5.3% of the attending CR population had comorbid stroke (NACR, 2018), indicating that this group of people post-stroke have potentially accessed aerobic exercise through their eligibility for, and subsequent participation in, CR.

Certain factors, or variables, have been shown to be associated with the uptake and completion of CR. Age and gender have been widely documented as being significantly associated with both starting and completing CR (Thomas et al., 1996, Halm et al., 1999, Ritchey et al., 2020, van Engen-Verheul et al., 2013, Al Quait and Doherty, 2017, Al Quait and Doherty, 2016, British Heart Foundation, 2024, Supervía et al., 2017, Galati et al., 2018, Colella et al., 2015, Anderson et al., 2016, Oosenbrug et al., 2016, NACR, 2015, NACR, 2019). Partnership status (Galdas, Harrison and Doherty, 2018, Molloy et al., 2008, Clark et al., 2012), ethnicity (Reges et al., 2014, Mochari et al., 2006, Galdas, Harrison and Doherty, 2018, Mead, Ramos and Grantham, 2016, Rees et al., 2005, Chauhan et al., 2010), deprivation (Galdas, Harrison and Doherty, 2018, Sage, 2013, Salman and Doherty, 2019), comorbidities (van Engen-Verheul et al., 2013, Grace et al., 2009, Soo Hoo, Gallagher and Elliott, 2016, Harrison, Doherty and Phillips, 2018), and having a previous cardiac event (McKee et al., 2014, Soo Hoo, Gallagher and Elliott, 2016) all have significant links with uptake of CR, as has length of hospital stay (Soo Hoo, Gallagher and Elliott, 2016, Dunlay et al., 2014). A number of service-related factors also influence uptake and completion of CR. The source of a referral to CR and the referring healthcare professional have been reported as important (Al Quait et al., 2017), with staffing, resources, and number and throughput of patients in a service also identified as factors in the literature (Doherty et al., 2015, Turk-Adawi et al., 2013). Additionally, data is collected by the NACR on the reasons why patients do not start or do not finish CR, although this is generally only recorded for a small proportion of patients (NACR, 2019). Even though these patient and service-related factors have been identified as influencing uptake and completion in the wider CR population, it is not known whether this is also the case for people with comorbid stroke.

4.3 Objectives

Thesis Objective 2. To conduct a retrospective observational study using system-level data of CR to explore the factors associated with the uptake and completion of CR by people with comorbid stroke in the UK.

- **Study Objective 2a**. To identify factors associated with the uptake of CR by individuals post-cardiac event with comorbid stroke using retrospective data analysis.
- **Study Objective 2b.** To identify factors associated with the completion of CR by individuals post-cardiac event with comorbid stroke using retrospective data analysis.
- **Study Objective 2c.** To compare and contrast the factors associated with uptake and completion of CR.

4.4 Methods

4.4.1 Study design

This study aimed to generate new knowledge on what influences the uptake and completion of CR amongst people with comorbid stroke who are eligible to attend a UK CR programme.

A large-scale retrospective observational study design was chosen as the most appropriate method to achieve this and answer the research question. To improve the accuracy of what was reported in this study, it was conducted in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement (Von Elm et al., 2014). This statement provides recommendations for items which should be reported in observational research papers. The checklist is not a means of quality assessment of studies, but does aim to improve reporting (Von Elm et al., 2014). A completed copy of the STROBE statement for this study can be found in *Appendix 4.1*.

Observational studies are used within epidemiology to collect data through observation without influencing the participants or surroundings in 'real-world' situations or settings (Anglemyer, Horvath and Bero, 2014). They are non-experimental and can be applied to specific populations and used to investigate associations between characteristics and outcomes (Johnson, 2018). This study design was chosen for several reasons. Firstly, the research question related to factors which are associated with uptake and completion in a real-world setting. Secondly, the population of interest, people post-cardiac event who have comorbid stroke, are often excluded from RCTs due to their multimorbidity. Thirdly, as this group are already eligible for CR in the UK, a timely, low-cost, and ethical method of answering the research question is to use data already collected, in this case by the NACR. Finally, a large number of patient- and service- level factors were being explored in this research, in contrast to trials where a single variable is modified. Hence, whilst acknowledging that causation could not be inferred in this study, multiple factors could be explored within one (observational) study rather than within multiple time-consuming and costly trials.

To address Thesis Objective 2, people who had been referred for CR and were recorded as having comorbid stroke were identified from data collected routinely for the NACR, and then included in the study. The factors which influenced their uptake and completion were then explored to address Study Objectives 2a and 2b, and the findings compared to fulfil Study Objective 2c.

Careful consideration was given to whether the data within the NACR registry was appropriate to answer this study's research question. The researcher benefitted from having previous clinical experience within CR, as well as knowledge of the work of experts in this area and existing informal contacts, which facilitated this search. Once the NACR dataset was identified, it was then informally evaluated regarding its purpose and data collection process in terms of who, what, when, and how as described by Stewart and Kamins (1993). This was completed using information provided by the primary investigators for the project regarding data content and method of collection, in addition to relevant published literature. Further information on the chosen dataset is provided below under 'Data source' with further justification for choosing a retrospective observational study design given in Chapter 2.

To fulfil Study Objectives 2a and 2b, this observational study involved two separate statistical analyses of secondary data selected from the NACR registry. The first analysis focussed on the factors influencing the uptake of CR by people with comorbid stroke, whilst the second focused on factors influencing completion of CR by people with comorbid stroke.

4.4.2 Data source

The secondary data identified for this retrospective study was collected for the NACR. The NACR is "*a strategic project supporting cardiovascular prevention and rehabilitation services to achieve the best possible outcomes for people with heart and circulatory diseases irrespective of where they live*" (NACR, 2020). It is the most comprehensive dataset relating to the delivery of CR in the UK, with data collected routinely from CR programmes across England, Wales, and Northern Ireland and reported on throughout each year and annually. The audit is hosted by the University of York in collaboration with the NHS Clinical Audit Team (formerly NHS Digital) and previously with the British Heart Foundation.

As is the case with the NACR dataset, secondary datasets are often large-scale. Although using a secondary dataset can save time and resources as the data has already been collected (Johnston, 2017), it has not been collected for the specific purposes of this research. Consequently, any limitations within the available data which had become apparent during analysis in relation to the research questions had to be acknowledged.

A process of secondary data analysis was used to guide evaluation of the NACR dataset to establish its appropriateness for this study (Stewart and Kamins, 1993, Johnston, 2017):

- **Purpose** – The primary aim of this audit is to improve the quality of CR service delivery for public benefit (NACR, 2020).
- **What** – The NACR collects data from CR programmes across the UK and currently has a 90% coverage for electronic data entry (NACR, 2022a). Data collected includes patients' demographics, risk factors, comorbidities, baseline measures prior to starting CR, and outcomes on discharge (full details available at www.cardiacrehabilitation.org.uk).
- **Who and how** – Data is collected by clinicians and via before-and-after self-reporting questionnaires completed by patients. Information from both sources is entered daily, weekly or monthly by a member of each CR team directly into either the national dataset or a local dataset which is then submitted to NACR via File Submission Upload, with some data being entered up to 12 months after CR (NHS Digital, 2023). Data on staff disciplines, hours worked and number per programme are collected separately by NACR via an online survey completed by programme co-ordinators (NACR, 2022b).

4.4.3 Data collection by NACR

The NACR has approval from the Confidential Advisory Group (CAG), under section 251 of the NHS Act 2006, to collect confidential patient information in England and Wales without consent from individual patients (NACR, 2020). The CAG provides advice to the Health Research Authority on the use of confidential patient information for research purposes (NHS Health Research Authority, 2024). This 251 exemption is reviewed annually by NHS Digital (NACR, 2020). The NACR registry does not hold identifiable patient information as all personal identifiers have been removed by NHS Digital before the data is transferred to the NACR dataset (NACR, 2022c). National data opt-out was introduced in 2018, following advice from the National Data Guardian, and allows patients to choose not to have their confidential information used for purposes such as research (NHS England, 2024). In December 2022, NACR was also granted exemption from the National Data Opt-Out by the Secretary of State due to its Section 251 approval (NHS England, 2024).

The NACR was established in 2005 as a system for service improvement and quality assurance of CR. Substantial changes were made in 2013 to the data entry system and clinical reporting which led to higher quality data, hence a start date of 1st January 2013 was chosen for data selection for this study. A National Certification Programme for CR (NCP_CR) (Furze, Doherty and Grant-Pearce, 2016) was introduced by the BACPR and NACR in 2016 as opt-in and then routinely run from 2018 onwards. CR programmes are assessed against seven key performance indicators comprising of three minimum standards and four standards. To gain certification, a programme must be entering data on the NACR and also meet all seven standards. NCP_CR is a means of assessing the quality of CR programmes, with appraisal conducted and updated annually. This contributes to the quality assurance of health services within the UK (NHS Digital, 2023).

Electronic data was acquired in a link-anonymised format from 230 programmes across England, Wales, and Northern Ireland with an 82% coverage for electronic data entry in 2019 (NACR, 2019). The number of programmes and degree of electronic entry varies year-on-year, for example, in 2022 there were 205 programmes but a 90% electronic coverage (NACR, 2022a).

4.4.4 Missing data

One disadvantage of a retrospective observational study is the potential for missing data which exists in large primary datasets. Missing data, or missingness, is where data fields or values are blank due to a number of potential reasons including lack of time or knowledge of the answer by the respondent, or problems with data entry or management (Allison, 2009). In both analyses for this study, certain variables were identified as important for inclusion based on the literature. These included participants' age, gender, ethnicity, and comorbidities. Further detail on these variables is provided under 'inclusion criteria'. For the regression analysis, a valid case method was employed whereby if data was missing for any of the important variables, that case was omitted from the regression analysis. To minimise bias in this analysis, a range of variables including age, gender, and ethnicity were compared between the study population and the total CR population to assess for significant differences between the groups. No significant differences were found. Age was deemed to be the most important of the comparable variables as this is a mandated field in the NACR dataset and therefore has no reporting bias.

4.4.5 Population of interest

For this research, the population of interest were those people eligible for CR within a specified time period, who had both recorded comorbidity and comorbid stroke. The research question was divided into two sections, with the first exploring the factors affecting the uptake, and the second the factors affecting completion, of CR by people with comorbid stroke. These are henceforth be referred to as Analysis 1 (uptake) and Analysis 2 (completion). Identical methods were used for both studies, but data selection and analyses were conducted separately. Data for Analysis 1 was selected and analysed before, and separately to, selection of data for Analysis 2. The data selection start date of 2013 was chosen for two reasons. Firstly, the quality and volume of NACR data increased and improved due to changes made to data entry in 2013, and secondly, the selected study population of those with comorbid stroke was likely to be small, so analysing data from across a longer time period was justified. Both analyses had the same start date, but the data selection window was longer for Analysis 2 to maximise sample size. The end date chosen for selection of data for both analyses was before the identification of the COVID-19 virus in December 2019, after which time many changes took place within CR services in terms of format, delivery, and staffing which have an ongoing impact (NACR, 2022a). This means that CR data collected since the onset of COVID-19 would be substantially different to data collected pre-COVID, and that extending the end date of data selection beyond November 2019 would potentially have introduced bias.

- **Analysis 1 (uptake)** – The population of interest was identified using demographic data collected for the NACR between 1st January 2013 and 30th January 2019. This group was then subdivided into those who had started and not started CR (*Figure 4.1*), and compared.

Figure 4.1. Analysis 1 - uptake of CR by people with comorbid stroke

- **Analysis 2 (completion) –** This population was identified using demographic data collected for the NACR between 1st January 2013 and 30th November 2019. The extended data selection period for Analysis 2 allowed for any delay in audit data input by clinicians and ensured that restrictions on data collection for the NACR resulting from the COVID-19 pandemic did not affect the study findings. The group who had started CR were subdivided into 2 further groups, completers and non-completers (
- *Figure* 4.2), and then compared.

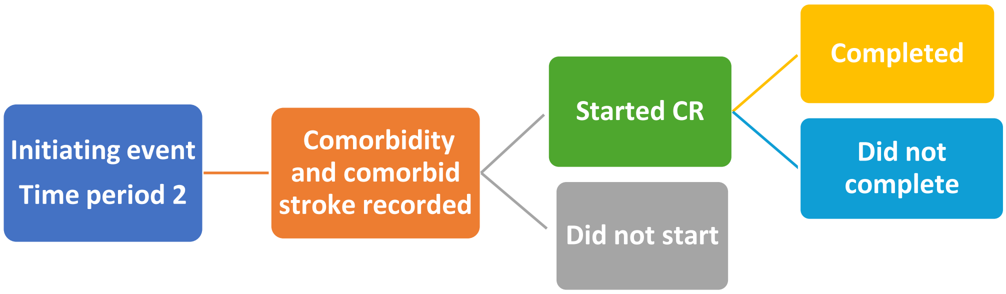

Figure 4.2. Analysis 2 - completion of CR by people with comorbid stroke

4.4.6 Inclusion criteria

For each analysis, patients were included if they had an initiating cardiac event between the specified time periods and were also recorded as having a comorbidity and comorbid stroke. A full list of initiating cardiac events can be found in the NACR annual report for 2020 (NACR, 2020).

4.4.7 Variables

The primary outcome variable for Analysis 1 was whether the person had started core CR (no, yes), also known as 'phase 3' (NACR, 2022c). The NACR and BACPR define this as the point at which the person has been assessed for core CR, their goals have been agreed and set, and their formal structured CR programme begins. For Analysis 2, the primary outcome variable was whether the person had completed their CR programme (no, yes). People were deemed as having completed if they were recorded as having completed or had a post-assessment with no other recorded reason for them not to have completed, e.g., dropping out, being too ill, or early termination for additional treatment.

The identification of other relevant important variables for inclusion in the analyses was based on previous research findings which identified associations with starting and/or completing CR amongst the wider CR population, or where they were identified in bivariate analysis. Variables were also considered for inclusion if they had been identified as a factor influencing implementation of aerobic exercise post-stroke in the systematic review in Chapter 3. These variables were divided into two categories, patient-level and service-level, as presented in *Table 4.1* and described below.

4.4.7.1 Patient-level variables

Having an initiating cardiac event within a specified time period, and a recorded comorbidity and comorbid stroke were deemed necessary variables for inclusion in order to address the objectives. Age (years) and gender (male/female) have been reported in the CR literature as being significantly associated with starting and completing CR (Thomas et al., 1996, Halm et al., 1999, Ritchey et al., 2020), and are often interlinked. Partnership status (single/partnered) is also well documented regarding influencing participation (Galdas, Harrison and Doherty, 2018). Those who were single, widowed, or separated were included within the term 'single', and those who were married, partnered or in civil partnership within 'partnered'. Ethnicity (White/minority ethnic) is also supported by literature (Reges et al., 2014, Mead, Ramos and Grantham, 2016), as is deprivation (Galdas, Harrison and Doherty, 2018, Salman and Doherty, 2019), measured using the English Index of Multiple Deprivation (IMD) (Ministry of Housing Communities & Local Government, 2019). In the IMD, neighbourhoods in England are scored by the government in terms of their level of deprivation. They are then divided into ten equal groups or deciles based on their scores to rank them from decile one, the most deprived, through to decile ten, the least deprived (Ministry of Housing Communities & Local Government, 2019). Data from the IMD is linked to the NACR, but is categorised instead into five equal groups based on these IMD scores. These groups rank from most deprived quintile (first or lowest), to least deprived (fifth or highest quintile). For analysis, the most deprived areas (first quintile) were compared to the second, third, fourth, and fifth quintiles as categorical variables. Having additional comorbidities (no, yes) and receiving cardiac treatment (none, Percutaneous Coronary Intervention (PCI), Coronary Artery Bypass Graft (CABG), other) were reported as significant in wider CR literature, as was hospital length of stay (days) (Soo Hoo, Gallagher and Elliott, 2016, van Engen-Verheul et al., 2013, Harrison, Doherty and Phillips, 2018, McKee et al., 2014).

4.4.7.2 Service-level variables

The source of referral, in terms of setting (hospital/primary care) and referring discipline, were evidenced in literature as influencing participation in CR and therefore included as categorical variables (Al Quait et al., 2017). In order to explore the influences of staffing and resources on uptake and completion, presence of a multidisciplinary team (MDT), comprising three or more different staff disciplines as per the BACPR and NACR National Certification Programme (BACPR and NACR, 2022), was included in both analyses. Presence of nurse, occupational therapist, and physiotherapist were included in the completion analysis as binary variables, to explore whether having contact with any of these disciplines influenced completion. Staff hours per patient, overall number of patients, and proportion of people with comorbid stroke in a service were added as continuous variables to indicate service capacity.

Table 4.1. Variables for Analysis 1 (uptake) and Analysis 2 (completion)

Variable (predictor)	**Details**	**Analysis 1 – uptake**	**Analysis 2 - completion**
Filtering variables required to identify the population			
Initiating cardiac event within a specified time period	01/01/2013 – 30/01/2019	✓	
	01/01/2013 – 30/11/2019		✓
Comorbid stroke	Binary variable – did the person have comorbidity recorded AND comorbid stroke recorded (no, yes)	✓	✓
Study outcomes (dependent variables)			
Analysis 1 – started CR	Binary variable – did the person start CR (no, yes)	✓	
Analysis 2 – completed CR	Binary variable – did the person complete CR (no, yes)		✓
Patient-level (independent variables)			
Age (+18)	Continuous variable – age in years	✓	✓
Gender	Binary variable – male, female	✓	✓
Ethnicity	Binary variable – White, non-White	✓	
Marital status	Binary variable – partnered, not partnered	✓	✓
Deprivation	Categorical variable – five categories	✓	✓

	as per the IMD score: • first quintile (most deprived) • second quintile • third quintile • fourth quintile • fifth quintile (least deprived)		
History of previous cardiac event	Binary variable – did the person have any of the following (myocardial infarction, cardiac arrest, revascularisation, cardiac surgery, angina, pacemaker, heart failure, arrhythmia, congenital heart defect, or unknown) as a previous cardiac event (no, yes)	✓	✓
Comorbidities	Binary variable – did the person have any comorbidities* in addition to stroke (no, yes) *these are displayed as eight unique comorbidity groups with each individual comorbidity included as a binary variable based on comorbidity status (no, yes); • musculoskeletal • ischemic • metabolic • cancer • hypertension • respiratory • psychosocial • erectile dysfunction	✓	✓
Cardiac treatment	Categorical variable – none, percutaneous coronary intervention, coronary artery bypass grafting, other	✓	✓
Length of hospital stay	Continuous variable – measured in days from admission to discharge	✓	
Source of referral	Categorical variable – hospital setting, private, NHS, primary care setting, GP	✓	
Referring health professional	Categorical variable – consultant, cardiac nurse, GP, primary care nurse, other	✓	
Service-level (independent variables)			
Proportion of patients with comorbid stroke in CR programme	Continuous variable – measured as % of the total number of patients in the programme	✓	✓
Overall number of patients in CR service	Continuous variable – total number of people in a CR programme at any	✓	✓

	given time		
Staff hours per patient	Continuous variable – measured as number of hours per patient attending per week	✓	✓
Multi-disciplinary team (MDT) (3+ staff disciplines)	Binary variable – was a MDT present (no, yes)	✓	✓
Nurse	Binary variable – was a nurse present (no, yes)		✓
Physiotherapist (PT)	Binary variable – was a PT present (no, yes)		✓
Occupational therapist (OT)	Binary variable – was an OT present (no, yes)		✓

4.4.8 Statistical analysis

The data selected for this study were quantitative, which are measurements expressed and coded as numbers (Williams et al., 2022). Quantitative data can be analysed using descriptive and inferential statistics. Descriptive statistics, also known as summary statistics, describe the features of a study population, for example using mean and standard deviation for continuous variables such as age, and frequencies and percentages for categorial variables such as gender (Mishra et al., 2019). Inferential statistics are used to make predictions or inferences about a population based on a sample (Mishra et al., 2019). The statistical tests used in this study were the t-test, chi-square test of independence, and logistic regression. The analyses were conducted in IBM Statistical Package for the Social Sciences (SPSS) V.25. (SPSS, Chicago, Illinois, USA). This comprehensive software package is used for complex statistical data analysis.

4.4.8.1 Descriptive statistics

The first stage of data exploration involved organising and summarising the data using descriptive statistics. This enabled comparison of the baseline characteristics of the included patients in each analysis. T-tests were used for continuous variables (mean) such as age and proportion of stroke patients in a programme, whilst chi-square tests were used for categorical variables such as gender and ethnicity. P-values < 0.05 were considered statistically significant and actual significant values were expressed as reported up to 0.001. Baseline univariate analysis involves analysis of just one variable, such as age or comorbidity, in order to describe that variable(Sandilands, 2014). Bivariate analysis was also conducted to explore associations between one predictor variable and one outcome variable at a time, such as between age and uptake or age and completion. As a large number of bivariate analyses were performed, the p-values in these were adjusted using Bonferroni correction which changed the threshold for significance to 0.004. Missingness within each variable was assessed and, to maximise inclusion of evidenced determinants, those with high or unique levels of missing data were removed. This was conducted in consultation with experts at the NACR and used an iterative approach comparing patterns and relationships of missingness to minimise reporting and selection biases. For deprivation, the Second, Third, Fourth and Fifth IMD quintiles were each compared to the First (least deprived) quintile which was the base group. Comorbidities were grouped into similar conditions as shown in *Table 4.1*. Cardiac treatments were recoded to compare 'none' to 'PCI', 'CABG', and 'other'. Ethnicity was grouped as 'White' and 'minority ethnic', the latter of which included all ethnic groups other than white. Multiple ethnicities were combined into one group, 'minority ethnic', for statistical analysis due to much lower numbers within each of these ethnic groups.

4.4.8.2 Reasons for not taking part or not completing CR

There are a proportion of patients who do not start or do not complete CR. As part of routine pathway recording by the NACR, programmes are asked to record the reasons for not starting or not completing (NACR, 2019). These fields are generally only completed for a small number of patients in comparison with other variables such as age or gender. As an example, for the wider CR population in the UK in 2019, reasons for not taking part in core CR (phase 3) were only recorded for around 30% of those who did not start and 20% of those who did not complete CR (NACR, 2019). However, despite the potential for bias, analysis of these reasons did provide an indication of why patients with comorbid stroke did not start or did not finish CR and enabled a comparison with the wider CR population. For this, the data selected within the time periods for Analysis 1 (uptake) and Analysis 2 (completion) for people who had comorbidity recorded, including 'no/none', excluding any with missing data in this field, were analysed. For Analysis 1, the group with comorbidity recorded was divided into those who had, and did not have, comorbid stroke recorded and had not started CR. The reasons for not starting were compared for these two groups. This process was repeated for Analysis 2 (completion) with the reasons for not completing CR compared for those with and without comorbid stroke.

4.4.8.3 Logistic regression

Logistic regression is an established method for analysing data which seeks to explore relations between predictor variables and a binary outcome (Lemeshow et al., 2013). In order to establish whether any of the patient- or service- level variables were significantly associated with the binary outcome variables of uptake and completion, a prediction model was built. This was conducted using backwards stepwise logistic regression which involves the sequential inclusion or exclusion of variables using stopping criteria. This is a quick and effective method for screening a larger number of variables (Lemeshow et al., 2013). Of the two approaches to stepwise logistic regression (forward selection with test for backward elimination, and backwards elimination with a test for forward selection) (Lemeshow et al., 2013), backwards elimination was selected. Backwards stepwise logistic regression starts with all variables included in the model (full model) and then at each step the least significant (highest p-value) variable is removed and statistics recomputed for forward selection until only significant variables remain, based on the set cut-off p-value (final model) (Chowdhury and Turin, 2020). For this study, this was set at $p<0.05$. As this analysis involved correlated binary data in multiple levels, hierarchical logistic regression models were built to assess the extent of the associations and allow for patient- and service- level data. Variables which would result in a 'best' model were selected based on existing literature and/or univariate analysis within the context of the research question and included for analysis if they had sufficient data to fulfil statistical distribution assessments ($N>30$). A valid case analysis method was used whereby people for whom values were completed for all the variables were included in the regression. People for whom any of these data were missing were excluded from both analyses. Once the model had been created, standard model checking was performed in collaboration with a NACR statistician to meet regression model assumptions. Model fit was assessed through the Hosmer Lemeshow Goodness of Fit test and the Nagelkerke R square. Model assumptions were checked and cases that were outliers were identified and processed (for categorical data) or trimmed (for continuous data) prior to running the analysis.

4.5 Results

4.5.1 Factors associated with the uptake of CR (Analysis 1)

The total number of patients entered into the NACR dataset during the specified time period of 1st January 2013 to 30th January 2019 who had comorbidity recorded was 402,405. Of these, 23,297 (5.3%) had comorbid stroke recorded and are henceforth referred to as the uptake study population. There were 10,359 people (44.46%) with comorbid stroke who started CR (*Figure 4.3*).

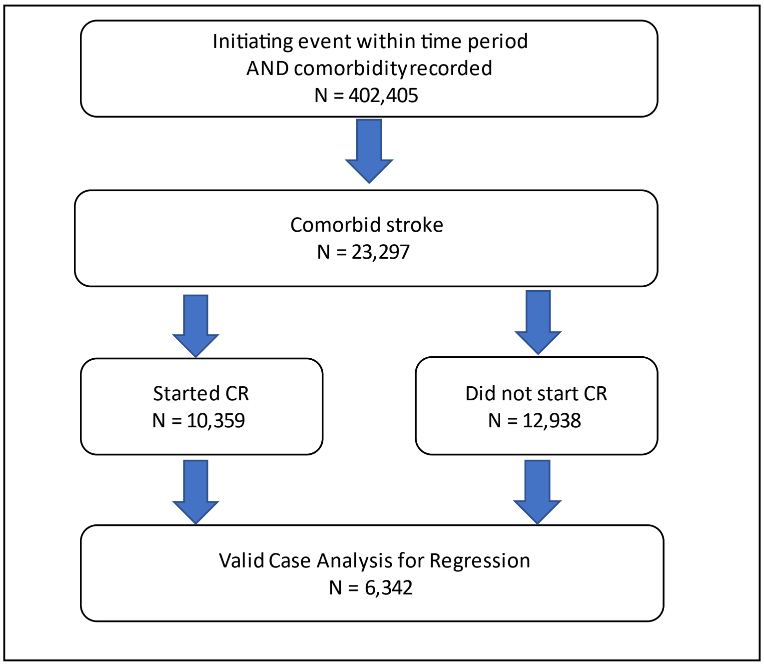

Figure 4.3. Flow diagram of study population for Analysis 1 identified via filtering variables

4.5.1.1 CR uptake study population

The average age of those within the uptake study population was 72 years old (SD 11.19). People who did not start CR were on average four years older than those who did. The overall majority in the population were male (67%) and White (75.3%). A lower proportion of females, and a lower proportion of those in the minority ethnic group, started CR, with 39.3% and 40.2% respectively (p=<0.001), in comparison with 47% of males and 54.1% of those in the White group who started. Deprivation was significant (p=<0.001), with the proportion who started CR increasing from 34.6% in the most deprived (first) quintile to 48.6% in the least deprived (fifth) quintile. However, these increases were not uniform as the second to fifth quintiles were each compared to the first (base group). The majority of the uptake population were partnered (68.6%), which was reflected in the starter group, which had a higher proportion of those with a partner (49.7%) compared with those who were single (40.6%). Furthermore, the non-starter group had a higher proportion of people who were single over partnered, 59.4% and 50.3% respectively. Essentially, the starter group was dominated by males (p=<0.001), those of White ethnicity (p=<0.001), and those who were partnered (p=<0.001) (*Table 4.2*).

The proportion of people who had had a previous cardiac event was significantly higher in the group which did not start than those who did (p=0.05). The musculoskeletal, psychosocial, and erectile dysfunction comorbidity groups had a significantly greater number of people who started with the opposite being true for all other comorbidity groups (*Table 4.3*). Cardiac treatment was significant (p=<0.001) with higher proportions of people in the non-starter group who had had PCI (51.7%), 'other' treatment (54.6%), or 'none' (72.2%). Contrastingly, there was a greater proportion of those who had had a CABG in the starter group (63.1%) compared with the non-starter group (36.9%). Length of hospital stay was not significant for uptake (p=0.084). The source of a referral, whether the referring healthcare professional was based in a hospital or primary care setting, was significant for uptake (p=0.001). Despite the majority of referrers being hospital-based (88.2%), the proportion of people referred from hospital and primary care settings who started was similar, 44.4% and 48.8% respectively.

A MDT comprising more than three staff disciplines, was present for 82.6% of the uptake study population and was a significant factor (p=<0.001), being linked with a 10% increase in the number starting. The average number of hours per patient per week also influenced uptake, with 16.09 (SD 26.49) hours for those in the starter group in comparison with a lower 12.44 (SD 20.01) hours for the non-starters (p=<0.001). The overall number of patients in a service and the proportion of patients with comorbid stroke were influencing factors. Services with stroke survivors who started CR had an average of 16.59 (SD 11.26) patients overall per week, compared to 17.71 (SD 11.85) patients in services where they did not start. The proportion of people with comorbid stroke in a service was lower where the stroke survivor started CR (6.86%) than did not start (7.10%) (p=<0.001). These service-specific data suggested that lack of a MDT, less staff hours per week, greater overall number of patients, and greater proportion of those with comorbid stroke in a service negatively influenced uptake of CR by stroke survivors.

4.5.1.2 Reasons for not starting CR

During this time period, reasons for not starting CR were recorded in the NACR registry for 4,293 people with comorbid stroke and for 58,929 for whom stroke was not a recorded comorbidity (*Table 4.4*). Overall, the most common reason for not starting was 'patient not interested/refused', which was lower in the group with comorbid stroke (32.5%), than without (38.1%). For those with comorbid stroke, 'physical incapacity' was the next most common reason which, at 18.4%, was almost double that for those without comorbid stroke (9.5%). The reasons 'mental incapacity', 'too ill' and 'rehabilitation not appropriate' were each reported 1.5 times more in the comorbid stroke group than the non-comorbid stroke group. A lower proportion of those in the comorbid stroke group had 'local exclusion criteria' reported as a reason, whereas 'died' was recorded for a higher proportion. 'Returned to work' was reported three times as often in the group without comorbid stroke. 'DNA/no contact' was recorded for a greater proportion of those in the non-comorbid stroke group, than in the comorbid stroke group, with 12.2% versus 8.5%.

4.5.1.3 Logistic regression

Valid case selection for the logistic regression for the uptake study population resulted in data for a total of 6,342 people in the final regression model (*Table 4.5*)**.** The model identified thirteen statistically significant variables associated with uptake of CR, nine of which were patient-level. A person's age was negatively associated, with every year increase in age resulting in a 2.5% reduced likelihood of starting (OR 0.975). Having a partner increased likelihood of uptake by 19.4% (OR 1.194, 95% CI 1.064 to 1.340; p=0.003), and if people had any cardiac treatment there was an 87.7% to more than twofold increased likelihood (Other OR 1.877, 95% CI 1.576 to 2.235; p=<0.001 and CABG OR 3.569, 95% CI 2.885 to 4.414; p=<0.001). Deprivation was also significant with likelihood incrementally increasing as deprivation decreased. The difference in moving from the most deprived (first) quintile to the second was a 24.3% increase in likelihood (OR 1.243, 95% CI 1.042 to 1.482; p=0.015), and from the most to the least deprived a 93% increased likelihood (OR 1.930, 95% CI 1.620 to 2.301; p=<0.001). Five of the comorbidity groups were significant. Having a comorbidity in the musculoskeletal (OR 1.571, p=<0.001), psychosocial (OR 1.430, p=<0.001), or erectile dysfunction (OR 1.289, p=<0.043) groups increased the likelihood of starting CR. However, comorbidities in the ischaemic and respiratory groups decreased the likelihood (OR 0.838, p=<0.004 and OR 0.794 p=<0.002).

There were four significant service-level factors for uptake. The proportion of people with comorbid stroke in a service was negatively associated with 6% reduced likelihood of starting (OR 0.940, 95% CI 0.920 to 0.961; p=<0.001). The number of patients seen in a service was also negatively associated (OR 0.986, 95% CI 0.982 to 0.990; p=<0.001). The two factors significantly positively associated with uptake were the presence of a multidisciplinary team, linked to a 63.8% increase in likelihood (OR 1.638, 95% CI 1.406 to 1.908; p=<0.001), and total staff hours, with every hour increase associated with a 1.9% increase in likelihood of uptake (OR 1.019, 95% CI 1.012 to 1.026; p=<0.001).

The Hosmer Lemeshow test for goodness of fit of the model, used for logistic regression, had a large p-value of 0.835 thereby indicating that the model was a good fit. The predictive power was 63.8% meaning it correctly predicted over 60% of values based on the created model. Nagelkerke R Square was 0.135 which is in the lower fifth of the possible values.

Table 4.2. Population descriptives divided into starters and non-starters

Independent variables		Did the patient start CR?				Total		Mean difference	p-value
		No		Yes					
Continuous variables		**Mean (SD)**	**Count**	**Mean (SD)**	**Count**	**Mean (SD)**	**Count**		
Age (years)[1]		74 (11.39)	12,938	70 (10.55)	10,359	72 (11.19)	23,297	3.867	<0.001
Hospital length of stay (days)[1]		11 (19.94)	9,862	12 (26.99)	8,371	12 (23.44)	18,233	0.601	0.084
Proportion of stroke patients in programme (%)[2]		7.10 (2.47)	12,938	6.86 (2.56)	10,359	6.99 (5.51)	23,297	0.245	<0.001
Patients by week (number of patients)[2]		17.71 (11.85)	12,938	16.59 (11.26)	10,359	17.21 (11.60)	23,297	1.119	<0.001
Staff hours per patient (hours)[2]		12.44 (20.01)	9,895	16.09 (26.49)	7,641	14.03 (23.13)	17,536	3.648	<0.001
Categorical variables		**Count**	**% did not start**	**Count**	**% started**	**Count**	**% by subgroup**	**Chi-square**	**p-value**
Gender[1]	Male	8,198	53.00%	7,280	47.00%	15,478	67.00%	124.382	<0.001
	Female	4,620	60.70%	2,988	39.30%	7,608	33.00%		
Ethnicity[1]	White	9,497	54.10%	8,047	45.90%	17,544	75.30%	56.598	<0.001
	Minority ethnic	3,441	59.80%	2,312	40.20%	5,753	24.70%		
Partnership status[1]	Single	3,097	59.40%	2,120	40.60%	5,217	31.40%	119.295	<0.001
	Partnered	5,734	50.30%	5,676	49.70%	11,410	68.60%		
Previous cardiac event[1]	No	5,851	54.80%	4,818	45.20%	10,669	45.80%	3.838	0.05
	Yes	7,087	56.10%	5,541	43.90%	12,628	54.20%		
Deprivation (IMD)[1]	Lowest quintile	2,370	65.40%	1,254	34.60%	3,624	19.00%	172.181	<0.001
	2nd quintile	2,226	59.50%	1,514	40.50%	3,740	19.60%		
	3rd quintile	2,154	56.60%	1,654	43.40%	3,808	20.00%		
	4th quintile	2,113	54.70%	1,747	45.30%	3,860	20.30%		
	5th quintile	2,061	51.40%	1,946	48.60%	4,007	21.00%		
Cardiac treatment[1]	None	3,444	72.20%	1,329	27.80%	4,773	20.49%	893.941	0.001

	PCI	4,153	51.70%	3,882	48.30%	8,035	34.49%		
	CABG	812	36.90%	1,388	63.10%	2,200	9.44%		
	Other	4,529	54.60%	3,760	45.40%	8,289	35.58%		
Multi-disciplinary team²	No	2,050	63.40%	1,184	36.60%	3,234	17.40%	115.825	<0.001
	Yes	8,167	53.00%	7,234	47.00%	15,401	82.60%		
Referring staff²	Hospital-based	9,726	55.60%	7,753	44.40%	17,479	88.20%	16.818	<0.001
	Primary care	1,197	51.20%	1,143	48.80%	2,340	11.80%		

** [1]patient-level variables, [2]service-level variables*

Table 4.3. Comorbidity groups of those with additional comorbidities, divided into those who started and did not start

Comorbidity groups		**Did the patient start CR?**				**Total**		**Chi-square**	**p-value**
		No		**Yes**					
		Count	**% did not start**	**Count**	**% started**	**Count**	**% by sub-group**		
Musculoskeletal	No	10,126	58.40%	7,222	41.60%	17,348	74.50%	221.087	<0.001
	Yes	2,812	47.30%	3,137	52.70%	5,949	25.50%		
Ischaemic	No	9,598	55.50%	7,682	44.50%	17,280	74.20%	0.002	0.963
	Yes	3,340	55.50%	2,677	44.50%	6,017	25.80%		
Metabolic	No	7,027	56.10%	5,507	43.90%	12,534	53.80%	3.068	0.08
	Yes	5,911	54.90%	4,852	45.10%	10,763	46.20%		
Cancer	No	11,762	55.70%	9,343	44.30%	21,105	90.60%	3.483	0.062
	Yes	1,176	53.60%	1,016	46.40%	2,192	9.40%		
Hypertension	No	5,841	55.80%	4,634	44.20%	10,475	45.00%	0.395	0.53
	Yes	7,097	55.40%	5,725	44.60%	12,822	55.00%		
Respiratory	No	10,721	55.20%	8,709	44.80%	19,430	83.40%	6.058	0.014

	Yes	2,217	57.30%	1,650	42.70%	3,867	16.60%		
Psychosocial	No	12,205	57.00%	9,193	43.00%	21,398	91.80%	240.147	<0.001
	Yes	733	38.60%	1,166	61.40%	1,899	8.20%		
Erectile dysfunction	No	12,384	56.00%	9,734	44.00%	22,118	94.90%	36.73	<0.001
	Yes	554	47.00%	625	53.00%	1,179	5.10%		

Table 4.4. Reasons for not starting CR divided into patients who did and did not have comorbid stroke

Admission date between 1st January 2013 and 31st January 2019 AND had comorbidity recorded, including 'no/none', but did not start CR	**Did the patient have comorbid stroke?**	
	No (n=58,350)	**Yes (n=4,245)**
Reason for not starting core rehabilitation (phase 3)		
Patient not interested / refused	38.1%	32.5%
Ongoing investigation	4.5%	4.4%
Physical incapacity	9.5%	18.4%
Returned to work	3.1%	0.9%
Local exclusion criteria	2.2%	1.7%
Language barrier	0.1%	0.2%
Holidaymaker	0.8%	0.6%
Mental incapacity	1.0%	1.5%
No transport	1.2%	1.5%
Died	1.9%	2.4%
Not referred	0.3%	0.4%
Too ill	4.1%	6.6%
Rehabilitation not needed	3.7%	2.2%
Rehabilitation not appropriate	6.6%	9.5%
Staff not available	0.1%	<0.1%

Rapid transfer to tertiary care	<0.1%	0.0%
Did not attend (DNA) / no contact	12.2%	8.5%
Patient request transfer to another programme	2.8%	2.3%
No service available	0.2%	0.3%
Transfer for PCI / treatment	0.1%	<0.1%
Transfer to DGH / Trust	1.2%	0.3%
Other	5.1%	4.6%
Unknown	1.1%	1.2%
Total	100.0%	100.0%

Table 4.5. Logistic regression results for the likelihood of people with comorbid stroke to start core (phase 3) CR (limited to England due to inclusion of IMD)

Variables included in the final step of backwards regression	**OR**	**p-value**	**95% CI for OR**	
			Lower	**Upper**
Age – at initiating event (years)[1]	0.975	0.000	0.970	0.980
Proportion of patients with comorbid stroke (%)[2]	0.940	0.000	0.920	0.961
Ethnicity – White[1]	0.884	0.096	0.765	1.022
Partnership status – single[1]	1.194	0.003	1.064	1.340
Treatment base none – PCI[1]	2.162	0.000	1.826	2.560
Treatment base none – CABG[1]	3.569	0.000	2.885	4.414
Treatment base none – other[1]	1.877	0.000	1.576	2.235
Deprivation (IMD) base most deprived quintile – 2nd quintile[1]	1.243	0.015	1.042	1.482
Deprivation (IMD) base most deprived quintile – 3rd quintile[1]	1.527	0.000	1.281	1.822
Deprivation (IMD) base most deprived quintile – 4th quintile[1]	1.788	0.000	1.502	2.128
Deprivation (IMD) base most deprived quintile – 5th quintile[1]	1.930	0.000	1.620	2.301
Comorbidity base none – musculoskeletal[1]	1.571	0.000	1.390	1.776

Comorbidity base none – ischaemic[1]	0.838	0.004	0.744	0.944
Comorbidity base none – cancer[1]	1.161	0.085	0.980	1.377
Comorbidity base none – respiratory[1]	0.794	0.002	0.686	0.919
Comorbidity – psychosocial[1]	1.430	0.001	1.163	1.757
Comorbidity – erectile dysfunction[1]	1.289	0.043	1.008	1.649
Number of patients seen per week[2]	0.986	0.000	0.982	0.990
Staff hours per patient[2]	1.019	0.000	1.012	1.026
Multi-disciplinary team (no <3)[2]	1.638	0.000	1.406	1.908
Constant	1.642	0.037		

** Model summary (n=6,342), predicted correctly 63.8%, Hosmer-Lemeshow 0.835; [1]patient-level variables, [2]service-level variables*

4.5.2 Factors associated with the completion of CR (Analysis 2)

As the time period for Analysis 2 differed from Analysis 1, demographic data analysis was re-run. The total number of patients entered into the NACR dataset during the specified time period of 1st January 2013 to 30th November 2019 who had comorbidity recorded was 423,888. Of these, 24,008 had comorbid stroke recorded and will henceforth be referred to as the completion study population. A total of 11,176 (46.6%) started CR (*Figure 4.4*), of which 49.1% were male and 41.6% female. Those who had started were then divided into 2 groups, completers and non-completers. Patients were deemed to have completed the programme if they were recorded as having completed or had a post-assessment with no other recorded reason for them not to have completed. Of the starters, 7,905 (70.7%) completed CR.

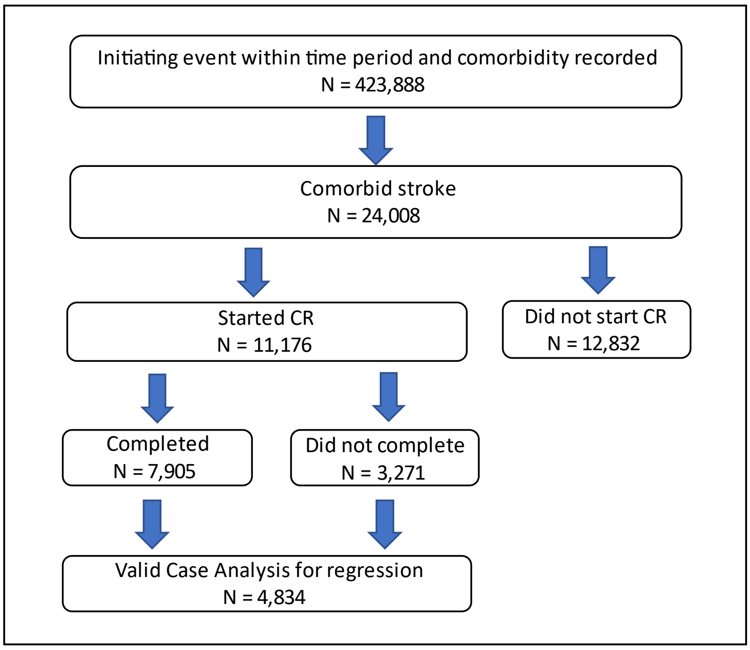

Figure 4.4. Flow diagram of study population for Analysis 2 identified via filtering variables

4.5.2.1 CR completion study population

Table 4.6 presents descriptive statistics for the study population divided into those who completed and did not complete the programme. 71.8% of male starters and 68.1% of female starters completed the programme. Those who completed were older, with a mean age of 71 years, than those who did not, with a mean of 69 years. In this completion population, women are on average older than their male counterparts. They are less likely to have comorbid stroke, but of those who do, fewer start CR and fewer complete. A greater proportion of those living in the least deprived areas completed CR (24.9%) compared with those from the most deprived areas (13.9%) ($p<0.001$). More people who had been treated with a coronary artery bypass graft completed CR (13.6%) than did not complete (10.8%) ($p<0.001$). The group who did not complete had a greater number of people who had had a previous cardiac event compared with those who did not have, 55% and 45% respectively ($p=0.031$). Ethnicity, length of hospital stay, and previous cardiac event were not significant in the descriptive statistics. Staff hours and proportion of stroke patients within the services were not significantly associated with completion (>0.05). There was no significant difference in the presence of nursing, physiotherapy, or occupational therapy staff, having a multidisciplinary team or receiving early CR (>0.05) in the population descriptives.

4.5.2.2 Reasons for not completing CR

During the study time period, 77.6% (n=2,540) of the people with comorbid stroke who did not complete CR had reasons recorded for this. In the same time period, there were 41,077 people without comorbid stroke who had not completed CR and had reasons recorded for non-completion (*Table 4.7*). It should be noted that over two thirds of the reasons in both groups for not completing CR are made up of 'DNA unknown reason' and 'other'. Aside from these, the most common reason for not completing was 'too ill', with this reported for 19.7% of the comorbid stroke group, and 13.5% of the non-comorbid stroke group. In those with comorbid stroke, 'hospital readmissions' was also higher (3.1% versus 1.8%) and almost double the proportion had 'died' as a reason (3.1% versus 1.6%). 'Returned to work' was recorded more often in the non-comorbid stroke group (8.4%) as a reason for not continuing, compared to the comorbid stroke group (2.7%).

4.5.2.3 Logistic regression

Valid case analysis for the logistic regression for the completion population selected data for 4,834 people in the final regression model. The model identified nine statistically significant variables for completion of CR, seven patient-level and two service-level (*Table 4.8*).

Age was significant, with a 1% increase in likelihood of completion for every year older a person was (OR 1.010, 95% CI 1.004 – 1.017, p=<0.001). There was a 40% increased likelihood for those who had a partner (OR 1.404, 95% CI 1.224 to 1.612; p=<0.001) and all quintiles of deprivation above the lowest were associated with a 37% to 57% increased likelihood of completion (OR 1.374, 95% CI 1.119 to 1.687 and OR 1.579, 95% CI 1.284 to 1.942; p=<0.001). The inclusion of deprivation limited the findings such that these results are for the England subset only. People who were treated with a CABG were 46.1% more likely to complete (OR 1.461, 95% CI 1.132 to 1.886; p=0.004), but those who had had a previous CVD event were less likely to complete (OR 0.875, 95% CI 0.768 to 0.998; p=0.047) . Having additional comorbidities in the metabolic (OR 0.858, p=0.018) or psychosocial (OR 0.738, p=0.001) groups were associated with a 14.1% and 25.6% decreased likelihood of completion respectively.

The two statistically significant service-level variables were the proportion of patients with comorbid stroke in a service and overall number of patients in a service. The proportion with comorbid stroke in a service was positively associated with a 4.6% increase in likelihood of completion (OR 1.046, 95% CI 1.011 to 1.081; p=0.008) whereas the overall number of patients in a service had a negative association. For every 1% increase in the overall number of patients, there was a 1.9% reduced likelihood of completion (OR 0.981, 95% CI 0.970 to 0.991).

4.5.3 Summary of results from Analyses 1 and 2

A summary of the results from both analyses is presented in *Table 4.9*. The populations with comorbid stroke identified for inclusion in the analyses were comparable in terms of mean age and proportion of males and females. A greater number of valid cases were selected for the analysis of uptake (n=6,342) than for completion (n=4,824).

4.5.3.1 Patient-level factors

These factors had varying significant associations with the outcomes. Increasing age was significantly associated with a reduced likelihood of uptake, yet an increased likelihood of completion. Having any cardiac treatment was associated positively with uptake, although only CABG was associated with completion. Whether or not having other comorbidities influenced uptake or completion varied depending on the type of comorbidity. For example, respiratory comorbidities were negatively associated with uptake, but were not statistically significant for completion. Having a partner and living in a deprived area were the only factors which had the same association for both uptake and completion, which was positive and negative respectively.

4.5.3.2 Service-level factors

There were fewer significant service-level than patient-level factors, with four in total across uptake and completion. The proportion of stroke patients in a programme was significantly associated with a reduced likelihood of uptake, yet an increased likelihood of completion. Increasing staff hours and having a multidisciplinary team (more than three disciplines) positively influenced the uptake of CR, but this factor was not significant for completion. The overall number of patients in a service was the only service-level factor which had a significant association in the same direction for both uptake and completion, and this was negative.

Table 4.6. Descriptives of the population divided into completers and non-completers

Independent variables		Did the patient complete CR?				Total		Mean difference	p-value
		No		Yes					
Continuous variables		**Mean (SD)**	**Count**	**Mean (SD)**	**Count**	**Mean (SD)**	**Count**		
Age (years)[1]		69.2 (11.5)	3,271	70.6 (10.2)	7,905	70.2 (10.6)	11,176	-1.43	<0.001
Hospital length of stay (days)[1]		11.5 (25.5)	2,659	12.7 (29)	6,412	12.3 (28)	9,071	-1.15	0.061
Waiting time from referral to start (days)[1]		41.5 (41.1)	2,774	42.7 (42.6)	6,819	42.3 (42.2)	9,593	-1.25	0.182
Staff hours per patient (hours)[2]		27.5 (31.2)	2,453	27.1 (35.4)	5,843	27.3 (35.6)	8,296	0.02	0.561
Patients by week (number of patients)[2]		10.2 (5.8)	2,751	9.5 (5.3)	6,478	9.7 (5.5)	9,229	0.65	<0.001
Proportion of stroke patients in programme (%)[2]		4.9 (2.1)	3,271	4.9 (2)	7,905	4.9 (2.1)	11,176	0.41	0.621
Categorical variables		**Count**	**% did not start**	**Count**	**% started**	**Count**	**% by subgroup**	**Chi-square**	**p-value**
Gender[1]	Male	2,209	68.00%	5,630	71.70%	7,839	70.60%	15.061	<0.001
	Female	1,038	32.00%	2,220	28.30%	3,258	29.40%		
Ethnicity[1]	White	2,514	76.90%	6,148	77.80%	8,662	77.50%	1.114	0.291
	Minority ethnic	757	23.10%	1,757	22.20%	2,514	22.50%		
Partnership status[1]	Single	782	32.10%	1,469	25.10%	2,251	27.10%	43.228	<0.001
	Partnered	1,654	67.90%	4,394	74.90%	6,048	72.90%		
Previous cardiac event[1]	No	1,473	45.00%	3,737	47.30%	5,210	46.60%	4.672	0.031
	Yes	1,798	55.00%	4,168	52.70%	5,966	53.40%		
Deprivation (IMD)[1]	Most deprived quintile	516	20.20%	868	13.90%	1,384	15.70%	88.153	<0.001
	Least deprived quintile	517	20.20%	1,557	24.90%	2,074	23.50%		
Cardiac treatment[1]	None	411	12.60%	952	12.00%	1,363	12.20%	16.291	0.001
	PCI	1,225	37.50%	2,885	36.50%	4,110	36.80%		
	CABG	353	10.80%	1,074	13.60%	1,427	12.80%		

	Other	1,282	39.20%	2,994	37.90%	4,276	38.30%		
Nursing staff²	No	180	7.30%	458	7.80%	638	7.60%	0.517	0.472
	Yes	2,287	92.70%	5,449	92.20%	7,736	92.40%		
Physiotherapy staff²	No	888	36.00%	2,074	35.10%	2,962	35.40%	0.595	0.44
	Yes	1,579	64.00%	3,833	64.90%	5,412	64.60%		
Occupational therapy staff²	No	1,792	72.60%	4,398	74.50%	6,190	73.90%	2.974	0.085
	Yes	675	27.40%	1,509	25.50%	2,184	26.10%		
Multi-disciplinary team²	No	234	9.50%	604	10.20%	838	10.00%	1.058	0.304
	Yes	2,233	90.50%	5,303	89.80%	7,536	90.00%		

** [1]patient-level variables, [2]service-level variables; IMD only presented for most and least deprived quintiles, p-value presented for all 5 quintiles*

Table 4.7. Reasons for not completing CR divided into patients with and without comorbid stroke

Admission date between 1st January 2013 and 30th November 2019 AND had comorbidity recorded AND had started CR but did not complete	**Did the patient have comorbid stroke?**	
	No (n=41,077)	**Yes (n=2,540)**
Reason for not completing core rehabilitation (phase 3)		
Did not attend (DNA) – unknown reason	34.7%	29.5%
Returned to work	8.4%	2.7%
Left this area	1.4%	0.8%
Achieved aims	0.2%	<0.1%
Planned / emergency intervention	2.1%	2.5%
Too ill	13.5%	19.7%
Died	1.6%	3.1%
Other	31.4%	34.0%
Hospital re-admission	1.9%	3.1%
Unknown	4.9%	4.5%

Total	100%	100%

Table 4.8. Logistic regression of the likelihood of patients with comorbid stroke completing core (phase 3) CR (limited to England due to inclusion of IMD)

Variables included in the final step of backwards regression	**OR**	**p-value**	**95% CI**	
			Lower	**Upper**
Age – centred around mean, 70 years[1]	1.010	0.001	1.004	1.016
Partnership status – effect of partnered[1]	1.404	0.000	1.224	1.612
Deprivation (IMD) – base most deprived quintile[1]		0.000		
Deprivation (IMD) – 2nd quintile[1]	1.383	0.002	1.123	1.703
Deprivation (IMD) – 3rd quintile[1]	1.374	0.002	1.119	1.687
Deprivation (IMD) – 4th quintile[1]	1.579	0.000	1.284	1.942
Deprivation (IMD) – least deprived quintile[1]	1.506	0.000	1.227	1.847
Previous CVD event – effect of yes[1]	0.875	0.047	0.768	0.998
Treatment – base none[1]		0.022		
Treatment – PCI[1]	1.138	0.219	0.926	1.400
Treatment – CABG[1]	1.461	0.004	1.132	1.886
Treatment – other[1]	1.104	0.350	0.897	1.358
Proportion of patients with comorbid stroke within programme %[2]	1.046	0.008	1.011	1.081
Number of patients attending by week[2]	0.981	0.000	0.970	0.991
Comorbidity – metabolic[1]	0.858	0.018	0.755	0.974
Comorbidity – psychosocial[1]	0.738	0.001	0.614	0.888
Constant	1.010	0.512		

** Model summary (n=4,834), predicted correctly 70.1%, Hosmer-Lemeshow 0.096, log likelihood 5,742,571; [1]patient-level variables, [2]service-level variables*

Table 4.9. Summary of factors significantly associated with uptake and completion of CR by people with comorbid stroke in the UK

Summary of results		Uptake (starters/non-starters)	Completion (completers/non-completers)
Demographics			
Population with comorbid stroke (count)		23,297	24,008
Age (mean, in years)		72	70
Male/female (proportion)		67% / 33%	70.6% / 29.4%
Regression			
Valid cases selected		6,342	4,824
Patient-level factors			
Age	increasing	↓	↑
Partnership status	partnered	↑	↑
Deprivation	increasing	↓	↓
Cardiac treatment	any	↑	-
	CABG only	-	↑
Previous CVD event	any	-	↓
Comorbidities	musculoskeletal	↑	-
	ischaemia	↓	-
	metabolic	-	↓
	respiratory	↓	-
	psychosocial	↑	↓
	erectile dysfunction	↑	-
Service-level factors			
Stroke patients in programme (%)		↓	↑
Overall number of people in a service		↓	↓

Staff hours per patient	↑	-
Presence of MDT	↑	-

** ↑ increased likelihood, ↓ decreased likelihood , - not significant*

4.6 Discussion

This study used retrospective analysis of NACR data to explore the factors associated with uptake and completion of CR in the UK for people post-cardiac event who had comorbid stroke. Previous research has looked at these factors within the wider CR population but has not specifically focused on people with comorbid stroke, a group disproportionately affected by cardiac events. Within the population eligible for CR in the UK, around 50% start and 70% of those complete (NACR, 2018, NACR, 2019). This study found that the rates of uptake and completion amongst those with comorbid stroke were 44% and 71% respectively, identifying a lower rate of uptake but similar rate of completion to the wider population. This rate of completion (71%) is higher than the completion rates for stroke survivors participating in routine CR in Canadian (67%) and Irish (61%) studies (Marzolini et al., 2020, Lennon et al., 2020). However, the participants in the Canadian and Irish studies had a primary diagnosis of stroke rather than stroke as a comorbidity. The Canadian study compared stroke survivor participants' attendance at routine CR with adapted CR, and found that the rate of completion was higher for adapted CR (89.7%, 35/39), than for traditional CR (66.7%, 14/21) (Marzolini et al., 2020).

This study identified a range of patient- and service- level characteristics which were statistically significantly associated with uptake and completion of CR for people with comorbid stroke. At a patient-level, age, partnership status, deprivation, previous cardiovascular event, comorbidities, and cardiac treatment were significantly associated with uptake and/or completion of CR. At a service-level, proportion of patients with comorbid stroke, overall numbers of patients in a service, staff hours, and MDT were significantly associated with uptake and/or completion. In this discussion, these factors will be considered in the context of existing literature and current practice.

4.6.1 Patient-level factors

4.6.1.1 Age

The average age of those in the uptake analysis, 72 years, was higher than in the wider CR population, 68 years (NACR, 2021), and lower than the average age within the wider stroke population, 77 years (Healthcare Quality Improvement Partnership, 2017), suggesting that younger stroke survivors have subsequently had a cardiac event and been referred for CR.

The significant result regarding age in the regression is not surprising, given the wealth of existing evidence around the links between age and CR participation. It is very well documented that the older a person is, the less likely they are to attend CR (Ades et al., 2022, van Engen-Verheul et al., 2013). In the wider CR population in the UK, for every year increase in age there was an associated 1.2% reduced likelihood of starting CR (Al Quait and Doherty, 2017), but in the comorbid stroke population, this was more than double with a 2.5% reduced likelihood. Older adults can believe that exercise for heart health is more beneficial when younger, and as a result, decline to participate (Back 2017). Prout et al. (2015) reported that older adults who had cardiac disease were less likely to be enrolled on an aerobic exercise programme post-stroke, despite the beneficial effects of exercise following both stroke and cardiac events.

People with CVD are living longer due to medical advances and with longevity comes an increased likelihood of other chronic conditions, frailty and becoming sedentary (Forman et al., 2018). This may mean that older adults are precluded from attending CR due to the limitations of their other conditions. However, evidence indicates that exercise, which is also one component of CR, can help combat the effects of frailty and sarcopenia and improve exercise capacity and quality of life in older adults (Schopfer and Forman, 2016). Whilst attending CR reduces rates of cardiovascular mortality in the wider CR population (Doll et al., 2015, Anderson et al., 2016), age is significant in terms of predicting outcomes from CR (Al Quait and Doherty, 2016). In the UK, outcomes for older adults (>65 years) have included improved body mass index and waist size, in contrast with younger adults (≤65 years) who have achieved significant positive outcomes for cholesterol, blood pressure, duration of moderate and vigorous physical activity, and smoking cessation (Al Quait and Doherty, 2016). However, an Italian observational study involving adults aged 75 years and older attending CR, reported meaningful improvements in strength and aerobic exercise capacity, although they did not have significant disability or cognitive decline at enrolment (Baldasseroni et al., 2016).

Even though people of increasing age who had comorbid stroke were less likely to start CR, once they had started, they were also more likely to complete than those who were younger and had comorbid stroke, and therefore reap the benefits of attending. This is consistent with a study by Al Quait and Doherty (2016) who reported that older women were more likely to complete CR than younger women and Baldasseroni and colleagues' (2016) study in which all of the participants completed the programme. The average retirement age in the UK is 66 years, meaning that older adults may have more time and flexibility to attend their entire CR programme than those 65 and under who may still be in employment. As the number of people living into older age increases, so does the number living in poor health (Office for National Statistics, 2023), creating an even greater need for CR.

4.6.1.2 Partnership status

Whilst without further research it is not possible to give a definitive answer as to why older adults with comorbid stroke are less likely to start yet more likely to complete CR, literature does point to some potential reasons. It may be related to the presence or absence of support from a partner or family. In this observational study, having a partner was significantly positively associated with both uptake and completion of CR, and is also strongly evidenced in both the wider CR and stroke literature. Being single or partnered has been shown to significantly affect the uptake of CR in the wider CR population (Galdas, Harrison and Doherty, 2018, Molloy et al., 2008). Men and women are respectively up to 33% and 47% more likely to attend if they are, or have previously been, partnered (Galdas, Harrison and Doherty, 2018). A meta-analysis exploring the association between partnership status and attendance at CR showed that being partnered resulted in a 1.5 - 2 times greater likelihood of attendance (Molloy et al., 2008). Families can provide both social and practical support, for example, by providing transport and motivation, to boost attendance (Clark et al., 2012). Following a stroke, family support is frequently referred to in the literature around rehabilitation, with family often assisting with rehabilitation both practically and through encouragement (Connell et al., 2015, Luker et al., 2017). Prout et al. (2017) found that lack of support from a spouse or family impacted negatively on the uptake of aerobic exercise post-stroke. However, the number of older adults living alone is increasing, with the 2021 UK census reporting that almost 3.3 million people over the age of 70 years live by themselves (Office for National Statistics, 2023).

4.6.1.3 Deprivation

Another important factor in uptake and completion of CR is that of deprivation. Living in a deprived area had a statistically significant negative association for both uptake and completion of CR amongst those with comorbid stroke. Given that the indicators used for calculating an area's level of deprivation are income, employment, education, health, crime, living environment, and access to housing and services (Ministry of Housing Communities & Local Government, 2019), this negative association comes as no surprise. In the literature, deprivation ranking has been shown to be significant in terms of uptake of CR (Sage, 2013) with people from less deprived areas more likely to start CR (Galdas, Harrison and Doherty, 2018). People from more deprived areas have a higher likelihood of debt and poverty, of engaging in poorer health behaviours, having multiple long-term conditions, and worse access to healthcare (Williams, 2022). They can experience a greater struggle to lead healthy lives.

Higher quality CR programmes recruit higher numbers of people from socially deprived areas than lower or mid-quality programmes do (Salman and Doherty, 2019), which is noteworthy as generally with health inequalities there exists inequitable access to care, whereby people who are most in need often receive poorer quality services and therefore have more unmet needs (Williams, 2022). Higher quality CR programmes are more likely to have multidisciplinary teams, defined as having 3 or more disciplines, than lower quality ones. This will be further explored later in this discussion. Deprivation is a complex issue for which concerted collaborative efforts are being made from local to national levels to tackle and not just within the UK's health and care system (Williams, 2022). From a practical point of view, at the point of delivery of CR, clinicians should be mindful that where their patient resides may have an impact on their uptake of, and participation in, CR. Consideration of the barriers these patients may be facing around communication, transport, and timing of services may enable clinicians to offer, or signpost towards, support. This could involve appointment reminders, providing information in alternative formats to aid communication, and sharing information about locally available support for transport costs. Offering flexibility in terms of timings and format of the service may also be helpful, whether this is within the confines of current capacity or as part of service redevelopment.

4.6.1.4 Previous cardiovascular event

Although having a previous cardiovascular event was not significant for uptake of CR, it was associated with a decreased likelihood of completion in the comorbid stroke group. This is consistent with Al Quait et al's (2017) findings that patients referred for CR in the UK who had had a previous cardiac event were less likely to engage with CR (OR 0.749 p=<0.001). IA Swedish study involving people with acute myocardial infarction (n=31,297) reported that having a history of acute myocardial infarction, PCI or CABG were predictors of non-attendance at CR (Borg et al., 2019). Within the wider CR population, patient-reported reasons for not completing a CR programme in Germany and the Netherlands (n=88) have been explored, but this was not specific to people with a history of cardiovascular events (Vonk et al., 2021). The reasons behind this association between completion and past cardiovascular history warrants further exploration within the UK.

4.6.1.5 Cardiac treatment

People who had had any cardiac treatment, including PCI and CABG, were more likely to start CR, but only CABG was significantly associated with completion in the comorbid stroke population. A Dutch study (n=35,752) found that having valve surgery or CABG were positively associated with uptake of CR in patients with acute coronary syndrome, although having a PCI electively was associated with reduced uptake (van Engen-Verheul et al., 2013). Data was collected retrospectively and was based on health insurance claims which were compulsory in the Netherlands at the time of data collection. However, in Ireland, McKee et al. (2014) reported that cardiac surgery was not significant for attendance at CR following an MI. This was a smaller study (n=1,172) in which participants had been diagnosed with myocardial infarction and data collected prospectively, pre-discharge from hospital, about intention to attend CR, and then 12 months later about actual attendance. These studies indicate that cardiac treatments have variable associations with the uptake and completion of CR.

4.6.1.6 Comorbidities

The people included in this study already had at least one comorbidity, that of stroke, in addition to their cardiac event. It is widely known that the incidence of having multi-morbidities is increasing globally (Chowdhury et al., 2023, Kingston et al., 2018), and a greater prevalence of comorbidities exists amongst older adults and women (Academy of Medical Sciences, 2018). The link between stroke and coronary heart disease has been explored, with a meta-analysis reporting that one third of people post-stroke without a cardiac history had more than 50% asymptomatic coronary stenosis and a 3% risk of myocardial infarction (Gunnoo et al., 2016). However, some evidence indicates that stroke survivors have a greater risk of recurrent stroke than a myocardial infarction (Boulanger et al., 2018).

In terms of CR and comorbidities, around 77% of patients attending CR in the UK in 2020 had comorbidities (NACR, 2020). Dutch and Canadian studies reported that comorbidities were associated with lower rates of uptake of CR, and in the UK a high proportion of those who did not start or did not complete CR in 2019 had 2 or more comorbidities (NACR, 2020, van Engen-Verheul et al., 2013, Grace et al., 2009). In this study involving those with comorbid stroke the significant associations varied, depending on the type of comorbidity. Having a comorbidity in the musculoskeletal, psychosocial, or erectile dysfunction groups increased the likelihood of uptake, whereas ischaemic and respiratory comorbidities reduced the likelihood, and metabolic comorbidities were not significant. Contrastingly, for completion, having a comorbidity in the metabolic or psychosocial groups was associated with a reduced likelihood, and none of the comorbidity groups increased likelihood of completion. Again, within the CR literature, different comorbidities have different associations with uptake or completion. In the PCI population, Al Quait and Doherty (2017) found that diabetes, a metabolic comorbidity, was associated with a reduced uptake of CR, which was consistent with a 2018 study which included MI, PCI, MI or PCI, and CABG populations (Harrison, Doherty and Phillips, 2018). However, the findings regarding musculoskeletal and psychosocial comorbidities increasing the likelihood of uptake in those with comorbid stroke differ from those of van Engen-Verheul et al. (2013) who reported that all comorbidities recorded for participants, which included diabetes, psychiatric disease, musculoskeletal conditions, and respiratory diseases, reduced the uptake of CR amongst those who had had a coronary intervention. In Canada, diabetes was associated with reduced completion of CR (Armstrong 2015), which aligns with the comorbid stroke study finding, but the authors of an American study, which investigated adherence to CR, reported that comorbidities were not influencing factors (Turk-Adawi et al., 2013). There is clearly some conflicting evidence within the wider CR literature about the influence of comorbidities on uptake and completion.

Comorbidities have also been considered within the CR after stroke literature. Regan et al. (2021b) identified high blood pressure, diabetes, CVD, and arthritis as amongst the most common comorbidities for participants in their American study integrating stroke survivors into CR. A Canadian study on CR after stroke reported hypertension and musculoskeletal issues such as arthritis as the most frequent comorbidities amongst participants (Marzolini et al., 2020).

4.6.2 Non-significant variables

There were several patient-level variables which are evidenced in the CR literature but, surprisingly, were not statistically significant in this study. These included gender, ethnicity, and hospital length of stay and are described below.

4.6.2.1 Gender

The ratio of males to females, 67% to 33%, in the included population was comparable with the wider CR population (NACR, 2019), but quite different to that of the wider stroke population which had approximately 51% male to 49% female from 2007 to 2016 (Public Health England, 2018a). This lower rate of participation in CR by women is well documented. Research over the last 20 years has shown that women globally are more likely to underutilise CR (McCarthy, Dickson and Chyun, 2011, Halm et al., 1999, Supervía et al., 2017, Galati et al., 2018, van Engen-Verheul et al., 2013), and are even underrepresented within randomized controlled trials for exercise-based CR (Anderson et al., 2016). They are less likely to be referred to outpatient CR in comparison with men (Colella et al., 2015) and less likely to be enrolled in CR than men (Samayoa et al., 2014). This is despite the fact that in the UK alone around 830,000 women have CHD, and one in 14 die from it (British Heart Foundation, 2018). In 2015, the NACR reported that of the 47% of women eligible for CR following MI, the actual proportion who started was around 35% (NACR, 2015), which had not improved by 2019, with an attendance rate of 15 – 38% (NACR, 2019). Furthermore, women are less likely to adhere to CR sessions in comparison with men, particularly if the CR programme is longer than 12 weeks or comprises less than 3 sessions per week (Oosenbrug et al., 2016). However, a 2019 Swedish study reported a positive association between females and CR attendance (Borg 2019), so factors such as context, culture or country of residence may be important. Interestingly, however, the regression analyses for the comorbid stroke study showed that gender was not statistically significant for uptake or completion for those with comorbid stroke. This was unanticipated given the link between gender and age within the wider CR literature, particularly as age was identified in the regression analyses as being significantly associated with both outcomes. However, in the stroke literature, stroke incidence in the UK is higher in men than women (Peters 2020).

4.6.2.2 Ethnicity

Ethnicity was not significant in the regression analysis for either uptake or completion in this study. This may have been due to including minority ethnic as a whole group, rather than individual groups, thereby masking any association between one specific group and the outcome measures. Previous literature has identified differences in minority ethnic groups' associations with CR participation (Reges et al., 2014). Unfortunately, this was unavoidable due to small numbers within these individual minority ethnic groups. However, in the wider literature, ethnicity has been linked with lack of engagement or participation in CR (Reges et al., 2014, Mochari et al., 2006, Galdas, Harrison and Doherty, 2018, Mead, Ramos and Grantham, 2016), but challenges exist around accurate investigation of factors driving this due to lack of accurate data recording on CR and minority ethnic groups. For example, in 2005, authors of a UK study reported they were unable to reliably estimate the proportions of patients from ethnic minorities who were referred, attended, and completed their programme as the numbers were so small, despite 34% of CR programmes actively promoting attendance in ethnic minority groups at the time (Rees et al., 2005). A 2018 study exploring factors influencing likelihood of engagement with CR found that, in comparison with the white group, people of all other ethnic groups, apart from the Black ethnic group, were up to 31% less likely to engage with CR (Galdas, Harrison and Doherty, 2018). Reduced uptake amongst ethnic minority groups may be due to the existing knowledge of heart disease, communication and transport difficulties (Chauhan et al., 2010).

4.6.2.3 Length of stay

The duration of a person's stay in hospital following their event has been shown in CR literature to be associated with their attendance at initial assessment for CR (Soo Hoo, Gallagher and Elliott, 2016). However, length of stay was not significantly associated with either uptake or completion for people with comorbid stroke. Again, although the source of referral to CR was significant in the descriptive analysis, it was not statistically significant in either of the regression analyses.

4.6.3 Service-level factors

There were four service-level variables associated with the study outcomes: proportion of patients with comorbid stroke in a service, overall number of patients in a service, staff hours and presence of a multidisciplinary team.

4.6.3.1 Proportion of patients with comorbid stroke in a service

The proportion of patients with comorbid stroke attending a programme was associated with a decreased likelihood of uptake of CR, yet increased likelihood of completing. Whilst further research would be required to establish the reasons for this, there is a possibility that staff-to-patient ratios may influence whether someone is offered a place on a CR programme. The ACPICR (2023) standards specify that there should be at least one appropriately qualified exercise professional present at an exercise session, and for early CR a minimum staff-to-patient ratio of 1:5 for health and safety reasons. The standards also stipulate that ratios should be adjusted depending on how early post-cardiac event the rehabilitation is taking place, the risk stratification, and degree to which the patient requires specialist support for any physical or cognitive disabilities. These ratios may then change as the patient progresses throughout their programme of CR depending on their needs. Patients with comorbid stroke may have resulting physical or cognitive issues meaning they require more support from staff during CR. Therefore, due to staff-to-patient ratios, the programme may only have capacity for a particular number of patients with these needs at any given time meaning they are unable to enrol all patients with comorbid stroke who have been referred. A Canadian study which enrolled stroke survivors onto either a traditional CR programme or CR-adapted programme used different staff-to-patient ratios of 1:12 to 1:8 and 1:5 respectively (Marzolini et al., 2020), which illustrates the potential need for a lower ratio for patients with comorbid stroke. Howes, Mahenderan and Freene (2020) reported limited staff-to-patient ratio as one of the barriers to stroke survivors attending CR in Australia. In Chapter 3, staff expressed concerns around patients' physical and cognitive abilities, and a perceived need for greater levels of supervision and adapted equipment to maintain patient safety when undertaking aerobic exercise. Furthermore, in a UK study involving adapted CR after stroke, CR staff identified a need for support with exercise delivery from a specialist stroke physiotherapist (Clague-Baker et al., 2024). However, current challenges exist around workforce capacity within the NHS, including with CR services which have reported ongoing challenges around staff recruitment and retention (NACR, 2023), so increasing staff-to-patient ratios is difficult.

Although the proportion of people with comorbid stroke in a service reduced likelihood of uptake by those with comorbid stroke, it increased the likelihood of completion. Again, further research would be needed to identify why this is the case, but a lesser likelihood of uptake could be related to selection bias, perhaps as only those with mild stroke-related impairments have been invited to CR as they require minimal or no additional supervision or adaptation of exercise compared to those with moderate or severe stroke. Toma et al. (2020) reported that stroke survivors excluded from Canadian CR programmes had more severe mobility, cognitive and impairments. It has been suggested that those with milder stroke could participate in routine CR (Howes, Mahenderan and Freene, 2020), so the positive association with completion may be due to stroke survivors' abilities to participate in the routine CR programme or to the staffs' skills in adapting the programme to suit the patient and provide the required support. Within CR, teams delivering the rehabilitation often adapt programme elements to suit individual patients and their comorbidities, as per the ACPICR standards (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). The BACPR (2023) standards advocate a patient-focussed approach, taking any comorbidities, physical or psychosocial needs into consideration when developing an individual treatment plan. This may mean that once the hurdles of starting on a CR programme have been overcome, staff are adept at facilitating these patients to complete.

Indicators of physical ability in the comorbid stroke population, including the 6-minute walk test and incremental shuttle walk test which are recorded in the NACR, were not included in the analysis due to the risk of bias created by the level of missing data. Levels of mobility post-stroke have been used in a Canadian guide to determining criteria for referral of stroke survivors to CR which include ratio of staff-to-patient, class size, equipment, and carer support (Marzolini, 2020). Also, stroke severity and cognition are not recorded in the NACR so the extent to which physical and cognitive abilities influenced participation in CR in this group of stroke survivors is unknown. Staff participating in Lennon et al. (2020) study of CR after stroke attributed the lower rate of uptake and completion of CR by stroke survivors to a perceived impaired cognitive ability. Certain patient characteristics may have influenced rates of completion in the comorbid stroke study, with the main reason cited for patients with comorbid stroke not completing CR, after 'DNA/Unknown'' and 'Other', was that patients were 'too ill' (19.7%). This was a higher proportion than for those without comorbid stroke (13.5%), which together with a twofold higher death rate (3.1% versus 1.6%) and higher hospital readmission ratio of 3:2, (3.1% versus 1.9%), suggests that this group's health conditions may have a greater impact on their attendance at CR.

4.6.3.2 Overall number of patients in a service

The overall number of patients in a service was associated with reduced likelihood of uptake and completion by those with comorbid stroke. Larger numbers of CR patients could potentially limit programmes' capacity for providing extra support to this group in terms of staff-to-patient ratios, particularly considering that the wider CR population can also have varying needs due to their cardiac conditions and other comorbidities, such as diabetes or musculoskeletal requiring more support (Salman and Doherty, 2019, NACR, 2019) . There is a possibility that lack of capacity within CR services is contributing to inequity of access for people with comorbid stroke. Concerns around safety for stroke patients taking part in CR, and in aerobic exercise generally, have been reported by CR coordinators in Australia (n=80) (Howes, Mahenderan and Freene, 2020). Amongst the reasons recorded in the NACR for people not starting CR, 'Physical incapacity' was cited for 18.4% of those with comorbid stroke versus 9.5% of those without, and 'Rehabilitation not appropriate' cited for 9.5% of those with comorbid stroke versus 6.6% of those without. These may indicate that people who had mild or moderate stroke were more likely to start CR, potentially meaning there is less provision for those with more severe stroke. Service capacity and inclusiveness have been reported as factors which influence equity of access to community exercise after stroke programmes in Scotland (Best et al., 2012). Also, within CR it has been evidenced that a larger throughput of patients is not associated with improved patient outcomes (Doherty et al., 2015), but that programme quality is associated with the proportion of patients with comorbidities who are taking part in a CR programme (Salman and Doherty, 2019). Salman and Doherty (2019) found that higher quality CR programmes took on more patients with comorbidities, with a higher proportion of patients with comorbid stroke in high quality programmes (3.79%) compared to low (2.07%).

4.6.3.3 Staff hours and multidisciplinary team

It had been anticipated that staffing would have an impact on uptake and completion of CR in this study due to previous evidence in the wider CR literature (Salman and Doherty, 2019). Both staff hours and presence of a MDT were positively associated with uptake of CR, but neither were significantly associated with completion. In the comorbid stroke study, when the relative size of the CR programme was considered, every hour increase in staff time was linked with a 1.9% increase in likelihood of uptake. These unique findings show that programmes which are well-resourced in terms of staffing are more likely to successfully engage people with comorbid stroke in CR. The issue of staffing has been cited within the CR after stroke literature (Marzolini, 2020, Howes, Mahenderan and Freene, 2020) and is further supported by a finding in the systematic review in Chapter 3 which identified staffing as a factor in the implementation of aerobic exercise after stroke.

It has been reported in the UK that 85.4% of higher quality programmes had a multidisciplinary team comprising three or more disciplines, as recommended in the NCP_CR (BACPR and NACR, 2022), in comparison with 63% of low quality programmes (Salman and Doherty, 2019). This is consistent with the findings for the comorbid stroke group, where presence of a MDT was associated with a 63.8% increased likelihood of uptake. Limited staffing, whether in terms of hours or number and type of discipline, contributes to inequity within the provision of CR for people with comorbid stroke.

4.6.4 Wider discussion

The patient-level factors identified in this study are either non-modifiable, such as age or partnership status, or very challenging to modify, such as deprivation or comorbidities. Some of the latter could be addressed via national government policies and public health strategies, and others by adapting the intervention to improve equity. Adaptation should be informed by local population health information, and co-designed with experts by experience, to ensure that inequalities are not inadvertently widened. For example, accessibility could be improved by providing transport, an interpreter, female-only classes, or alternative times for CR classes, such as evenings, depending on local needs.

The service-level factors identified in this study illustrate the impact of resources and capacity on CR delivery for those with comorbid stroke. Given the current constraints on resources and capacity within healthcare services, alternative modes of delivery of exercise for stroke survivors should be, and are being, considered. Within the UK stroke guidelines (2023), collaboration with other exercise-based services, including CR, are recommended for the purposes of sharing skills and resources. As mentioned previously, CR continues to be investigated as a delivery model for exercise after stroke and TIA, both in the UK and elsewhere, and from a feasibility perspective, this approach is promising (Clague-Baker, 2020, Regan et al., 2021a, Kirk et al., 2014, Marzolini et al., 2016b). Stroke survivors have reported many benefits to participation in standard CR, including peer and professional support, and feelings of safety (Regan et al., 2021a, Clague-Baker, 2020). Referral eligibility criteria for CR guided by level of mobility post-stroke recommends that some stroke survivors with mild mobility deficits may be able to join existing CR programmes without the need to adapt exercise modalities or extra supervision (Marzolini, 2020). However, this guidance does not account for other deficits such as cognitive and neurological deficits which may affect participation and are a concern for CR staff (Howes, Mahenderan and Freene, 2020). Adapted CR is acceptable to people with mild stroke (Clague-Baker et al., 2022), and in Canada, Marzolini et al. (2020) found that patients enrolled onto a stroke-adapted CR programme had a higher rate of uptake (87.1%) and completion (89.7%) than those enrolled on a traditional programme (66.1% and 66.7% respectively). However, CR services in the UK already face challenges around staffing and rates of uptake within the wider CR population (NACR, 2023) and UK national standards do not specify that those with a primary diagnosis of stroke are eligible for CR in the UK. Furthermore, the increasing rate of multimorbidity across the world and need for rehabilitation has led to research around multimorbidity care and rehabilitation (Forman et al., 2018, Chowdhury et al., 2023, Barker et al., 2018). Both the World Health Organisation (WHO, 2016) and UK's Chief Medical Officer (Whitty, 2023) have called for the maintenance of generalist skills amongst medics and primary care, with encouragement to move away from single-condition, siloed working in order to provide patient-focussed care and rehabilitation for people with multi-morbidities. The PERFORM trial is an example of ongoing collaborative research around exercise-based rehabilitation for people with multiple conditions (National Institute for Health and Care Research, 2022).

4.6.5 Strengths and limitations

This study had a number of strengths and limitations which are described below.
The logistic regression model was a good fit. However, it only correctly predicted 60% and the Nagelkerke R Square was less than 0.2, which indicates that the model may be improved by adding more variables. Other variables were considered for inclusion in the analysis, but there were known predictors in the dataset which didn't meet the threshold for inclusion without creating too much bias or restricting generalisability, and other predictors identified in the literature which are not collected by the NACR. Examples of variables of interest that are collected by the NACR included the six-minute walk test and shuttle walk test, but these had restrictively high or unique levels of missing data in the population of interest so were excluded. Furthermore, the NACR database is not stroke-specific, meaning there are predictors that have been identified in the literature as important for rehabilitation, but are not recorded in the NACR. For example, McGlinchey et al. (2019) analysed data from the UK SSNAP and reported that lower stroke severity was linked with a higher intensity of rehabilitation during inpatient rehabilitation, but stroke severity is not recorded in the NACR. Other predictors which are not collected by the NACR but could influence stroke survivors' engagement with CR include time since stroke, cognitive ability, incontinence, education, transport, and the equipment available to CR services. Support from family or carers has been identified as important for participation and rehabilitation. However, the closest variable to this in the NACR was 'partnership status', which gave an indication, but not a definitive answer, about their support network. One of the limitations of analysing secondary data is the researcher's lack of autonomy over the questions being asked and data that is collected.

A strength of this study was the large primary dataset from which data was selected. Using routinely collected data was an economical, convenient, and time-saving method of identifying the associations with uptake and completion of CR. Furthermore, as the population of interest had at least one comorbidity, real-world data was an appropriate source. However, only 5% of the total CR population had comorbid stroke, which was only a fraction of the full yearly sample size of >60,000 patients receiving CR in the UK. The total number of cases n=11,176 (Analysis 1=6,342 and Analysis 2=4,834) included in the study analyses was still large (NACR, 2020).

The data selected for this study was from before the COVID-19 pandemic, and, as a result, the relevance of these study findings could be questioned. However, services pre-COVID-19 were quite different to services during and post-COVID-19. Data entry to the NACR was impacted during the pandemic due to the widespread disruption to NHS services, including CR (NACR, 2020). Changes to CR programme delivery have included a continued move towards home-based and hybrid modes, with 50% of patients participating in a home-based programme in 2023 compared with just 9% in 2019 (NACR, 2019, NACR, 2023). The rate of use of hybrid services, a combination of group and home-based CR, has also increased from 14% in 2022 to 23% in 2023 (NACR, 2022a, NACR, 2023), and there are ongoing challenges around recruitment and retention of staff within CR services (NACR, 2023). For these reasons, the decision was made not to extend data selection beyond November 2019 due to the risk of introducing bias. Future research could investigate the factors in the time period since COVID-19, and then compare with the findings from before COVID-19.

4.7 Implications for research and practice

The insight provided by these findings may give clinicians a better understanding of what influences people with comorbid stroke to start or complete CR. Clinicians who are mindful of referrals for people with comorbid stroke, and the influence factors such as age, deprivation, partnership status, and comorbidities have on their likelihood of engagement, could use this knowledge to facilitate uptake and completion amongst this group. However, some CR staff have identified a limited knowledge of the physical and cognitive effects of stroke (Clague-Baker et al., 2024), which is important given specific considerations, such as reduced functional capacity and fatigue, that could affect exercise testing and prescription post-stroke (Liguori, 2020, Clague-Baker et al., 2024). Furthermore, an Australian survey of CR coordinators reported that one of the perceived barriers to including stroke survivors in CR was a lack of experience of working with them (Howes, Mahenderan and Freene, 2020).

A lack of knowledge, which was also a factor identified in the staff perspectives study in relation to aerobic exercise prescription, is a modifiable factor which could be addressed through training and education, and support from stroke rehabilitation staff (Clague-Baker et al., 2022, Regan et al., 2021a).

This observational study has highlighted the importance of patients' needs in relation to their uptake and completion of CR. The finding around deprivation emphasises that health inequalities need to be considered, and a focus on health equity integrated into implementation strategies and pathways of care (Brownson et al., 2021). Although there is much discussion around patient need and patient choice, services are often quite rigid in what they offer, and people who do not have sufficient social or economic resources to enable them to attend CR, simply cannot participate. Alternative formats of CR delivery, based on local population needs, should be explored to ensure modes of delivery are acceptable and tailored for those groups. Changes within CR in the UK have already been implemented, accelerated by the effects of the COVID-19 pandemic, with a reported increase in home-based and hybrid delivery models (NACR, 2023). These alternative formats of CR delivery may enable a greater number of those to attend and complete CR by eliminating the need for transport (Ades 2022), made possible by increased access to healthcare via technology. However, care must be taken not to widen inequalities in relation to the digital divide, and some people will still benefit most from centre-based CR. Specifically in relation to stroke survivors attending CR, some literature suggests that those with mild stroke or TIA may be able to participate in CR without a need to increase staff-to-patient ratios (Howes, Mahenderan and Freene, 2020). However, this would depend on national recommendations around ratios, which is currently 1:5 for early CR in the UK (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). The importance of the service-level factors found in this study, including resources such as staffing and multidisciplinary teams, should be raised with policy-makers and commissioners.

Adapted CR for stroke has been proven as a feasible intervention (Clague-Baker et al., 2022, Regan et al., 2021a). However, further research needs to be conducted around how to successfully and sustainably implement this into routine practice in the UK, particularly in the current challenging economic climate. This could include the development and evaluation of training for CR staff around delivering CR to stroke survivors, and for stroke rehabilitation staff to support CR delivery. It will be important to involve patients, carers, and the public in any research conducted, to ensure it is relevant to service users, and developed in response to local needs, resulting in services designed with stroke survivor care centremost.

4.8 Patient, carer, and public involvement

PCPI was not conducted by the author in relation to this observational study specifically. However, the Cardiovascular Care Partnership UK (CCP UK), which represents those affected by CVD, has a regular presence on the NACR Steering committee (NACR, 2023). They contribute to the direction taken by the audit, as well as its focus on service improvement to ensure relevancy to patients and carers.

4.9 Conclusion

This observational study provides the first UK-specific insight into the factors associated with the uptake and completion of CR by stroke survivors. Data analysis from the NACR showed that some people with comorbid stroke have been able to access prescribed exercise where they have been eligible for CR due to a cardiac event. CR programmes need to be aware of these factors and make every effort to tailor the offer of CR for patients, particularly given the BACPR's emphasis on a patient-focussed approach to CR delivery. A number of the patient-level findings were consistent with those of the wider CR literature, which suggests a need to explore different models of service delivery to cater for an increasingly diverse population. Although the service-level findings were specific to this comorbid stroke population, further research could explore uptake and completion factors and the reasons for these amongst those with other comorbidities for comparison. These findings, together with the wider literature, could then be used to inform appropriate service redesign to increase overall rates of uptake and completion of CR.

4.10 Chapter summary

This chapter has described the retrospective observational study conducted to address the Thesis Objective 2, which was to explore the factors associated with the uptake and completion of CR by people with comorbid stroke in the UK. Patient-level factors associated with uptake and completion included age, partnership status, deprivation, previous cardiovascular event, comorbidities, and cardiac treatment. Service-level factors identified as being associated with uptake and completion were the proportion of patients with comorbid stroke in a service, the overall number of patients in a service, staff hours, and presence of a multidisciplinary team. The next chapter will describe the study conducted around stroke survivor views of aerobic exercise.

CHAPTER 5 STROKE SURVIVOR PERSPECTIVES OF AEROBIC EXERCISE: AN ONLINE SURVEY

5.1 Chapter overview

Staff and system perspectives were explored in Chapters 3 and 4, so Chapter 5 focuses on stroke survivors' perspectives of aerobic exercise in the UK to address **Thesis Objective 3**. The background, objectives, and methods for **Study 3** are described, followed by the findings and discussion of the results within the context of the literature. A section on the patient and public involvement in this study is provided before the conclusion is reached.

5.1.1 Original contribution to knowledge

Previous studies have been published on stroke survivor perspectives of physical activity and fitness training in the UK (Dam and Rhind, 2020, Jackson, Mercer and Singer, 2018, Morris et al., 2017, Nicholson et al., 2014, Poltawski et al., 2015). However, to the best of the author's knowledge, this was the first study to identify stroke survivors' perspectives of aerobic exercise after stroke in the UK. This findings from this chapter were presented at the European Life After Stroke Forum in 2024 as a poster entitled, '*UK stroke survivors' perspectives of aerobic exercise: an online survey'*.

5.2 Introduction

Stroke survivors' perspectives are an integral aspect of addressing the implementation challenges around aerobic exercise after stroke. The James Lind Alliance (JLA) Priority Setting Partnership is example of how greater importance is now being placed on collaborative working between patients, carers, clinicians, and researchers to prioritise research which is both relevant and beneficial (JLA, 2024). As part of the Stroke Priority Setting Partnership project in 2021, exploration of the best interventions for improving strength and fitness to aid recovery and prevention of further stroke was identified by the stroke community as one of the top 10 priorities for further research in stroke rehabilitation and long-term care (Hill et al., 2022). This provides an indication of the level of importance with which stroke survivors view cardiorespiratory fitness and secondary stroke prevention.

5.2.1 Physical activity and aerobic exercise after stroke

The UK Stroke Clinical Guideline (2023) recommend physical activity and aerobic exercise as part of risk factor management to improve fitness following stroke and transient ischaemic attack. To reiterate, as described previously in Chapter 1, physical activity is any movement of the body using skeletal muscle which involves expending energy (WHO, 2023). Exercise is a type of physical activity which improves physical fitness (Caspersen, Powell and Christenson, 1985). Cardiorespiratory endurance is a component of physical fitness (Liguori, 2020), whilst cardiorespiratory fitness refers to the circulatory and respiratory systems' abilities to transport and use oxygen for physical work (Ross et al., 2016). Cardiorespiratory fitness can be improved by undertaking aerobic exercise such as swimming, dancing or walking (Liguori, 2020). Aerobic exercise has a range of benefits post-stroke including improved ability to carry out daily activities, increased walking endurance and speed, as well as secondary prevention (Billinger et al., 2014, Saunders et al., 2020, D'Isabella et al., 2017).

To date, most research has focussed on the effects and benefits, and modes of delivery, of physical activity, aerobic exercise, group exercise, and CR after stroke (Saunders, Greig and Mead, 2014, Sammut et al., 2020, D'Isabella et al., 2017, Marsden et al., 2017, Saunders et al., 2020, Valkenborghs et al., 2019, Regan et al., 2021b), with less reported on stroke survivors' views of these interventions. Furthermore, some confusion still exists around the definition of 'aerobic exercise'. The terms 'physical activity', 'exercise', 'cardiorespiratory fitness', and 'aerobic exercise' are often used interchangeably within the spheres of research, public health messaging and the media, even though they are different concepts (Caspersen, Powell and Christenson, 1985). For example, the 2019 UK Chief Medical Officers' physical activity guidelines include moderate, vigorous, and very vigorous intensity 'cardiovascular activity' as part of 'physical activity' (Department of Health & Social Care, 2019), whereas the WHO advises 'aerobic physical activity' of moderate or vigorous intensity to improve 'cardiorespiratory fitness' (Bull et al., 2020). The discussion with the UK stroke support group in 2018 (see section 3.10) and previous literature (Simpson et al., 2011) supports this lack of awareness and knowledge amongst stroke survivors around aerobic exercise and its benefits.

5.2.2 Importance of seeking stroke survivor perspectives

Aerobic exercise cannot be implemented successfully without input from service users themselves, not least because their experiences and perceptions of exercise are not always positive. Stroke survivors have reported feeling frustrated when unable to achieve the benefits they expected from exercise due to skills they had lost as a result of their stroke (Morris et al., 2017), whilst others believed it was important to accept their limitations to then proceed positively (Poltawski et al., 2015). Having the motivation to engage with an intervention in relation to health is a significant characteristic within the health belief model (Becker and Maiman, 1975). This motivation could be influenced by perceived capability or self-efficacy to participate, which may, in turn, be determined by the perceived barriers and/or facilitators to engagement in aerobic exercise (Sheeran et al., 2016). Engagement with a particular health behaviour or intervention is influenced by a person's motivation in relation to their health, their knowledge about the efficacy of the intervention, whether the perceived benefits to uptake outweigh the perceived barriers, and the person's self-efficacy in carrying out the intervention (Becker and Maiman, 1975, Carpenter, 2010, Sheeran et al., 2016). Although having knowledge of the health benefits of an intervention can elicit motivation to participate (Becker and Maiman, 1975, Carpenter, 2010), knowledge alone does not drive behaviour change. Motivation and capability are two of the three essential conditions, or factors, which can change behaviour according to a behaviour change framework called the COM-B model (Capability, Opportunity, Motivation – Behaviour) (Michie, van Stralen and West, 2011). The third factor, opportunity, includes physical, environmental, and social opportunities, and is an external factor, in contrast to motivation and capability which are internal factors (Michie, van Stralen and West, 2011, Michie, Atkins and West, 2014). Capability and opportunity can each influence a person's motivation, and making a change to just one of these three factors can change their behaviour.

Stroke survivors' perspectives of aerobic exercise can inform and improve the design and implementation of this intervention, which in turn can increase their engagement with it (Norris et al., 2013). This is especially important given the long-term adherence to exercise required as part of lifestyle changes to reduce the risk of recurrent stroke (Intercollegiate Stroke Working Party, 2023). However, limited evidence is available regarding stroke survivors' perspectives of aerobic exercise, particularly in the UK, where studies have focussed on perspectives of community-based group exercise, the barriers and motivators to physical activity, and participation in exercise programmes (Nicholson et al., 2013, Nicholson et al., 2017, Nicholson et al., 2014, Jackson, Mercer and Singer, 2018, Morris et al., 2017, Dam and Rhind, 2020, Poltawski et al., 2015, Norris et al., 2013). Furthermore, stroke survivors may have differing views on aerobic exercise to those of health professionals and service providers with some examples of these in the literature. For example, in Canada, clinicians' perceived barriers to the use of aerobic exercise in neurorehabilitation included a lack of motivation to exercise, and fitness not being a rehabilitation goal for patients (Doyle and MacKay-Lyons, 2013). Contrastingly, in another Canadian study, patients seldom mentioned lack of motivation, but did cite lack of encouragement by family members as a barrier to aerobic exercise (Prout et al., 2017). These studies highlight the importance of establishing what stroke survivor views of aerobic exercise are, as this will facilitate tailored, appropriate, and effective provision of aerobic exercise. Due to the interchangeable use of the terms physical activity and exercise, and the growing body of evidence around CR after stroke (Lennon et al., 2020, Marzolini et al., 2023, Regan et al., 2021b, Howes, Mahenderan and Freene, 2020, Clague-Baker et al., 2022), the literature around stroke survivors' perspectives of physical activity and exercise, participation in exercise after stroke programmes, and CR was explored as background for this study.

5.2.3 Perspectives of physical activity and exercise

Perspectives including the perceived barriers and motivators to participation in physical activity have been reported both internationally and within the UK (Jackson, Mercer and Singer, 2018, Morris et al., 2017, Nicholson et al., 2017, Nicholson et al., 2013, Simpson et al., 2011). The three UK studies consisted of one survey of community-dwelling stroke survivors (n=76) conducted by Jackson, Mercer and Singer (2018), and two qualitative interview studies with stroke survivors by Morris et al. (2017) and Nicholson et al. (2014), n=38 and n=13 respectively. These identified a range of factors influencing stroke survivors' participation which included fear of falling, the physical effects of stroke, social support, transport, and inclement weather (Jackson, Mercer and Singer, 2018, Morris et al., 2017, Nicholson et al., 2014). Two of these UK studies also reported that beliefs about the benefits of physical activity and exercise, and participants' confidence and capabilities to undertake physical activity, facilitated their engagement (Nicholson et al., 2014, Morris et al., 2017).

However, the majority of participants in the three UK studies were older, aged 60 to 80 years (Morris et al., 2017) or with a mean age of 75 and 76 years respectively (Jackson, Mercer and Singer, 2018, Nicholson et al., 2014), meaning the perspectives of younger stroke survivors were not well-represented. Morris et al (2017) did not specify participant level of mobility, but participants were sampled to include a range of physical disabilities, whereas most participants in the other two studies were ambulatory. Again, this is generally reflective of the literature around exercise after stroke, where most participants have experienced a mild stroke or TIA. From a participant diversity perspective, ethnicity was only reported in one study, where 85% (n=65) of participants were white British (Jackson, Mercer and Singer, 2018).

In Canada, a qualitative study investigated stroke survivors' (n=11) knowledge and beliefs around physical activity and exercise, and also explored the barriers and facilitators to participation (Simpson et al., 2011). The authors acknowledged that although the two terms, 'PA' and 'exercise', are used interchangeably, they do have different meanings. Half of the focus group participants believed that physical activity and exercise were one and the same, with the other half initially identifying them as different, but then later becoming less sure of the distinction between the two concepts (Simpson et al., 2011). The factors these stroke survivors reported as influencing engagement with physical activity and exercise included self-efficacy, external support to exercise and the benefit of improving mobility and balance, with just one person citing secondary prevention as a reason to exercise. A lack of awareness amongst participants regarding the link between exercise and risk of further stroke was also identified.

5.2.4 Exercise after stroke programmes

UK studies around exercise were generally limited to perspectives on participation in exercise programmes and were conducted before the COVID-19 pandemic began in 2020. The factors influencing participation broadly fall into the categories of beliefs about physical capabilities, social support, and environmental factors. Two qualitative studies conducted in the UK investigated the factors perceived by stroke survivors to influence their participation in exercise programmes (Norris et al., 2013, Poltawski et al., 2015). The study by Norris et al. (2013) sought stroke survivors' views (n=22) about participation in an existing 12-week community-based exercise programme, which incidentally was the exercise training approach on which the intervention for the other UK study was based (Poltawski et al., 2015). Poltawski et al. (2015) synthesised findings from two studies, a focus group consultation and feasibility study, around the motivational factors perceived by stroke survivors (n=17) to influence their participation in one 12-week stroke-specific exercise programme and in exercise in general. The number of participants (n=22 and n=17) and time since stroke was similar in both studies, 0.5 – 15 years and 1.2 – 16 years respectively, with participants having a wide range of disability levels. The mean ages of 62 and 67 years were younger than in the studies around physical activity, and there were more males than females in both. In contrast with the feasibility study design used by Poltawski et al. (2015), Norris et al. (2013) used an evaluative design and collected data over a period of 16 months, during which time four groups completed the exercise programme. Despite the slight differences in focus and design of each study, the findings were broadly similar. The identified themes, that influenced participation in exercise programmes, included improvements in mood and confidence, physical improvements, and the importance of social and peer support in terms of helping to maintain the motivation to exercise. Access to exercise in community- or home-based settings away from healthcare facilities was indicated as important for engagement.

5.2.5 Aerobic exercise

Most of the research around stroke survivors' perspectives of aerobic exercise was conducted in Canada and Brazil. A Canadian study investigated the perspectives of 32 people diagnosed with acute stroke on the inclusion of aerobic exercise during inpatient rehabilitation (Prout et al., 2017). Participants were no longer than 3 months post-stroke, and were recruited from three rehabilitation centres, one of which offered group aerobic exercise. Again, similar to the UK studies on exercise in this population, there were more males than females, and the average age was 68 years. One considerable difference was that participants were an average of just 12.6 days post-stroke and still hospital inpatients when they took part in the survey which offered a different perspective to the other studies. The inclusion criteria stipulated that they needed to be able to transfer with assistance from one person or less, and sit independently, but participants' levels of mobility were not expressly described. The results of the survey showed that almost all (97%) patients agreed that aerobic exercise was beneficial to recovery after stroke and contributed to a healthy heart, with 91% agreeing that it is an essential part of inpatient rehabilitation, highlighting the importance these stroke survivors attached to aerobic exercise. The main barriers to participation were lack of family support, inability to follow instructions, other health problems and fear of falling, indicating lots of similarities in the factors influencing participation with aerobic exercise for people in the acute and chronic stages of stroke.

In Brazil, two studies were conducted more recently around exercise after stroke (Débora Pacheco et al., 2019, Aguiar et al., 2022). The first, in 2019, explored the barriers to exercise perceived by the 95 participants who were in the sub-acute stage following stroke using an exploratory study design (Débora Pacheco et al., 2019). This reported that fatigue, accessibility of an exercise venue, lack of knowledge on how to exercise, and lack of support to exercise were the main perceived barriers to exercise amongst stroke survivors in the community (Débora Pacheco et al., 2019). The other Brazilian study, conducted in 2022 with 15 people with chronic stroke who had participated in 12 weeks of aerobic treadmill training, used a cross-sectional study design to investigate participants' perspectives and perceived barriers in the context of a developing country (Aguiar et al., 2022). Certain findings in this study, including a lack of peer and other support, and lack of knowledge on how to exercise, were similar to those of Débora Pacheco et al. (2019). However, they also identified fear of falling, physical and cognitive impairments, and lack of equipment as main barriers to participation.

5.2.6 Cardiac rehabilitation after stroke

Regarding CR after stroke, an American study investigated stroke survivor views of participation in routine CR (n=12), and a Canadian study explored the perceived barriers to attendance at an adapted CR programme by stroke survivors (n=61) (Regan et al., 2021a, Marzolini et al., 2016a). Regan et al. (2021a) interviewed 12 ambulatory stroke survivors, 11 of whom had, and one who had not, completed a 12-week routine CR programme. Participants in the study by Marzolini et al. (2016a) completed a questionnaire following attendance at an adapted CR programme of 6 months duration. Similar to the factors that influenced participation in physical activity and exercise, these studies reported that additional health problems, financial and transport issues, and lack of interest in exercise were barriers to participation. The perceived benefits of exercise and support from family, peers or CR staff were identified as facilitators in the study conducted by Regan et al. (2021a), whereas severe weather was the most common barrier in the study by Marzolini et al. (2016a) and, for non-English speaking participants, lack of social support and family responsibilities were also barriers.

5.2.7 Summary

Within the existing global literature, the factors perceived by stroke survivors as influencing their engagement with physical activity, community-based exercise, and CR are broadly similar and include social support, cognitive and physical impairments, lack of knowledge, and transport issues. However, stroke survivors' perspectives specifically of aerobic exercise are not known to have been investigated in the UK, and their views could differ to those outside the UK. Their perspectives are essential to the development of effective engaging local services that address their specific needs to improve their quality of life, prevent further stroke and reduce the need for further healthcare.

5.3 Objectives

Thesis Objective 3. To conduct an online survey with stroke survivors in the UK to investigate their knowledge, perspectives, and experiences of aerobic exercise.

- **Study Objective 3a.** To develop and distribute a survey for completion by UK stroke survivors.
- **Study Objective 3b.** To explore stroke survivors' knowledge of aerobic exercise.
- **Study Objective 3c.** To describe stroke survivors' views regarding their participation in aerobic exercise.
- **Study Objective 3d.** To identify the factors influencing participation in aerobic exercise after stroke from stroke survivors' perspectives.

5.4 Methods

5.4.1 Study design

The study design was a cross-sectional survey using a self-administered electronic questionnaire. The survey was designed to explore stroke survivors' knowledge and perspectives of aerobic exercise, and the factors affecting their participation in this. An online survey design was chosen to enable a diverse range of stroke survivors across all regions of the UK to provide their views.

5.4.2 Questionnaire development and content

5.4.2.1 Initial survey development

An initial draft questionnaire was developed iteratively using multiple drafts, based on a survey used in a similar study conducted in Canada in 2017 (Prout et al., 2017) and supplemented with information from published literature (Rimmer, Wang and Smith, 2008, Banks et al., 2012, Regan et al., 2021b, Prout et al., 2016, Boyne et al., 2017a, Shaughnessy, Resnick and Macko, 2004). The Short Outcome Expectations for Exercise Scale (SOEE), about the potential benefits of exercise, was included as a single question in the questionnaire. The SOEE has been validated for use with stroke survivors in relation to regular exercise (Shaughnessy, Resnick and Macko, 2004) and used in other studies on exercise, physical activity, and CR after stroke (Prout et al., 2017, Jackson, Mercer and Singer, 2018, Aguiar et al., 2022, Regan et al., 2021b). The questions within the questionnaire were designed to elicit:

- Demographic information using questions based on published literature and including characteristics known to influence participation in aerobic exercise after stroke.
- Stroke survivor knowledge of the importance and benefits of aerobic exercise both pre- and post-stroke.
- Stroke survivor perspectives around self-reported participation in aerobic exercise after stroke.
- Whether information about aerobic exercise was provided, or signposted to, during rehabilitation, or if aerobic exercise was delivered during rehabilitation.
- The barriers and facilitators which influence participation in aerobic exercise after stroke.

The design and format of the questionnaire was carefully considered, taking into account the target population, in an effort to facilitate participation by stroke survivors. Therefore, the survey was divided into comprehensive short sections, and the questions were clear and concise, comprising of mainly multiple-choice questions with an open text option and Likert questions. Advice was informally sought from an optician as to the most suitable background colour, font style and size, to aid completion by people with visual issues, with changes made to the layout and formatting of the survey accordingly. The draft questionnaire was reviewed by the author's supervisory team in preparation for discussion at a patient, carer, and public involvement (PCPI) group meeting.

5.4.2.2 Patient, carer, and public involvement

A PCPI group, consisting of five members who had lived experience of stroke, was formed to ensure this research was relevant and beneficial to stroke survivors, and that the survey and accompanying documents were user-friendly. An online discussion group was held to discuss and provide feedback on the written materials created for the study participants, including the advertisement, participant information sheet (PIS), consent section and survey questions. Feedback obtained included expanding use of the multiple-choice question format throughout the survey and adding an open text 'other' option, providing an option to request a summary of the results and the addition of 'sources of support' to each 'end of survey' message. Changes were then made to these documents based on this feedback. Full details of the feedback and resulting changes can be found in *Appendix 5.1.* The group also provided suggestions on how to maximise the diversity of participants recruited and how and where to recruit, such as by sharing the advertisement through mental health charities and via the group members' personal contacts. A more detailed description of, and reflection on, the PCPI for this study, can be found in section 5.8 below.

5.4.2.3 Pilot

The purpose of the pilot was to assess ease of use of the survey, determine the length of time to complete and identify any further required amendments to wording or layout. The amended questionnaire was piloted with three stroke survivors and two members of the public who were identified via either the PCPI group or existing contacts of the author and their supervisory team. The electronic questionnaire was created and hosted in Qualtrics, a web-based survey platform (Qualtrics, 2020) and was accessed using an electronic link. One recurring piece of feedback was that the PIS was too long and may not be required or desired by all participants. Therefore, a short version, which contained a link to the full version, was created and added to the initial information section in place of the full version. Final changes were made to the survey as indicated by feedback from the pilot (*Appendix 5.2*). A final copy of the questionnaire can be found in *Appendix 5.3.*

5.4.3 Study population and recruitment

Participants were adult stroke survivors who were living in the UK at the time of survey completion. A two-pronged snowballing recruitment strategy was utilised. The survey was advertised on social media, including Twitter and LinkedIn, and also emailed to personal contacts of the author and their supervisory team. Recipients of the advertisement from both avenues, which included the PCPI group members, stroke support groups, stroke charities, current and previous work colleagues, and stroke survivors, were then asked to share it with their contacts to maximise reach to stroke survivors.

Snowball sampling is a non-probability sampling method where the researcher shares the invitation to participate with a small number of contacts who then contact potential participants through their existing networks, rather than the researcher recruiting participants directly (Teddlie and Tashakkori, 2009, Leighton et al., 2021). It is an efficient and cost-effective way of reaching potential participants with specific characteristics (Naderifar, Goli and Ghaljaie, 2017), who for this study were adults with stroke, and has been used with social media (Leighton et al., 2021). The disadvantages of this type of sampling are the lack of control the researcher has over who is recruited, its potential to introduce biases, such as when participants share similar perspectives, and the lack of certainty as to whether the sample is representative of the target population (Leighton et al., 2021). During the planning and development stages of this survey, the effects of the COVID-19 pandemic were ongoing in terms of the challenges to NHS staff around workload and capacity. Recruitment via targeted invitations through the NHS was considered but decided against because of the prohibitive pressures caused by COVID-19 and its effects on the target population. Additionally, this survey was designed to be completed by participants at any time following their stroke, from the acute to the chronic phases, to capture a range of perspectives throughout the stroke journey. Recruitment via the NHS would likely have limited the sample to those with acute stroke. The survey remained active for 4 weeks, from the 23rd May 2022 to 20th June 2022, to enable regular re-circulation of the advertisement during this recruitment phase, as per the snowballing method, and to give participants sufficient time to complete the survey.

5.4.4 Data collection

Potential participants clicked a link in the advertisement (*Appendix 5.4*), which took them to a brief summary of the study on the Qualtrics platform (*Appendix 5.5*), where a downloadable long version of the participant information sheet (PIS) was available (*Appendix 5.6*).

5.4.4.1 Screening for eligibility

Participants were asked to complete three compulsory 'Yes/No' screening questions to ascertain their eligibility for the study; were they aged 18 or over, had they had a stroke, and were they living in the UK? If 'No' was selected for any of these three questions, the survey automatically skipped to the end where participants received a message thanking them for their interest, an explanation of their ineligibility for participation, and a list of appropriate sources of support post-stroke. Selecting 'Yes' in response to all three screening questions, automatically took participants to the short version of the participant information sheet (PIS) (*Appendix 5.7*) and the consent section (*Appendix 5.8*).

5.4.4.2 Consent

The compulsory consent section consisted of statements for participants to confirm they had read the information sheet and were consenting to take part in the survey (*Appendix 5.8*). If consent was not provided, they automatically received an end of survey message thanking them for their time.

5.4.4.3 Questionnaire

Survey responses were saved anonymously at each 'end of survey' point. Participants could skip any questions they did not wish to answer, apart from the compulsory screening and consent questions, and could withdraw at any point up until 'Submit' was clicked by closing their browser. Participants could also opt-in to receive a summary of the study findings and/or be contacted about taking part in further research about aerobic exercise in connection with this PhD by providing their email address only (*Appendix 5.9*). To do so, they clicked a link at the end of the first (main) questionnaire taking them to a second entirely separate survey where they could provide their email address. Use of this second survey ensured that participants' main survey response data was collected anonymously and was in no way linked to their contact details. Participants were advised that if they had provided contact details and then changed their mind, they could contact the author via email for up to four weeks after the survey had closed to request deletion of their contact details. Within the 'end of survey' messages, participants were signposted to a Stroke Association webpage on exercise after stroke (agreed in advance with the Stroke Association) and to appropriate sources of support following stroke including their GP, the Stroke Association, MIND and Headway.

5.4.4.4 Data management and analysis

All data were managed in accordance with university procedures in keeping with data protection legislation. Access to data was limited to the author and their supervisory team. Participants were assigned a unique study ID used to identify their demographic data and questionnaire data. Contact details were only processed and held for the stipulated purpose that consent was obtained for under Data Protection legislation including GDPR, e.g., to receive a summary of the study findings and/or be contacted about taking part in further research about aerobic exercise in connection with this PhD.

5.4.5 Analysis

Data from the electronic main survey were exported for analysis to SPSS (IBM, 2022), a statistical software package. Data from the second survey containing participant email addresses were downloaded separately from the Qualtrics platform to a separate password-protected Microsoft Excel spreadsheet. Data from the main survey were analysed in SPSS using descriptive statistics. The main variable of interest was aerobic exercise. Frequencies were calculated based on the number of responses to each multiple-choice question and then expressed as counts and proportions/percentages as these were designed as categorical data. Categorical data were reported as proportions. Beliefs around the stated benefits or outcomes of exercise from the SOEE were analysed by collapsing the five scale responses into three categories consisting of; 'Agree' combining 'Agree' and 'Strongly agree'; Neutral as 'Neither agree nor disagree'; and 'Disagree' combining 'Strongly disagree' and 'Disagree'. Each responses' rating was summed and divided by the number of responses and then the mean and standard deviation were reported. Qualitative data from open questions were imported into Microsoft Excel with the intention of undertaking inductive thematic analysis of this data. However, due to a paucity of data, this analysis was not possible. Sub-group analysis was conducted if deemed appropriate given the small number of respondents investigating variations related to age, gender, ethnicity, home support, time since stroke and level of mobility.

5.4.6 Patient, carer, and public involvement reporting

On conclusion of the PCPI activities, The Guidance for Reporting Involvement of Patients and the Public Short Form checklist (GRIPP2-SF) (Staniszewska et al., 2017) was completed in order to describe the aims and methods used for PCPI, and the extent of its influence on the study (*Appendix 5.10*). This form is appropriate for use where PCPI is a secondary focus within a study (Staniszewska et al., 2017), as was the case with this survey.

5.4.7 Ethical approval

Ethical approval was obtained from the Health Ethics Review Panel at the University of Central Lancashire (Reference: HEALTH 0310) (*Appendix 2.2*).

5.5 Results

5.5.1 Demographics

A total of 51 respondents met the inclusion criteria of being an adult stroke survivor residing in the UK. Of these, over half were female (n=27), half were aged 55-64 years (n=25), and around a quarter were 45-54 years (n=14). Virtually all respondents described their ethnicity as 'White' (n=50). Respondents lived in England (n=39), Wales (n=3), or Scotland (n=7), but there were no respondents from Northern Ireland, and two people did not provide an answer (*Table 5.1*).

Table 5.1. Participant demographics

Demographic characteristic		Count	%
Age group (years)	35-44	1	2.0%
	45-54	14	27.5%
	55-64	25	49.0%
	65-74	7	13.7%
	75-84	3	5.9%
	85+	1	2.0%
Gender	Male	24	47.1%
	Female	27	52.9%
Ethnicity	White	50	98.0%
	Prefer not to say	1	2.0%
Country	England	39	79.6%
	Scotland	7	14.3%
	Wales	3	6.1%
	NI	0	0
	Not provided	2	3.9%
Living situation	Lives alone	13	25%
	Lives with others	38	75%
Time since stroke	6 weeks to 3 months	1	2%
	4 - 6 months	1	2%
	7 months - 1 year	4	8%
	1 - 2 years	8	16%
	2-3 years	9	18%
	3 years +	28	55%
Mobility	Independent no walking aid	21	41%
	Independent with walking aid	23	45%
	Assistance no walking aid	1	2%
	Assistance plus walking aid	3	6%
	Wheelchair	2	4%
	Other	1	2%

Most people (n=38) lived with someone else with just 25% of respondents living alone. When asked about their mobility, the majority were independently mobile, either with or without a walking aid (n=44, 86%). In terms of how long it was since their most recent stroke, 28 respondents (55%) reported that it was at least 3 years, 17 (34%) said 1-3 years, and six people (12%) were within 12 months of having had a stroke.

5.5.1.1 Index of multiple deprivation

Based on analysis of the outward postcode data for England provided by 36 of the respondents, the median IMD quintile shows representation from all five domains, from the first (lowest) through to the fifth quintile. This means that respondents were residents across all areas of deprivation.

5.5.2 Knowledge of aerobic exercise

Respondents were asked to define aerobic exercise prior to being provided with the definition. A non-exclusive list of four potential definitions, which were exercise to improve balance, strength, cardiovascular fitness, or flexibility, were provided with instructions to select as many as were appropriate. All 51 respondents answered this question with 33 (64.7%) choosing the definition of aerobic exercise exclusively, of whom 20 were female. Another six respondents (11.7%) selected aerobic exercise plus one or more of the other three options (balance, strength, or flexibility) leaving 12 people (23.5%) who did not select aerobic exercise at all. Six (11.7%) chose the flexibility training definition alone, and three (5.8%) chose the balance definition alone, but no one selected the strength exercise definition alone. A total of nine respondents (17.6%) had selected more than one option (*Figure 5.1*).

The following explanation about aerobic exercise was then provided before respondents continued with the questionnaire, so that they knew what the correct definition of aerobic exercise was when answering the remaining questions:

"Aerobic exercise ***improves your heart and lungs*** *and* ***makes you fitter****. It is the type of exercise which raises your heart rate, makes you breathe faster, and feel warmer. It* ***involves moving continuously for at least 10 minutes*** *and using larger muscle groups, such as our leg muscles. Some examples of aerobic exercise are* ***brisk walking, cycling, climbing stairs, running, swimming, dancing, or rowing.****"*

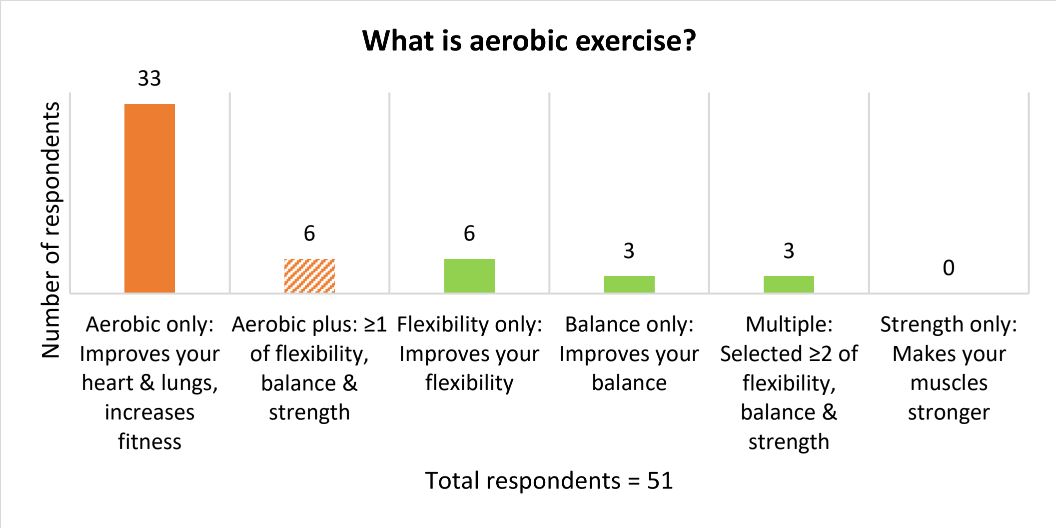

Figure 5.1. Responses to 'what is aerobic exercise?'

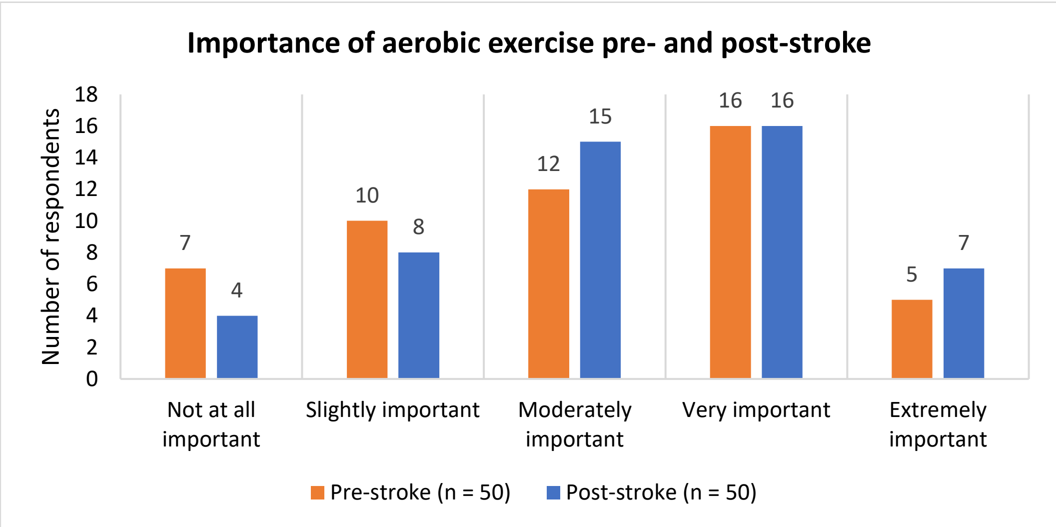

Figure 5.2. Responses to 'how important aerobic exercise was pre- and post-stroke?'

5.6.3 Importance and benefits of aerobic exercise pre- and post-stroke

Almost all respondents (n=50, 98%) answered the questions on how important aerobic exercise was to them before and since their stroke (*Figure 5.2*). The majority reported that it was either 'moderately' or 'very' important both before (n=28, 56%) and after (n=31, 62%) their stroke, with 7 (14%) and 4 (8%) reporting it as 'not important at all' pre- and post-stroke respectively. Furthermore, 40% (n=20) of respondents gave an identical answer both pre- and post-stroke, e.g., their opinion on the importance of aerobic exercise did not change after their stroke.

The analysis of the SOEE scores showed positive outcome expectations for participating in aerobic exercise, with a mean of 4.02 ± 0.91 (out of 5; n=41) (*Figure 5.3*). Participants' opinions were sought on the benefits of aerobic exercise following stroke. The majority of respondents (n=33, 64.7%) believed that aerobic exercise was recommended following stroke, three (5.8%) said that it was not, and 15 (29.4%) did not know (*Figure 5.4*).

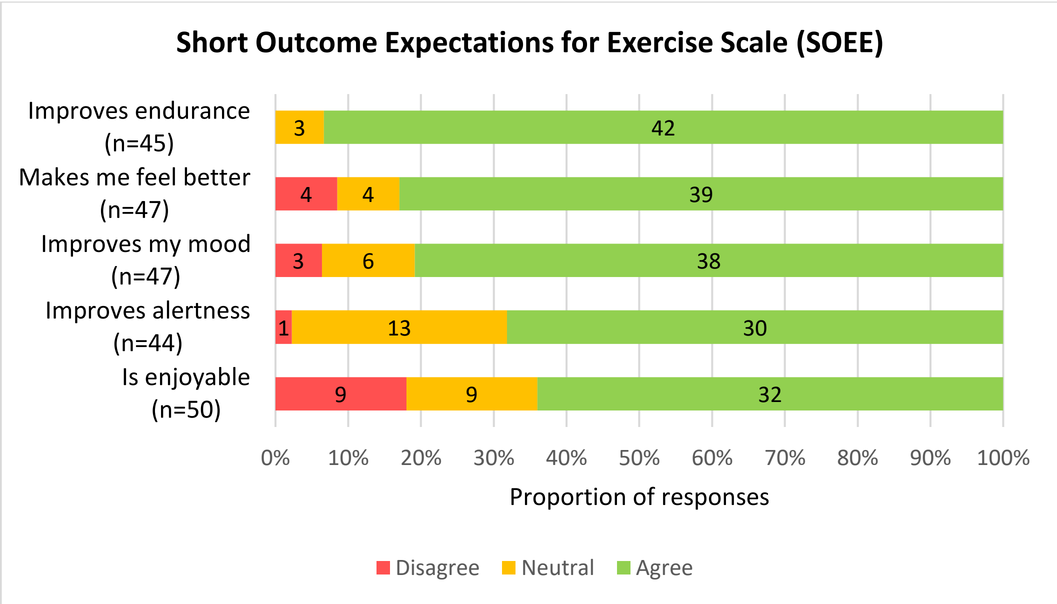

Figure 5.3. Responses to the outcome expectations for aerobic exercise

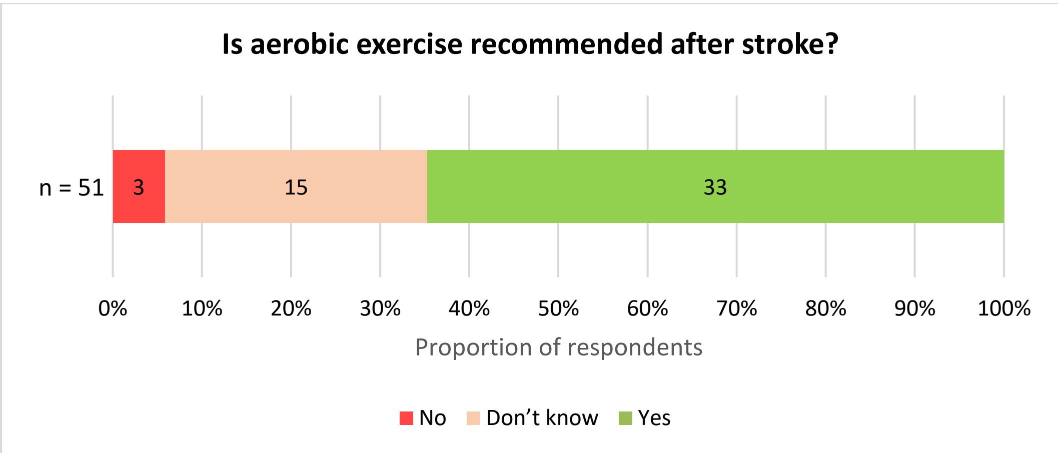

Figure 5.4. Responses to 'is aerobic exercise recommended after stroke?'

Participants were asked their opinion about whether aerobic exercise could help with fitness, walking, balance, everyday activities, mood, and mental activities. All 51 participants answered this question. Most agreed that it could benefit all of these, although fewer (n=30, 58.8%) believed that it could help with improving mental activities and one person reported under 'other, please specify' that it could help with maintaining a healthy weight (*Figure 5.5*).

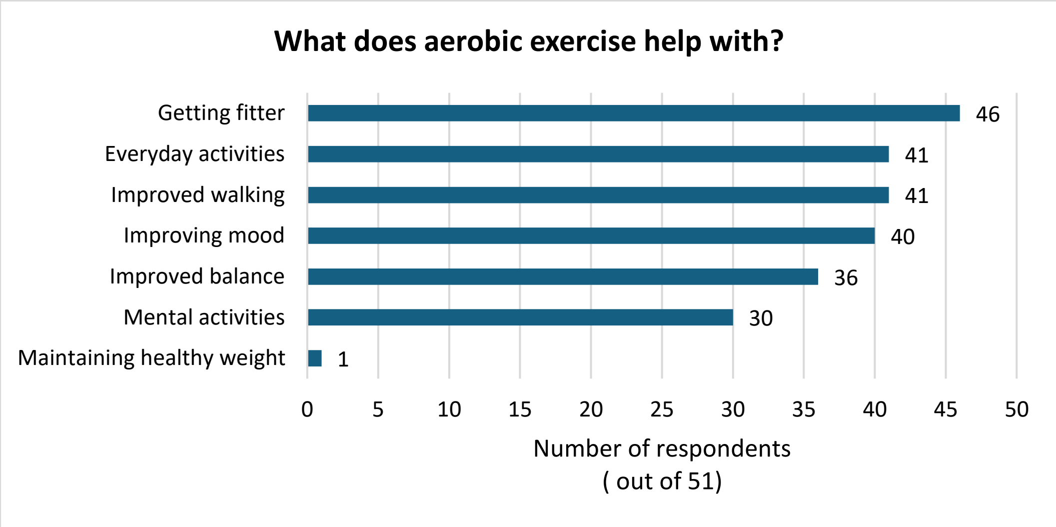

Figure 5.5. Responses to 'what does aerobic exercise help with?'

As aerobic exercise is linked with secondary prevention, a separate question asked about whether aerobic exercise might help to prevent another stroke. Over half of respondents (n=31, 60.7%) said it would, five stated that it would not, and 15 did not know.

5.5.4 Participation in aerobic exercise

Respondents were asked whether they had taken part in aerobic exercise before and since their stroke. Before their stroke, 80% (n=41) were participating in aerobic exercise, which decreased to 69% (n=35) of respondents post-stroke (*Figure 5.6*). The most common times to start exercising were at 3-6 months (n=9, 25.7%) or 6-12 months (n=9, 25.7%) after stroke, with no one starting earlier than one week post-stroke (*Figure 5.7*). The majority of people who took part in aerobic exercise before (n=41) and after stroke (n=35) were independently mobile, either with (n=34, 82.9%) or without (n=30, 85.7%) a walking aid (*Figure 5.8*).

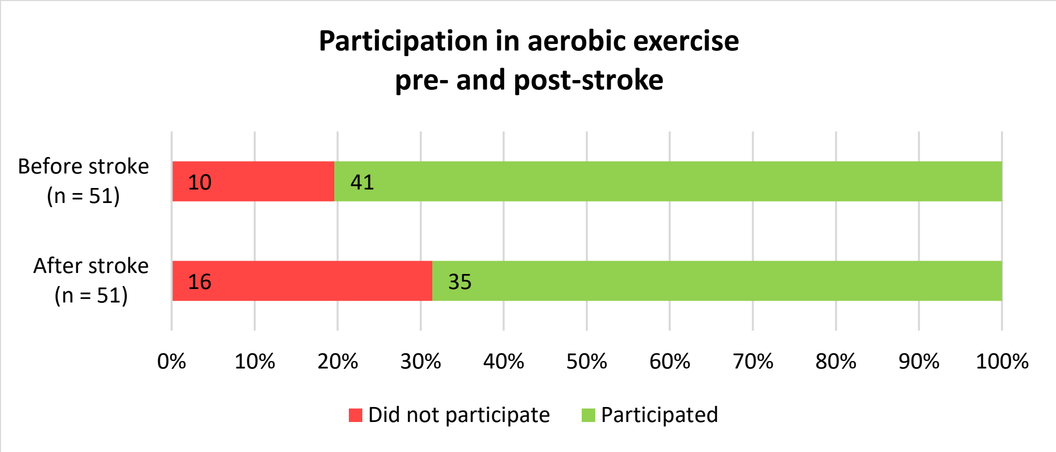

Figure 5.6. Responses to participation in aerobic exercise pre- and post-stroke

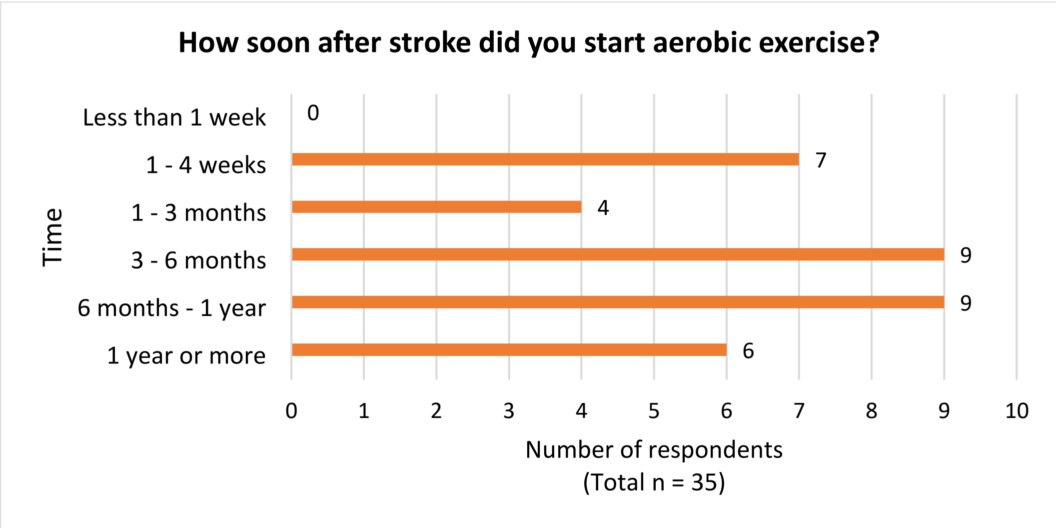

Figure 5.7. Responses to 'how soon after your stroke did you start aerobic exercise?'

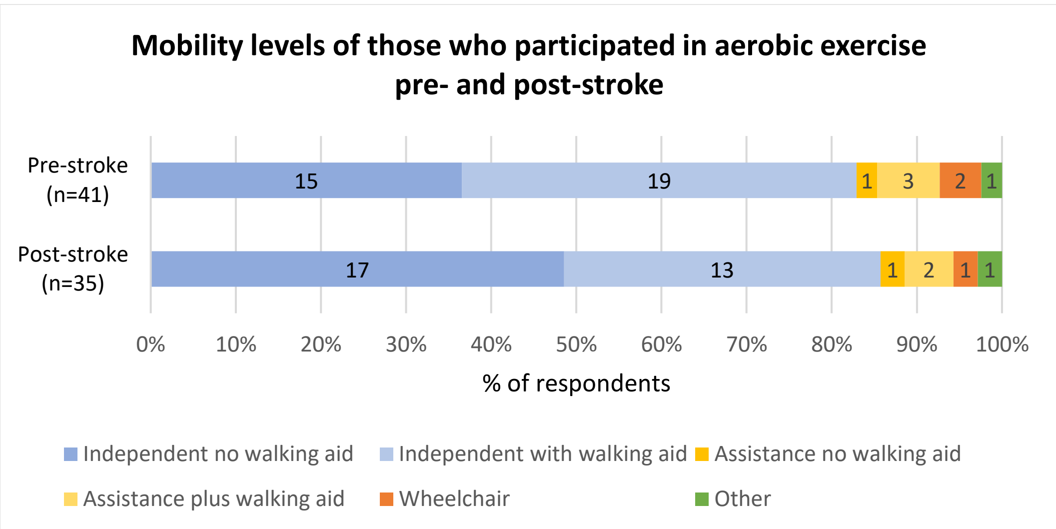

Figure 5.8. Responses to mobility levels for those who participated in aerobic exercise

Participants were asked about whether since their stroke, they preferred to exercise alone, in a group, or to do both. Most indicated that they preferred to exercise both alone, and in a group (n=18, 51.4%), with exercising alone being the next most popular (n=11, 31.4%) and group exercise the least popular answer (n=6, 17.1%) (*Figure 5.9*).

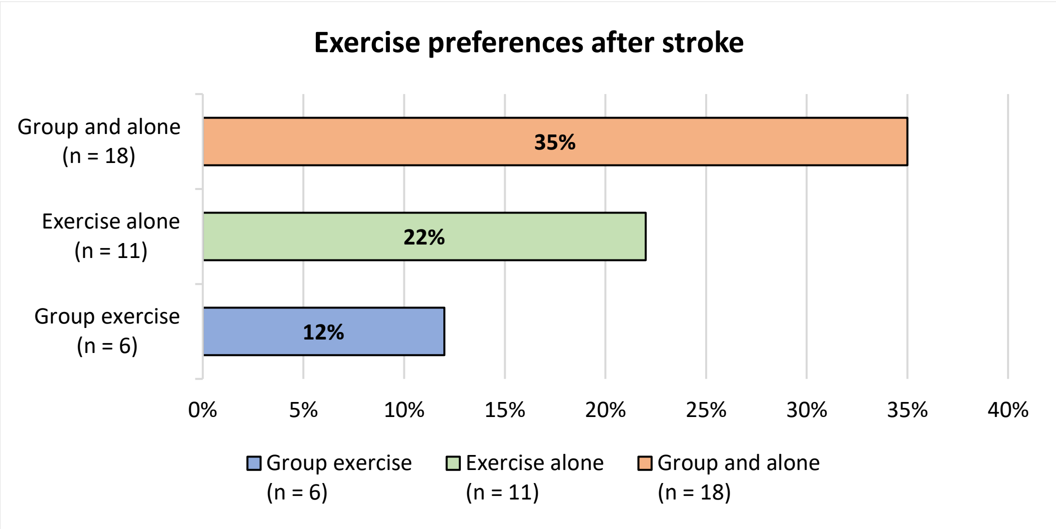

Figure 5.9. Responses to exercise preferences after stroke

5.5.5 Rehabilitation and aerobic exercise

Participants were asked about the rehabilitation that they may have had following their stroke. Before the questions were presented, they were reminded that they may have been contacted by a health professional, such as a speech therapist, occupational therapist, nurse, doctor, physiotherapist or other regarding rehabilitation. They were then advised that rehabilitation may have taken place in hospital, at a community centre, a gym, their home, via phone or video call or a combination of these. A summary of the aims of stroke rehabilitation was provided before they were asked about their experiences of aerobic exercise during their rehabilitation. Over 90% (n=47) of respondents reported that they had received rehabilitation following their stroke (*Figure 5.10*). This rehabilitation had mostly taken place in hospital (n=34, 72.3%) or at home (n=31, 65.9%), with 8 (17%) respondents having received rehabilitation in hospital only (*Figure 5.11*).

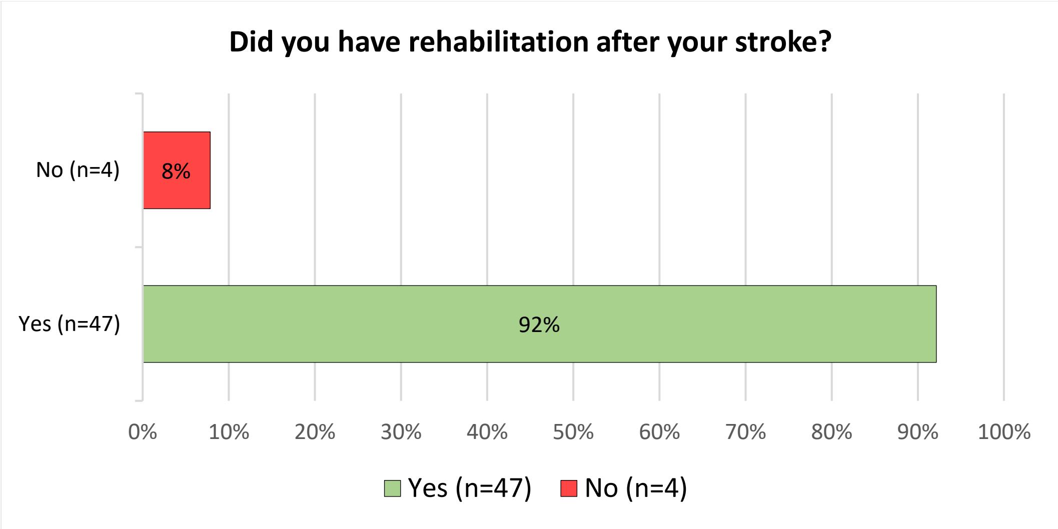

Figure 5.10. Responses to 'did you have rehabilitation after your stroke?'

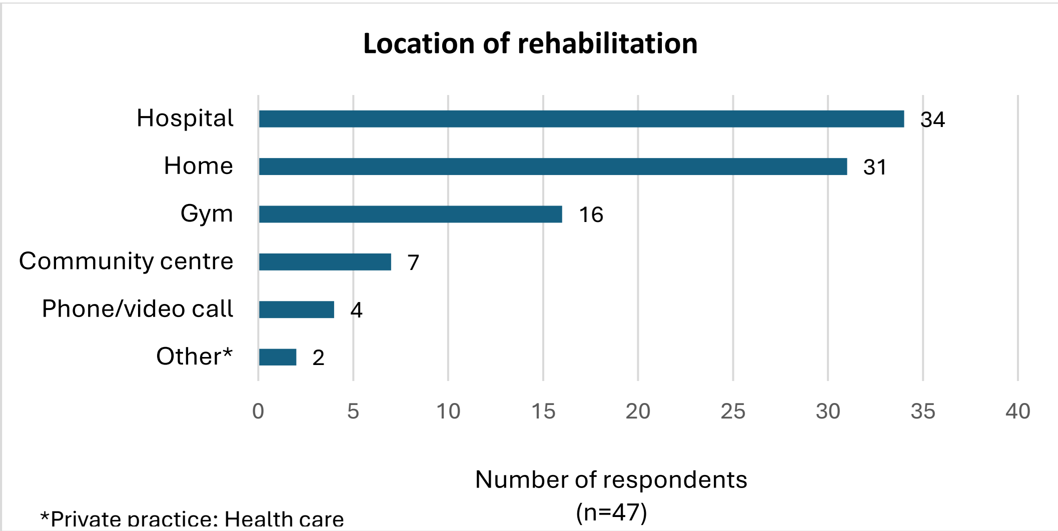

Figure 5.11. Responses to location of rehabilitation

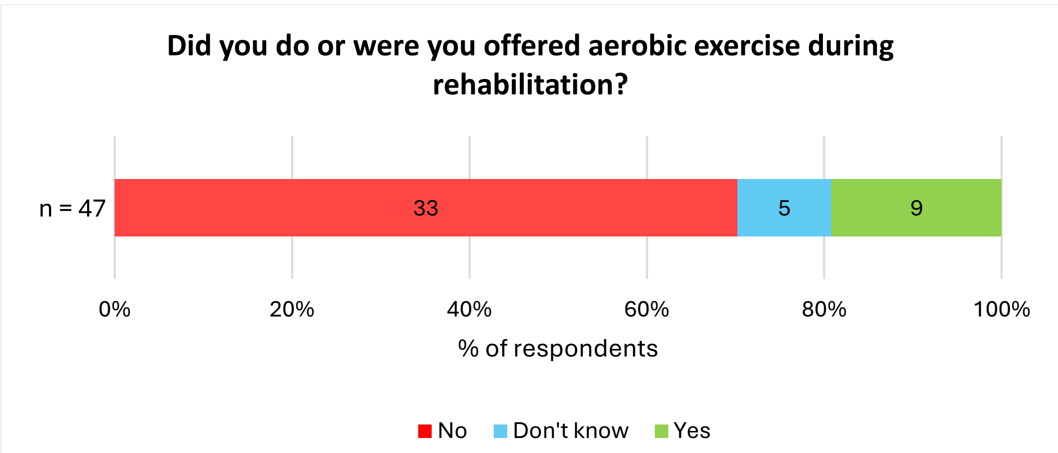

Figure 5.12. Responses to 'did you do or were you offered aerobic exercise during rehabilitation?'

The 47 respondents who had received rehabilitation were asked whether they had participated in, or were offered, any aerobic exercise as part of this. Just 19% (n=9) said that they had with 70% (n=33) indicating that they had not and 11% (n=5) did not know (*Figure 5.12*).

5.5.6 Information about aerobic exercise during rehabilitation

Respondents were asked about whether any member(s) of their healthcare team had spoken with them about aerobic exercise during their rehabilitation. Of the 47 people who answered this question, 74% (n=35) reported that no one had spoken with them (*Figure 5.13*).

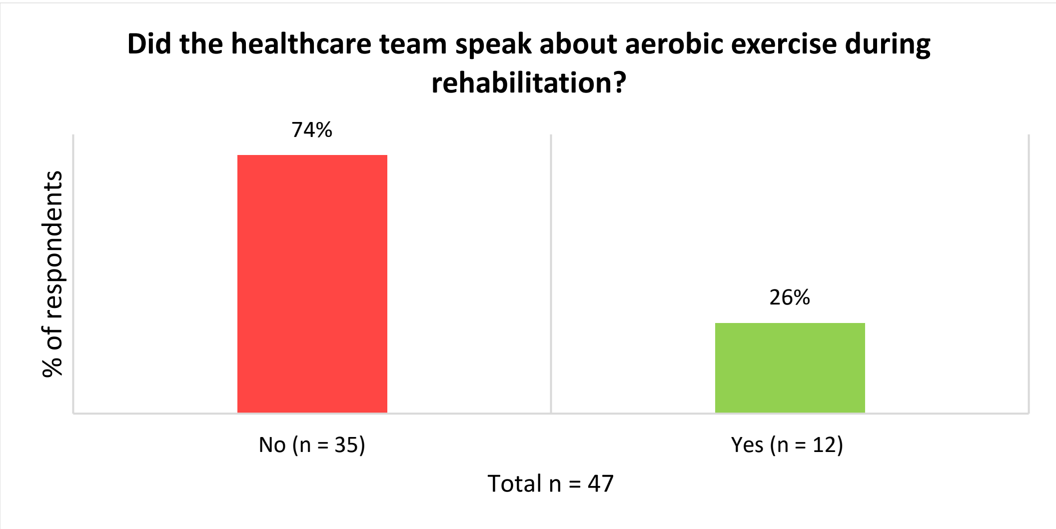

Figure 5.13. Responses to 'did the healthcare team speak about aerobic exercise during rehabilitation?'

Of those who had not been spoken with, over three-quarters (n=27, 77.1%) would have liked to have been given some information about aerobic exercise during their rehabilitation (*Figure 5.14*).

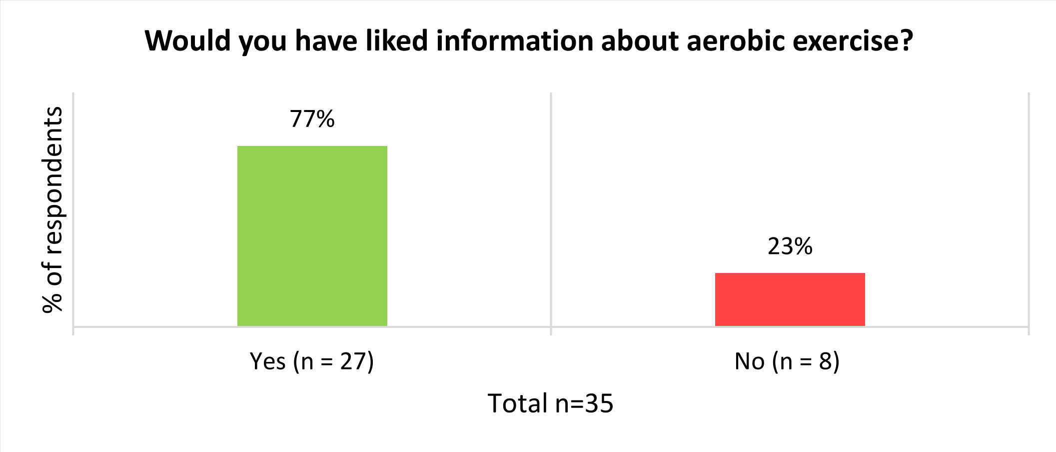

Figure 5.14. Responses to 'would you have liked information about aerobic exercise?'

All participants answered the question about their most preferred time for beginning aerobic exercise following stroke. For the majority (n=22, 43.1%), this was during the hospital inpatient stay although 13 (25.4%) selected starting at home with support from the community healthcare team, and another 13 (25.4%) preferred to start following discharge from their rehabilitation or healthcare team (*Figure 5.15*).

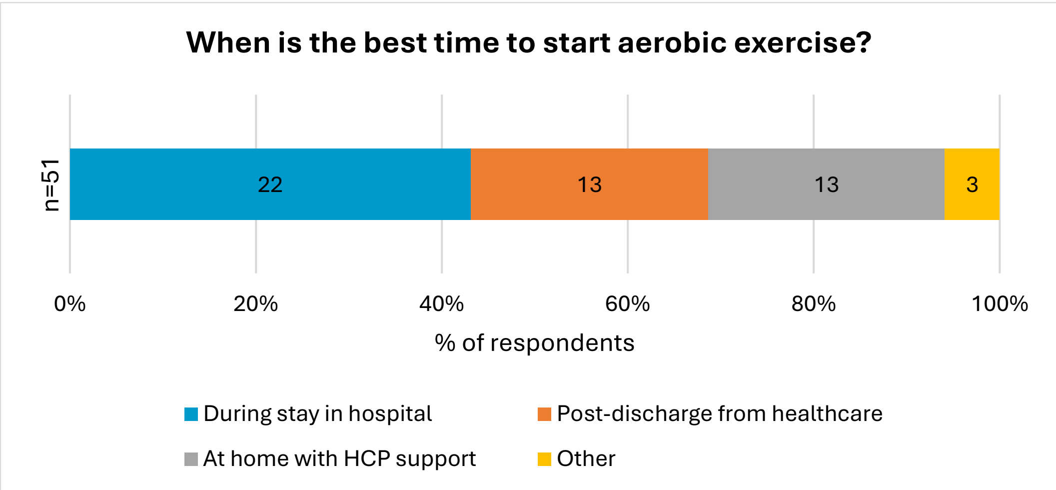

Figure 5.15. Responses to 'when is the best time to start aerobic exercise after stroke?'

5.5.7 Factors influencing participation in aerobic exercise

The majority of the respondents (n=33, 94.2%) who completed the question about how confident they felt about doing aerobic exercise said they were confident. There were only two stroke survivors (5.7%) who said they were not confident (*Figure 5.16*).

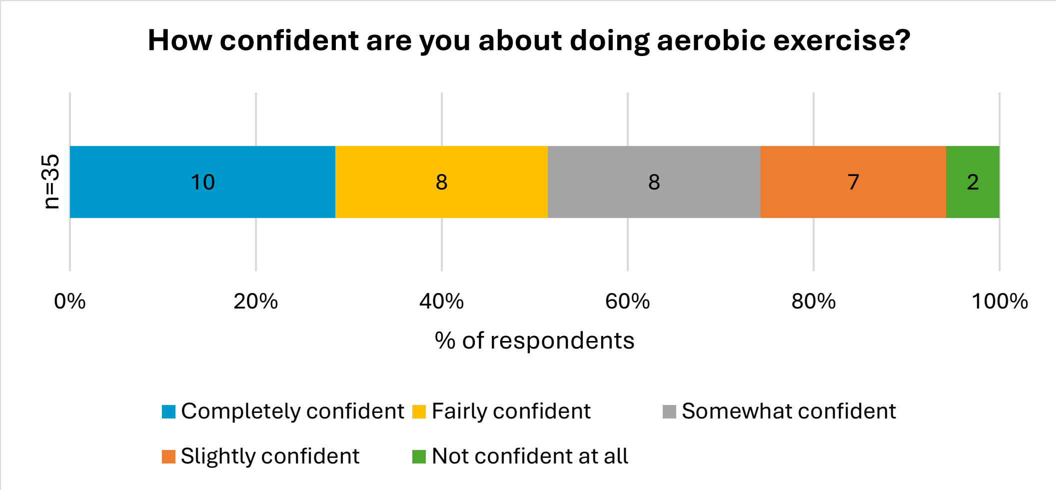

Figure 5.16. Responses to confidence to participate in aerobic exercise after stroke

5.5.7.1 Barriers

All 51 participants were asked about what they believed discouraged them from taking part in aerobic exercise and could select as many factors as applied. The three most common barriers to participation were a lack of knowledge on how to do aerobic exercise post-stroke (n=23, 45%), a fear of injury (n=19, 37.2%), and a lack of interest or motivation to do aerobic exercise (n=16, 31.3%). Interestingly lack of time, exercise facilities and fear of bringing on another stroke were selected least often (*Table 5.2*).

Table 5.2. Barriers to participation in aerobic exercise after stroke

Barriers to participation	Count	%
Lack of knowledge about how to exercise	23	45%
Fear of injury	19	37%
Lack of interest or motivation	16	31%
Lack of support	15	29%
Lack of transport	13	25%
Other	12	24%
Cost	11	22%
Fear of bringing on another stroke	6	12%
No exercise facilities locally	6	12%
Lack of time	4	8%
Nothing	4	8%

5.5.7.2 Facilitators

Participants were also asked about what factors would encourage them to take part in aerobic exercise. The three most common facilitators were the option of being able to exercise as part of a group (n=30, 58.8%), being supervised by a personal trainer or other exercise professional (n=29, 56.8%), and provision of information on how to exercise safely post-stroke (n=24, 47%). A few participants said they did not require any further help or encouragement (n=3, 5.8%) (*Table 5.3*).

Table 5.3. Facilitators for participation in aerobic exercise after stroke

Facilitators for participation	Count	%
Group exercise option	30	59%
Personal trainer/exercise professional supervision	29	57%
Information on exercising safely	24	47%
Information about benefits/effects of aerobic exercise	21	41%
Signposting to support regarding aerobic exercise	21	41%
Company during exercise or when travelling to/from exercise facilities	18	35%
Help with transport to a gym or sports centre	17	33%
Advice on sports equipment	12	24%
Digital tools, e.g., apps/websites	10	20%
I do not need any further help or encouragement	5	10%
Other	3	6%

5.6 Discussion

This study explored UK stroke survivors' perspectives of aerobic exercise via an online survey. A total of fifty-one stroke survivors completed the survey from May to June 2022. Their participation enabled analysis of stroke survivors' knowledge of aerobic exercise, views on its importance and benefits, experiences during rehabilitation, and the factors they perceived to influence their participation in aerobic exercise. These results will now be discussed in the context of the literature, although the implications are tempered by the limited sample size.

5.6.1 Study sample

Most respondents lived in England, with some from Scotland and Wales. Just over half were female (n=27, 52.3%), the majority were aged 45 to 64 years (n=39, 76.4%) and of White ethnicity (n=50, 98%). In England, there was representation from all areas of deprivation based on the English Index of Multiple Deprivation (n=36). Most were three or more years post-stroke (n=28, 55%), living with others (n=38, 75%), and independently mobile, either with or without a walking aid (n=44, 86%). It should be noted that it was not possible to conduct subgroup or in-depth analyses around the links between the factors or deprivation given the low number of respondents.

In the wider stroke population, stroke incidence is generally higher amongst men than women, and most people who have had a stroke in the UK are over 70 years of age (Public Health England, 2018a). However, although most respondents to this survey were younger than average, the age of stroke incidence in the UK has been lowering over the last decade (Public Health England, 2018a). In 2016, 38% of people who had a stroke were between the ages of 40 and 69 years (Public Health England, 2018a), similar to the age category of most of these survey respondents (45 to 64 years). The survey respondents therefore reflect this decreasing age of stroke demographic, although it's possible that younger people are simply more likely to respond to online research surveys such as this one. Within the wider literature around exercise after stroke, the average age of participating stroke survivors has also been similar to this study, mostly between 51 and 68 years (Prout et al., 2017, Poltawski et al., 2015, Dam and Rhind, 2020, Aguiar et al., 2022, Débora Pacheco et al., 2019) This survey did have a higher than usual proportion of female respondents than previous studies, whose authors have reported predominantly male study cohorts (Prout et al., 2017, Poltawski et al., 2015, Aguiar et al., 2022, Débora Pacheco et al., 2019, Simpson et al., 2011). All respondents except one were white, which, whilst disappointingly did not achieve the desired representation from minority ethnic groups in the UK, is potentially a reflection of the fact that over 80% of people resident in England in 2021 were white (Office for National Statistics, 2022). This lack of diversity amongst respondents also highlighted the challenges of recruiting people from minority ethnic groups to research studies. Most respondents had had their last stroke three or more years previous to the survey, meaning their stroke had occurred before the COVID-19 pandemic emerged. They would also have had time to adjust to their lives after stroke, similar to participants in Regan et al.'s (2021a) study on CR after stroke, who were on average 2.5 years post-stroke. Survey respondents were also mostly independently mobile, which again is reflected within the exercise after stroke literature whereby most research conducted has involved participants with less severe stroke or who are ambulatory (Aguiar et al., 2022, Débora Pacheco et al., 2019, Simpson et al., 2011).

5.6.2 Knowledge of aerobic exercise

In contradiction to findings from a discussion with a UK stroke support group in 2018 (section 3.10), and previous literature (Simpson et al., 2011) where both reported a lack of awareness and knowledge around aerobic exercise, this survey showed that most respondents (n=33, 64.7%) correctly identified aerobic exercise as the type which improves their heart and lungs and increases fitness. Furthermore, most survey respondents also correctly indicated that aerobic exercise is recommended post-stroke, and can improve fitness levels, walking, balance, everyday activities, mood, and mental activities. Only a small proportion (n=5, 9.8%) did not think it was recommended. This group of people demonstrated a level of awareness and understanding of aerobic exercise that contrasted with those of the stroke support group, possibly due to the majority of the group having been engaged with exercise prior to their stroke, meaning they had first-hand knowledge and experience of the outcomes of participation.

The majority of respondents viewed aerobic exercise as important, both pre- and post-stroke. They expected mainly positive benefits from exercise, particularly around improving endurance and making them feel better. As mentioned above, this may a reflection of their previous engagement and resulting positive experiences of participating in aerobic exercise as 15 of the 38 participants who rated aerobic exercise as moderately, very, or extremely important post-stroke, had not changed their rating from pre-stroke. However, other studies have reported similar findings in terms of stroke survivors attaching high levels of importance to aerobic exercise and having high expectations of its benefits (Prout et al., 2017, Aguiar et al., 2022).

As mentioned previously, robust evidence demonstrates that aerobic exercise is a modifiable risk factor for cardiovascular disease including stroke, and as such, is recommended in stroke guidelines in the UK and elsewhere (Intercollegiate Stroke Working Party, 2023, Heart and Stroke Foundation Canadian Partnership for Stroke Recovery, 2019). Interestingly, despite the apparent level of knowledge of this group of participants, only 60.7% (n=31) believed that it could help to prevent another stroke. This view was also noted by Simpson et al (2011) who concluded that stroke survivors may not always recognise or understand the link between exercise and secondary prevention.

5.6.3 Participation in aerobic exercise

Although the wider literature suggests that people post-stroke tend to be inactive (Fini et al., 2017, English et al., 2016, Tieges et al., 2015, Saunders et al., 2018), the results of this survey show that the self-reported rate of participation in aerobic exercise post-stroke (n=35, 68.6%) had only dropped slightly from that of pre-stroke (n=41, 80.3%). The vast majority of those who were exercising post-stroke were mostly confident about participation, with only 2 (5.7%) indicating that they were not. Additionally, 32 (91.4%) of those exercising after stroke had also been engaged with aerobic exercise before stroke. This link between engagement with exercise and/or physical activity pre- and post-stroke has been reported previously (Simpson et al., 2017, Dam and Rhind, 2020, Morris et al., 2017, Fini, Bernhardt and Holland, 2022). Dam and Rhind (2020) found that study participants voluntarily attending group exercise sessions post-stroke in the UK had engaged with physical activities, including swimming and walking, before their stroke. Also, in an Australian study, over 95% (n=48) of stroke survivors who had been active before their stroke, returned to activity after it (Fini, Bernhardt and Holland, 2022). A possible reason for this link is provided in another UK study by Morris et al. (2017) involving physical activity post-stroke (n=38). The authors found that participants who had engaged with physical activity prior to their stroke regarded it as part of their identity, were motivated about physical activity, and prioritised it after stroke, believing that it was beneficial and would influence their recovery (Morris et al., 2017). However, the converse was also true, with those who had not attached importance to, or participated in, physical activity pre-stroke, being less likely to engage after their stroke (Morris et al., 2017). This link is not exclusive to stroke, as previous experience of exercise has been shown to positively influence beliefs around exercise following a cardiac event (Bäck, Öberg and Krevers, 2017).

Exercising pre-stroke also appears to be associated with longer-term exercise engagement following stroke. An Australian study (n=276) reported that adherence to exercise up to 10 years post-stroke was associated with younger age, independent mobility, and exercise prior to stroke (Simpson et al., 2017). This is consistent with the findings of this survey, where those respondents who were exercising post-stroke were mostly younger, independently mobile, and had also exercised pre-stroke. The baseline data for Simpson et al.'s (2017) study was collected from 1996-1999 meaning the final 10-year data would have been from 2006-2009, which suggests that these factors have not particularly changed over the time between their study and this survey. Given these findings, level of mobility must also be considered as potentially influencing post-stroke participation in aerobic exercise, whether in the short or longer-term. Level of mobility is recorded in a number of the studies around exercise and PA. All participants in Dam et al.'s (2020) group exercise study were ambulatory, as were the majority of participants in the physical activity studies by Jackson, Mercer and Singer (2018) and Fini, Bernhardt and Holland (2022). This may have limited the generalisability of their findings, as was also the case with the survey. However, other studies had recruited participants with a broader range of physical disabilities and may therefore be applicable more widely (Norris et al., 2013, Poltawski et al., 2015, Morris et al., 2017). The link between exercise and/or physical activity pre- and post-stroke does suggest that encouraging engagement with aerobic exercise amongst the general population may lead to increased motivation to continue with it in those who go on to experience an event such as a stroke, thereby contributing to secondary prevention and improved quality of life post-event.

5.6.4 Rehabilitation and aerobic exercise

The vast majority of respondents reported that they had received some rehabilitation following their stroke (n=47, 92%), but most (n=35, 68.6%) reported that their healthcare team had not spoken with them about aerobic exercise, nor had they been offered aerobic exercise, resulting in very few participating in aerobic exercise during their rehabilitation. Furthermore, a high proportion of those who were not offered or did not participate would have liked to have been given information about aerobic exercise. This finding highlights a lack of exercise prescription and delivery, and a lack of provision of information for this small group of stroke survivors. There are several different angles that this can be viewed from. Firstly, the healthcare staff may not have had the knowledge or resources to be able to provide this information, both of which were barriers to implementation of aerobic exercise identified in the staff perspectives study. Regarding resources, this may have been a consequence of the drive to reduce inpatient length of stay, thereby reducing opportunities to introduce aerobic exercise to the stroke survivor. Another possibility is that aerobic exercise was not a priority for rehabilitation for either the patient or the staff at that time, as interventions targeting function are often prioritised over aerobic exercise (Clague-Baker et al., 2024, Regan et al., 2021b). There is also a question around whether information was offered at some point post-stroke, but perhaps not at the optimal time or in the most accessible format for it to be absorbed by the stroke survivor, as the ability to understand and use information can be impacted by stroke characteristics (Flink et al., 2023). The optimal timing for commencement of post-stroke interventions also varies from person to person, depending on their recovery and capabilities (Hall et al., 2020). Although the actual reasons why aerobic exercise was not included in rehabilitation for these participants are not known, a need clearly exists to offer more information about aerobic exercise to stroke survivors.

5.6.5 Exercise preferences and format

To maximise engagement with aerobic exercise, it is necessary to provide a service that meets the needs of stroke survivors, considers their exercise preferences, and the perceived barriers and facilitators to their participation. The preferred time for starting aerobic exercise after stroke indicated by most survey participants was during the inpatient stay in hospital. This was consistent with stroke survivor participants (n=32) in a Canadian study who were willing to begin aerobic exercise early in their rehabilitative journey, at a median time of just 1.3 days post-stroke (Prout et al., 2017). Provided there are no medical reasons to delay beginning aerobic exercise, it can be started at any time post-stroke, regardless of stroke severity (Intercollegiate Stroke Working Party, 2023). There are certain advantages to starting during inpatient rehabilitation, although methods to encourage long-term engagement with aerobic exercise following discharge must be considered. Within this safe supervised environment, healthcare professionals can assess and prescribe exercise, as well as impart knowledge and guidance on how to exercise safely within appropriate individual limits during rehabilitation and beyond (Intercollegiate Stroke Working Party, 2023). However, there are known challenges around capacity to provide quality stroke care within the current NHS, including a workforce crisis and overstretched resources which are unevenly distributed across the UK (Stroke Association, 2023b). This potentially requires a much wider discussion in the UK around the resources required for rehabilitation, how and by whom these are funded, and the importance of capturing evidence to build a case for support. Regarding aerobic exercise during the hospital stay, it may be that a similar approach to that used within CR would be appropriate and adaptable for use following stroke. For CR, patients are, where possible, provided with information about addressing risk factors and individualised goal-setting prior to their discharge from hospital (National Institute for Health and Care Excellence, 2020, British Association for Cardiovascular Prevention and Rehabilitation, 2023) or as early as practicable within their care pathway. This information usually includes individualised advice on how to safely begin or return to exercise following their cardiac event. Patients are also simultaneously referred to a CR programme where possible, followed by a timely initial assessment which includes priority setting, and subsequent enrolment to a CR programme as agreed with the patient. The programme may be offered in a variety of format options such as centre-based, home-based, online or a combination, using a person-centred approach and conducted either individually or in groups as per patient preference. (British Association for Cardiovascular Prevention and Rehabilitation, 2023). It may be helpful to consider how to implement such an approach for aerobic exercise provision post-stroke, including thorough exploration of alternative ways of working within existing resources, if there is no prospect of increasing resources.

One potential option, which may be an easier mode of delivery than one-to-one where staffing is limited, is that of group exercise provision, as this can provide a range of benefits such as peer and professional support, building self-confidence and generating motivation for stroke survivors (Davison et al., 2022, Poltawski et al., 2015, Dam and Rhind, 2020, Morris et al., 2017). Exercise preferences varied within the literature (Norris et al., 2013, Poltawski et al., 2015, Banks et al., 2012, Dam and Rhind, 2020), highlighting that there is no 'one size fits all' approach to provision of exercise. Indeed, the Stroke Exercise Preference Inventory (SEPI) was developed specifically for the purpose of tailoring exercise programmes for stroke survivors (Bonner et al., 2016). Preferences were likely to have been influenced by the individual, their previous experiences and confidence to participate, as well as what services were available. This was discussed at the PCPI group meeting who provided examples of people who prefer different formats and advised that cultural sensitivities also need to be considered when making decisions about format. For instance, people with mental health issues usually prefer not to exercise in groups, and as Muslim women would not wish to exercise with men, women-only exercise sessions may be more acceptable.

The option of group exercise was the most common facilitator reported in the survey, although the most preferred format was a mixture of group and individual sessions, with exercising alone being the second most preferred. Provision of one-to-one attention within group sessions for the purpose of focusing on individual need is possible, and was reported as advantageous in a stroke-specific exercise programme as it enabled person-specific adaptations to be made to the group activities (Norris et al., 2013). Individual prescription of exercise is important as it facilitates long-term adherence to exercise (Billinger et al., 2014, Fini et al., 2021). Within CR, education and exercise are often provided in group sessions, but for the exercise component, assessment and person-specific exercise prescription are usually conducted individually, and ideally in person, in advance of participation in any exercise sessions (British Association for Cardiovascular Prevention and Rehabilitation, 2023, Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). Evidence and current UK stroke guidelines recommend that collaboration between stroke rehabilitation professionals and those in CR could enable a pooling of skills, knowledge, and resources around stroke and exercise to facilitate exercise provision after stroke and benefit stroke survivors (Intercollegiate Stroke Working Party, 2023, Clague-Baker et al., 2022, Clague-Baker et al., 2020). This would be advantageous for the clinicians in both specialities as increasing numbers of patients are presenting with multi-morbidities (Kingston et al., 2018). The PCPI group involved with the survey reported that services often say they do not have the resources to adapt exercise provision for those with stroke, so this collaboration may at least provide a partial solution to this problem. Part of a discussion with the CR staff as part of the patient and public involvement for the systematic review (section 3.9.3.1) was around using a more functional patient-focussed approach to CR rather than condition-specific. In short, everyone has different exercise preferences, and these differences need to be reflected in the choice of exercise formats and settings offered to stroke survivors.

5.6.6 Factors influencing participation in aerobic exercise

The three most commonly perceived barriers to participation in aerobic exercise in the survey were a lack of knowledge about how to exercise safely, fear of injury, and lack of interest or motivation. Whilst lack of knowledge and fear of falling or injury were also reported as barriers in the physical activity and exercise after stroke literature (Aguiar et al., 2022, Davison et al., 2022, Débora Pacheco et al., 2019, Prout et al., 2017, Morris et al., 2017), the findings in relation to lack of interest or motivation to exercise after stroke were variable. For example, 72% (n=23) of stroke survivor participants in a study by Prout et al. (2017) agreed that stroke survivors were motivated about taking part in aerobic exercise, whereas participants in a study by Poltawski et al. (2015) believed that motivation was challenging to maintain, and Dam and Rhind (2020) noted that group exercise can help increase motivation. It is possible, however, that a lack of knowledge on how to exercise is linked with fear of falling or injury and negatively affects motivation to participate. Referring to the COM-B behaviour change model (Michie, van Stralen and West, 2011), if a stroke survivor's capability could be improved by equipping them with sufficient knowledge about how aerobic exercise participation can reduce their risk of further stroke, and with the skills to engage with aerobic exercise, this could positively influence their beliefs and therefore motivation in seeking out opportunities to take part in exercise. These three perceived barriers of lack of knowledge, fear of injury, and lack of motivation, may be an indication that essential information and skills about exercise after stroke, such as how, when, and where to participate, is inadequate, unavailable, or simply not provided during or after stroke rehabilitation in the UK. Furthermore, the third most selected facilitator in the survey was the provision of information on exercising safely. To improve stroke survivors' knowledge and skills around aerobic exercise, it is necessary to consider what care and post-stroke information is being provided, by whom and at what point in the stroke pathway, whilst maintaining a person-centred focus. Challenges clearly exist around capacity and resources within the NHS and public services (Stroke Association, 2023b). However, the recommendations for cardiorespiratory fitness training within the UK stroke clinical guidelines (Intercollegiate Stroke Working Party, 2023) may provide an opportunity to produce more specific advice for clinicians to increase their knowledge and skills and enable them to confidently prescribe aerobic exercise during rehabilitation, provide patient-specific individualised information, and/or signpost to sources of information for stroke survivors to access themselves. One existing example of an exercise prescription guideline following stroke is the Canadian Aerobic Exercise Recommendations to Optimize Best Practices In Care after Stroke (AEROBICS), originally developed in 2013 and updated in 2019, which covers all phases of recovery post-stroke (MacKay-Lyons et al., 2019, Heart and Stroke Foundation Canadian Partnership for Stroke Recovery, 2013). This provides specific recommendations for clinicians on screening post-stroke and post-TIA for aerobic exercise, as well as exercise testing and prescription. Within the UK, the Stroke Clinical Guideline (2023), together with the BACPR (2023) and ACPICR standards (2023) for CR could be used as a starting point for the development of similar UK stroke-specific guidelines. In terms of facilitating longer-term engagement with aerobic exercise amongst stroke survivors, methods to expand the provision of group or individual community-based exercise should be further investigated. This is warranted as social support has been reported as important in helping stroke survivors to maintain their motivation (Prout et al., 2017, Poltawski et al., 2015) and some UK literature supports this exercise format (Norris et al., 2013, Dam and Rhind, 2020, Dean et al., 2018).

5.6.7 Support

Support as a factor influencing participation was reported in all of the studies around physical activity, exercise, and CR after stroke which were explored in the introduction (Jackson, Mercer and Singer, 2018, Morris et al., 2017, Nicholson et al., 2014, Poltawski et al., 2015, Prout et al., 2017). The survey results were consistent with the literature, as the survey respondents cited support as the second most common facilitator and fourth most common barrier to their participation in aerobic exercise. Support in this context can be provided from different sources, including peer support, support from partners, family and/or friends, and professionals. Each study either identified the presence of one or more types of support as facilitators for participation in physical activity, exercise, or CR, or cited a lack of support as a barrier. When present, partner or family support which is encouraging can help with motivation to be active, but overprotective family support can limit the person’s progress (Morris et al., 2017). Family or friends can give practical assistance, such as with transport to or from the exercise venue to enable participation, or as an exercise ‘buddy’ (Morris et al., 2023), whereas peers can provide encouragement and understanding through their shared experiences and, in some instances, friendship (Dam and Rhind, 2020, Norris et al., 2013). Peer support was strongly demonstrated in the UK community-based group exercise programme, Action for Rehabilitation in Neurological Injury (ARNI), evaluated by Norris et al. (2013). In this case, the exercise programme had been developed by a stroke survivor in addition to one of the instructors being a stroke survivor, both of which were viewed extremely positively by the attendees in terms of credibility and appropriateness of content. Again, this highlights the importance of developing interventions in collaboration with those whom the intervention is intended to benefit.

Healthcare and exercise professionals’ support and skills were also valued by survey participants, with supervision by a personal trainer or exercise professional reported as being the second most common facilitator in the survey. Their roles can involve education on exercising safely, setting goals, prescribing, adapting, and progressing exercise, as well as signposting to any other support that may be required by the stroke survivor or their carer(s) across all stages of stroke. A lack of professional support following discharge from care can be a barrier to engagement with aerobic exercise (Nicholson et al., 2014), therefore careful transfer to and integration into community-based services is essential. An up-to-date knowledge of local services, community support, and points of contact to refer or signpost to on discharge from inpatient or outpatient care is vital to maintain continuity and motivation.

Essentially, if there were no restrictions on resources or staffing, the ideal would be to provide a menu of options for exercising after stroke, regardless of geographical location, to accommodate all exercise preferences and improve accessibility to aerobic exercise for stroke survivors. However, with the limited resources available in the UK system, context-adaptable aerobic exercise formats developed and implemented in collaboration with local people affected by stroke, together with local authority and GP population data, may constitute a more realistic approach to this challenge.

5.6.8 Recruitment challenges

The total number of respondents to this survey (n=51) was lower than anticipated despite repeated efforts to boost dissemination of the advertisement via social media, patient and public involvement groups, charitable organisations, and personal contacts over the 4-week period the survey was open. The challenges of recruiting participants to research studies are well-documented (Price et al., 2020, Preston et al., 2016, Newington and Metcalfe, 2014, Berge et al., 2016, Rockliffe et al., 2018) yet successful recruitment is vital for the development of beneficial evidence-based research which improves care (Preston et al., 2016). Recruitment involves the identification of potential participants, approaching them with an invitation to take part, and seeking their agreement and consent (Price et al., 2020, Preston et al., 2016, Newington and Metcalfe, 2014). Strategies for improving recruitment have been explored, including within the area of stroke research, although few have been evaluated (Berge et al., 2016). These have included financial incentives, personalised e-letters, using a picture or shorter or personalised questionnaires. It was not feasible to offer financial incentives or personalised e-letters to boost participant recruitment within the constraints of this PhD, but the survey had short sections, comprising mainly multiple-choice clear and concise questions.

The COVID-19 pandemic was ongoing during the preparation and planning for this research study. This influenced people's knowledge of research and their participation in it. Some gained a greater awareness of research, and their willingness to participate increased, but certain factors influenced their decisions. For example, with regards to clinical trials, motivators for participation included personal gain and potential benefits to others, whereas barriers were around personal safety and avoiding risks due to COVID, as well as accessibility and inconvenience (Abdulhussein et al., 2022). During the pandemic, online surveys became a particularly popular and feasible method of data collection for research, as they avoided some of the COVID-specific barriers to participation such as face-to-face contact. Additionally, they are a cost-effective method of data collection. Nevertheless, challenges to their use still existed, not least because of the digital divide (Watts, 2020, Litchfield, Shukla and Greenfield, 2021) and the increasing numbers of survey requests leading to 'survey fatigue' (de Koning et al., 2021).

Given the target population's potential vulnerabilities and a move towards the use of technological devices and the internet for communication amongst those who could access it, the decision was made to use an online survey for this study as face-to-face data collection would have been unwise as well as challenging. It was hoped that this method would also have a wider geographical reach, enabling recruitment of stroke survivors from across the UK. Furthermore, considering the well-publicised strain on staff's capacity within the NHS to contribute to research at the time and the public policies to increase internet access and digital knowledge as a result of the pandemic (Watts, 2020), this was a justified and pragmatic decision. However, as is often the case with research, certain unexpected issues arose during the period running up to the launch of the survey. The PCPI group had suggested several charitable organisations and groups to approach for help with dissemination of the survey advertisement. Unfortunately, these either did not reply or were unable to assist, and one major stroke charity did not follow through due to a staff shortage and subsequent administrative error. Although initial contact with these organisations had been attempted or made four months prior to the survey launch, in future this could be sought even earlier, although organisations may not know their capacity too far in advance. These issues unfortunately contributed to a reduced survey reach and low recruitment rate. The total number of participants was discussed at the follow-up session with the PCPI group who suggested that for future studies, the survey could be left open for six to eight weeks to allow more time for dissemination and sharing of the advert. Now that the pandemic has ended, the group recommended visiting community centres and local drop-ins to promote the research with the aim of increasing diversity and number of participants. Participants could also be approached through community groups who can facilitate communication with those who are harder to reach (Wieland et al., 2021). Another method for increasing accessibility and diversity would be to translate the participant-facing documents, including the advertisement, into other languages and/or produce an audio or audio-visual version (Berge et al., 2016). Unfortunately, as these activities would have required further resources than were available for this survey, they could not be utilised but should be considered for future research in this area.

5.6.9 Strengths and limitations

This study had a number of strengths and limitations. In contrast with other studies which were generally male dominated (Simpson et al., 2011, Aguiar et al., 2022), this survey had a greater number of female (n=27) than male (n=24) respondents. As 56% of stroke survivors globally are women (Feigin et al., 2022), it is vital that their views are represented within research, so having this higher proportion of females is a strength of this survey.

Another strength was the meaningful involvement of patients, carers, and the public in the design of the participant-facing survey documents, and in piloting the survey. This ensured that the research was relevant to stroke survivors, and the documents developed were as accessible as possible to this group. Further details of their involvement are described below in Section 5.8.

Despite extensive literature searching, no suitable existing questionnaire was found for this survey, which is a limitation of this survey. Therefore, one was developed based on previous surveys exploring stroke survivor perspectives of exercise and existing literature. Although this was not validated, the questionnaire was modified based on feedback received from the PCPI group and the pilot before it was launched. Furthermore, no theory, model, or framework was used in the development of this survey. The benefits of using a theoretical approach include gaining a more comprehensive understanding or explanation of what influences behaviour and implementation outcomes (Nilsen, 2015). This knowledge can then be used to support the design of more effective interventions (Brehaut et al., 2021). On reflection, a theoretical approach such as the Theoretical Domains Framework (Atkins et al., 2017) or COM-B system (Michie, van Stralen and West, 2011), which focus on behavioural theory and implementation, could have been used to inform the development of the survey and should be considered for any future surveys. The lack of a theoretical approach could therefore be classed as a limitation to this study.

As with all online surveys, this was a self-selecting sample. The use of an online survey method and digital dissemination of the advertisement is likely to have favoured those who were digitally literate and had internet access, and precluded some people from participation because of digital inequality, whereby socioeconomic status, age or geographical area of residence influence skills and access to digital technologies (Watts, 2020). Furthermore, it was not possible to conduct subgroup or in-depth analyses around the links between the factors or any other interesting characteristics given the low number of respondents. For this same reason, these findings were not generalisable to the wider UK stroke population, but instead provided an insight into the perspectives of a group of stroke survivors who were largely engaged with aerobic exercise both prior to and after their stroke. It is worth noting that in the stroke physical activity literature, self-reports of activity (both pre- and post-stroke) can overestimate actual levels of activity which may be due to errors in recall (Fini, Bernhardt and Holland, 2022), so there is always a possibility of recollection biases within the survey data collected.

5.7 Patient, carer, and public involvement

5.7.1 Aim

To ensure that the survey was relevant and beneficial to stroke survivors, people with lived experience of stroke were recruited to a PCPI discussion group as described below.

5.7.2 Method

A PCPI group was formed with members recruited via an advertisement on the NIHR People in Research website. The advertisement for this opportunity outlined the research, purpose of the PCPI, and type of experience sought as well as the activities planned, and the reimbursement offered for their involvement (*Appendix 5.11)*. Funding for these activities was secured from the Research Design Service (RDS) North West Coast. Communication was maintained using email. Two meetings were planned with the dates selected via a Doodle poll and email. The meetings took place virtually via video call to enable as many members as possible to attend. All members were asked beforehand whether they were familiar with, and agreed to use, video call for both meetings. The researcher offered to carry out a short practice video call, but this was declined by all members. Members were given the opportunity to have any meeting documents sent via email or post and their preferences noted.

5.7.3 Meetings, discussions, and outcomes

5.7.3.1 PCPI Meeting 1

Prior to the first meeting, draft copies of the Participant Information Sheet (PIS) and survey questions were circulated to each member of the group. The aim of this meeting was to ensure that this information was user-friendly and relevant to stroke survivors. A brief explanation of PCPI was given, followed by discussion with the group around the advertisement, initial information and screening questions, PIS, survey, and methods of survey dissemination and participant recruitment. Permission was sought in advance from each member via email for the meeting to be recorded for the purpose of taking accurate notes.

Feedback was given by each member of the group and collated after the meeting (*Appendix 5.1).* This included advice around the choice of wording, font colour and size, where sources of support were given on the PIS, and the order and types of advantages/disadvantages of taking part. The group also provided suggestions on how to maximise the diversity of participants recruited to the study and how and where to share the advertisement, for example, by contacting mental health charities such as MIND and McPIN, and local stroke groups.

This feedback was considered carefully with appropriate changes made to the documents as a direct result of this feedback. Following this advice, MIND and The McPIN Foundation were contacted via email. MIND responded to say they were unable to assist student research projects. The McPin Foundation did not reply, and the Stroke Association was unable to assist due to not having staff in place to deal with requests such as these at that time.

5.7.3.2 PCPI Meeting 2

The second meeting took place following completion of initial data analysis. The group's views were sought on the implications of the study findings and whether the conclusions were valid from a public perspective. Future direction of the research and how to ensure its relevancy to stroke survivors were also discussed. The sole attendee was asked to reflect on their involvement in this research, considering what went well / did not go well, and their satisfaction with communication and how the meetings went.

As for Meeting 1, feedback was collated and reflected upon following the meeting (*Appendix 5.1*). The member advised that the survey should have been open for longer than 4 weeks, which may have helped with recruitment. They were pleased that the number of male and female participants was relatively even, and that some were doing aerobic exercise both before and after their stroke. Exercise preferences were discussed, including considerations around those with mental health issues and cultural sensitivities, and why people do or do not exercise. Lack of resources were described as barriers to services being able to adapt to suit people with stroke. Suggestions were made to carry out a further study focussing initially on a small geographical area with the research conducted from community centres or facilities.

The researcher briefly described plans to carry out a stakeholder consensus event to share findings from this project and discuss ways to increase the use of aerobic exercise after stroke. This was viewed positively, with the member stating that such an event would help to share the findings more widely. They suggested some stakeholder groups to invite to the event, as well as perhaps creating a video about the study to share with healthcare professionals and service users.

5.7.4 Reflections

5.7.4.1 Reflections of the group on their involvement

The group member was asked to reflect on their involvement in this study. They felt they were fully briefed and engaged throughout the study, were satisfied with the researcher's communication, and happy that they could take part in the survey pilot and contribute to the survey. They also appreciated the opportunity to reflect on their own experiences as a stroke survivor, particularly when the initial survey findings were shared.

In terms of what could have gone better, they recommended giving group members at least 2-3 weeks' notice of a meeting once the date has been confirmed. The organisation of the second meeting had been rushed due to the deadline for the RDS funding, so these timings need to be considered in future. The member also felt it would have been helpful to know how long the whole project would take. This had been stated in the People in Research advertisement, but in future it would be helpful to reiterate this when people respond and express an interest in the opportunity advertised.

5.7.4.2 Reflections of the author on PCPI in this study

Some useful thought-provoking feedback regarding the study was provided at both meetings. This was used to improve the participant-facing information and survey prior to the pilot. The ethics committee accepted the use of a short version of the Participant Information Sheet (PIS) with a link to the full PIS which improved the user-friendliness of the survey. The importance of sharing the findings with the group to maintain engagement and a sense of satisfaction over their involvement in a project was also apparent.

Organising a PCPI group from applying for funding through to conducting the first meeting and collating the feedback was a fantastic learning experience. There were both positives and negatives to this process. As this group would be meeting remotely, recruitment could take place across the entire UK and therefore widen the potential for diversity amongst members which was a positive. It was difficult to ascertain people's backgrounds and/or ethnicities unless they volunteered this information. Conducting remote meetings did mean that participation was largely an exercise in trust in terms of people having the lived experience they claimed they had, and being who they said they were, particularly if they subsequently did not engage well during meetings or kept their cameras off. Conducting a short one-to-one interview with prospective members would have helped dispel these uncertainties. Setting up and running the PCPI group was time-consuming due to the number of tasks it entailed such as creating advertisements, corresponding with potential members, arranging, and conducting meetings, providing technological support to members, facilitating payments, collating feedback, and resolving any issues.

For the first meeting, two members were well-prepared and on time, with five joining altogether, although one person clearly had technological issues and emailed me to apologise and offered to give feedback via email. The other two joined late and hadn't contacted me to let me know in advance, so this was quite disruptive. More time should have been allocated for introductions, as these took longer than expected. Despite these issues, the group gave very useful feedback although not everyone agreed on every point. All feedback was considered valuable, and duly noted and considered carefully before decisions were made regarding the study.

Only one member joined the second meeting despite four others accepting the invitation. Unfortunately, this resulted in disappointment for the group member who did attend the second meeting, but led to a useful discussion on the process of recruiting a PCPI group which will valuable in future. The attending member was experienced in PCPI and recommended conducting short interviews with prospective group members to discuss their interest in the topic, commitment to attend meetings, willingness to engage with a group and, if meetings are to taking place remotely, to have their camera on. It is important to note the factors that can be discouraging to a group, including members not engaging well, not contributing to meetings, leaving cameras off during remote meetings, and not joining when they had accepted the invitation, so that the organiser can attempt to mitigate these by being organised, giving sufficient notice of meetings, maintaining regular contact with members and setting ground rules for meetings, particularly those taking place remotely. Overall, organising this PCPI group was positive and enjoyable and provided lots of learning opportunities as well as some encouraging positive feedback about the study. The group members agreed that they would like to continue to be involved with this project as it progresses and gave permission for their contact details to be kept on file. This is important as patient and carer involvement should continue throughout a project.

5.7.5 Reporting PCPI using the GRIPP2

There has been a notable increase in the understanding of, and requirement for, PCPI within research (Scholz et al., 2018). Whilst this is clearly important, it has led to concerns regarding best practice for PCPI. There exists a potential for tokenistic service user involvement, power imbalances, and a lack of reporting of the influence of PCPI on research (Scholz and Bevan, 2021, Scholz et al., 2018, Happell et al., 2019). Efforts are being made to address the lack of reporting of PCPI in research, through the use of checklists such as the Guidance for Reporting Involvement of Patients and the Public Short Form (GRIPP2-SF), and GRIPP2 Long Form (GRIPP2-LF) (Staniszewska et al., 2017). However, these checklists themselves can give the impression that PCPI is unusual, allow tokenism to remain hidden, and favour clinical or research experience over service users lived experience (Scholz and Bevan, 2021). Reflexivity is important and should be encouraged when practicing PCPI (Scholz and Bevan, 2021), whether PCPI is the main or secondary focus of a study (Staniszewska et al., 2017). Scholz and Bevan (2021) suggest use of the GRIPP2 should be conducted thoughtfully with meaningful contributions by service users considered. Authors should reflexively report how PCPI influenced the research, what challenges there were and how these were addressed. In order to describe the aims and methods used for PCPI, and the extent of its influence on the study, the GRIPP2-SF was used following completion of the PCPI activities. This form is appropriate for use where PCPI is a secondary focus within a study, whereas the GRIPP2-LF is used when PCPI is the primary study focus (Staniszewska et al., 2017). A copy of the completed GRIPP2-SF for this study can be found in *Appendix 5.12.* This checklist has been included in dissemination activities.

5.7.6 Funding

The PCPI for this study was supported by a grant awarded by the NIHR Research Design Service (RDS) North West Public Involvement Fund.

5.8 Conclusion

This is the first study to explore stroke survivor perspectives of aerobic exercise in the UK using an online survey. However, this study population was biased towards those who were engaged with exercise prior to and since their stroke. Despite this, it still provided valuable stroke survivor perspectives on aerobic exercise in the UK, including the factors influencing their participation, and added to the limited literature in this area of research. Furthermore, it contributed to a stroke research priority identified in the 2021 John Lind Alliance Priority Setting Partnership around the use of exercise to improve fitness and help prevent further stroke.

This evidence indicates a need to develop and implement context-appropriate methods of raising awareness of the benefits of aerobic exercise amongst stroke survivors, of equipping healthcare professionals with the knowledge and skills to confidently provide information and prescribe aerobic exercise after stroke, and of resourcing services within local communities to encourage long-term engagement with aerobic exercise.

5.9 Chapter summary

This chapter has described the survey conducted to address **Thesis Objective 3** by exploring UK stroke survivors' perspectives of aerobic exercise. Most participants were aware off, and participated in, aerobic exercise, both before and since their stroke. However, the majority said they had not been spoken to, or offered aerobic exercise as part of the rehabilitation. The three main barriers to participation in aerobic exercise from these stroke survivors' perspectives (n = 51) were lack of knowledge, fear of injury, and lack of interest or motivation. However, as noted previously in sections 3.5.4.2, 5.2.2, and 5.6.6, there are conflicting views about stroke survivor motivation in the literature, with some reporting that stroke survivors are motivated to exercise, and others describing a lack of motivation, so this requires further research. The top three facilitators were having a group exercise option, supervision from an exercise trainer or exercise professional, and information on exercising safely. The next chapter will integrate the findings from all three studies, and interpret and discuss the integrated findings in the context of existing literature and stakeholder engagement.

CHAPTER 6 FACTORS INFLUENCING THE IMPLEMENTATION OF AEROBIC EXERCISE AFTER STROKE FROM STAFF, SYSTEM, AND STROKE SURVIVOR PERSPECTIVES: INTEGRATED FINDINGS

6.1 Chapter overview

The previous chapters have described the three studies which addressed Thesis Objectives 1, 2 and 3 by exploring the factors influencing the implementation of aerobic exercise after stroke from the perspectives of staff, a system, and stroke survivors, respectively. The purpose of this chapter is to address **Thesis Objective 4** by describing the process of integrating the findings from the three individual studies, as well as the interpretation, discussion, and stakeholder views of the integrated findings.

6.2 Introduction

There are four main steps to a convergent mixed methods approach as described in section 2.3.2. The first step was completed by collecting data for Studies 1, 2 and 3. The findings from each study were analysed separately using appropriate methods, thereby completing step 2. Step 3 involves integrating the three sets of findings using a joint display. The degree to which the integrated findings converge or diverge are then interpreted for step 4, which is the final step in this approach. This integration and interpretation generate a greater understanding of the factors influencing the implementation of aerobic exercise after stroke than is possible when each perspective is considered in isolation.

6.3 Objectives

Thesis Objective 4. To integrate and interpret the findings from the systematic review, observational study, and survey, using a convergent mixed methods approach to generate a more complete understanding of the factors influencing the implementation of aerobic exercise after stroke in the UK from the perspectives of staff, system, and stroke survivors.

- **Study Objective 4a.** Integrate the findings from Study 1, 2, and 3, and present these in a joint display table to identify points of convergence or divergence.
- **Study Objective 4b**. Interpret how the integration of findings generates a more

complete understanding of the factors influencing implementation.

6.4 Integration

6.4.1 Intent of the integration

The intention of the integration was to facilitate comparison of the qualitative and quantitative results, where each had equal emphasis, in terms of convergence and divergence, to expand understanding and provide insight into the research question.

6.4.2 Integration methods

6.4.2.1 Joint display

The findings from the three studies were integrated in a side-by-side joint display that was structured using the domains and relevant constructs from the most recent version of the CFIR (Damschroder et al., 2022) (*Appendix 2.1*). A brief description of the updated CFIR is provided in section 2.5.3. This was conducted by deductively coding the findings from each study to constructs within the CFIR, beginning with the systematic review (staff perspectives), followed by the survey (stroke survivor perspectives), and finally the observational study (system perspective). In the first iteration of the joint display, column 1 contained the CFIR domains and definitions of the subject of each domain in the context of this thesis. Column 2 stated the CFIR constructs to which data were coded. Columns 3, 4 and 5 displayed findings from each of the three studies coded to each construct. Column 5 indicated convergence, divergence, or where data was from one perspective only. Data were classed as convergent where they confirmed or agreed with each other, and divergent where they disconfirmed or disagreed. Constructs for which no data were entered were removed from the joint display table.

6.4.2.2 Stakeholder engagement

The integration was carried out by the author with feedback from her supervisory team, then stakeholder engagement sessions were conducted to enhance validity and add credibility to the integrated findings. In preparation for these meetings, the author created a concise summarised colour-coded version of the initial joint display table, and a visual representation of the condensed findings using an adapted version of the CFIR diagram (Center for Implementation, 2023). During stakeholder meetings, a brief overview of the

PhD was given, and the summarised integrated findings shared and discussed with the stakeholders. Based on stakeholder discussions and supervisor feedback, both the concise version of the joint display and the diagram were amended to indicate whether factors were barriers, facilitators, or context-dependent, and which perspective(s) each finding was from, i.e., stroke survivor, staff, or system.

6.4.3 Integration results

The integrated findings are shown in *Table 6.1,* the concise version of the joint display. A full version of the joint display can be found in *Appendix 6.1*. In *Table 6.1*, a summarised definition of the subject of each CFIR domain is provided in the first column, as recommended in the CFIR guidance. As context determined whether factors were positive or negative, results were colour-coded as green for facilitators, red for barriers, and blue for context-dependent. Context-dependent factors could be either a barrier or facilitator and in some cases were not defined as one or the other. The last column indicates whether the factor was from a stroke survivor, staff, or system perspective. In *Figure 6.1*, the integrated findings are displayed visually. These factors are interpreted and discussed in section 6.5.

Table 6.1. Factors influencing the implementation of aerobic exercise after stroke from staff, system, and stroke survivor perspectives

*CFIR Domains	Factors	Perspective		
		Stroke Survivor	Staff	CR System
Innovation **Aerobic exercise (AEx) after stroke: participation or process of its delivery (initial referral → discharge or onward referral)**	Screening for AEx prescription		✓	
	Number of professionals involved		✓	
	Important post-stroke	✓	✓	
	Recommended post-stroke	✓	✓	
	Adaptable post-stroke		✓	
	Expected positive outcomes	✓		
Outer setting **UK Politics, guidelines, COVID-19,**	Networking and skill-sharing between organisations (e.g., healthcare and community exercise)		✓	

healthcare system, community exercise settings				
Inner setting **Local NHS services, leisure centres, gyms, and other community-based exercise providers**	Funding models for AEx delivery		✓	
	Lack of time to implement		✓	
	% of stroke survivors in programme (CR)			✓
	Overall numbers of patients in a service (CR)			✓
	Interprofessional communication and collaboration within organisations		✓	
	Knowledge sharing between professionals and services		✓	
	Training, funding, and resources		✓	✓
	Improving skills to deliver aerobic exercise		✓	
	Stroke service organisation and provision		✓	
	Geographical coverage of services		✓	
	Fit of implementation within staff role, responsibility, and workflow		✓	
	Stroke survivor social (support) and cultural factors	✓	✓	✓
	Onward referral process		✓	
Individuals (Recipients) **Stroke survivors**	Lack of knowledge on how to exercise	✓		
	Fear of injury	✓		
	Lack of interest/motivation	✓		
	Information on exercising safely and effects of aerobic exercise	✓		
	Confident about participation in AEx	✓		
Individuals (Deliverers) **Staff**	Lack of knowledge on how to prescribe		✓	
	Fear of liability and making stroke survivor worse		✓	
	Confidence to prescribe exercise varied		✓	

	Concerns about stroke survivor motivation and ability to participate		✓	
	Willingness to undergo training to implement		✓	
	Service accessibility		✓	
Implementation process **Usual practice within healthcare or exercise settings in the UK**	Impact of stroke survivor needs and comorbidities on ability to participate		✓	✓
	Safety and perceived risk to stroke survivor		✓	
	Supervision from professionals	✓		
	Group exercise option	✓		
	Commence aerobic exercise during inpatient stay	✓		
	Stroke survivor characteristics – age, deprivation, additional comorbidities, cardiac treatment, and previous cardiovascular disease event			✓

*Domains as per the updated CFIR *(Appendix 2.1)*

Key	Barrier	Facilitator	Context-dependent

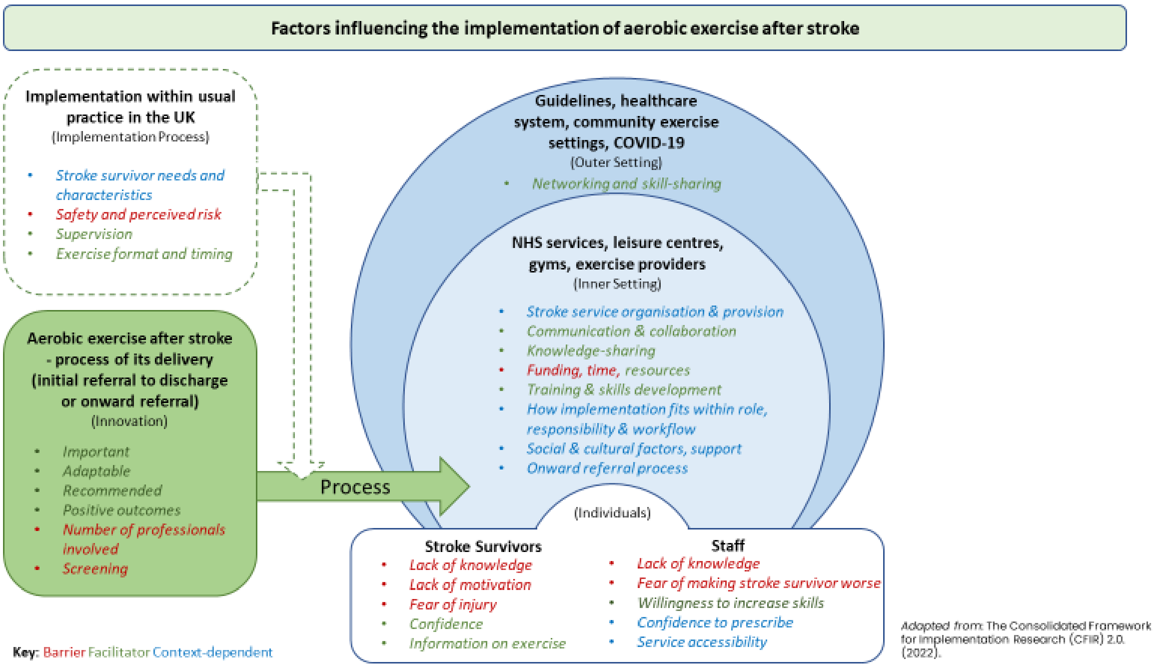

Figure 6.1. Integrated thesis findings organised and displayed as per the CFIR domains, adapted from The Consolidated Framework for Implementation Research (CFIR) 2.0. Adapted from Damschroder, L. J., Reardon, C. M., Widerquist, M. A. O., et al. (2022). The updated consolidated framework for implementation research based on user feedback. Implementation Science, 17, 75. https://doi.org/10.1186/s13012-022-01245-0. Image adapted by The Center for Implementation, © 2022. Version: V2024.01. https://thecenterforimplementation.com/toolbox/cfir.

6.5 Interpretation and discussion of the integrated findings

The following interpretation and discussion of the integrated findings has been organised using the five CFIR domains of *Innovation, Outer Setting, Inner Setting, Individuals,* and *Implementation Process*, although there can be overlap of findings across these domains.

6.5.1 Innovation domain

The subject of the *innovation* (or intervention) domain was defined as aerobic exercise after stroke and the process of its delivery. As described in section 2.5.3, this definition was necessarily broad, as it has become clear over the course of this PhD that the term 'aerobic exercise' has different meanings from different perspectives. For example, stroke survivors may view it as where, when, and how they participate in any type of exercise which is aerobic in nature, whereas staff are likely to consider the wider aspects of the process of implementing aerobic exercise, including elements such as initial referral, screening, assessment, exercise prescription and delivery, as well as discharge from a service, and/or onward referral to another professional, service or setting. The CR system views aerobic exercise as one element within CR which forms part of the wider provision of CR from an organisational perspective. The constructs to which findings were coded under the *Innovation* domain were *Evidence-base*, *Adaptability* and *Complexity*.

6.5.1.1 Evidence-base

There was a point of convergence within this construct as staff and stroke survivors shared similar positive views of aerobic exercise in terms of its importance and benefits.

Staff believed aerobic exercise was important and should be prescribed post-stroke, whilst stroke survivors recognised it was recommended and expected to experience positive outcomes from their participation. These views are reassuring as they indicate that staff and stroke survivors perceived value in delivering and participating in aerobic exercise, particularly given the major changes to the UK stroke clinical guidelines (2023), with cardiorespiratory training now very clearly advocated for all stroke survivors once medically stable. Cardiorespiratory fitness can be improved using aerobic exercise that is of sufficient intensity to generate a training effect, and be carried out throughout rehabilitation, regardless of time since stroke, the person’s age, or how severe their impairments are (Intercollegiate Stroke Working Party, 2023). Furthermore, exercise as part of secondary prevention was identified as one of the top ten research priorities in rehabilitation by the stroke community in the UK (Hill et al., 2022). However, improving cardiorespiratory fitness is just one element of stroke rehabilitation, with other impairments such as balance, cognition, upper limb weakness, and fatigue, as well as person-specific risk factors, that may need to be addressed post-stroke (NHS, 2022). Furthermore, the focus and priority during rehabilitation is often on function rather than exercise (Regan et al., 2021b, Clague-Baker et al., 2024), despite the benefits of improving cardiovascular fitness and its importance for secondary prevention.

6.5.1.2 Adaptability and complexity

The factors within these two constructs were from a single perspective only. Staff agreed that aerobic exercise could be adapted and individualised for stroke survivors and identified this as a facilitator. However, its adaptability overlapped with staff concerns for the complexity of its implementation, citing the number of steps and number of professionals required as barriers. Although positive about the intervention, staff expressed concerns about how to screen patients for aerobic exercise. The UK stroke clinical guidelines (2023) recommend pre-participation screening, and provide examples of screening tests that could be used, such as the 6 minute walk test (6MWT) or shuttle walk test (SWT), which are field-based exercise tests. Lack of knowledge on how to conduct screening tests have been reported by physiotherapists in Canada (Legasto-Mulvale, Inness and Salbach, 2024), despite provision of specific information and rationale on screening and conducting exercise testing pre-participation in the Canadian Aerobic Exercise Recommendations to Optimize Best Practices In Care after Stroke (AEROBICS) (MacKay-Lyons et al., 2019). This suggests that guidelines and recommendations alone do not provide a solution to lack of knowledge, and that additional elements are needed to address this. The challenges of implementing practice guidelines or recommendations within stroke and other areas of healthcare are documented in the literature (Cormican, Hirani and McKeown, 2023, Fischer et al., 2016). Indeed, it was in response to the acknowledgement that the clinical uptake of the Canadian stroke guidelines (2020) was suboptimal, that experts originally developed the AEROBICS practical guide to post-stroke exercise screening and testing and continue to update this regularly (MacKay-Lyons et al., 2019). However, there is currently no known equivalent guide available in the UK. In the UK stroke guidelines, staff working in stroke services are encouraged to collaborate with CR or pulmonary rehabilitation services to access screening protocols, develop exercise programmes, and access equipment (Intercollegiate Stroke Working Party, 2023). This does indicate that sharing knowledge and skills could help to address the concerns around screening.

6.5.2 Outer setting domain

The subject of the *Outer setting* domain was defined as the political context, relevant guidelines and policies, the COVID-19 pandemic, economic conditions, and funding and commissioning of services at one level, and the UK healthcare system and community exercise settings at the next level. There is, however, some overlap with the *Inner setting* domain. The UK publicly funded healthcare system is complex and consists of numerous organisations at central, national, regional, and local levels which have different roles and responsibilities (NHS, 2024). For example, Integrated Stroke Delivery Networks (ISDN) are at a regional level, whereas hospital services are at local levels. Findings were coded to just one construct within the *Outer setting*, *Partnerships and Connections*.

6.5.2.1 Networking and skill-sharing between organisations

One factor was coded to this domain, under the *Partnerships and Connections* construct, and was from a staff perspective only. Networking and skill-sharing between organisations, was viewed as a facilitator for the implementation of aerobic exercise post-stroke. One known example of how this is operationalised in the UK is a collaborative approach between the NHS and the Stroke Association, a third sector organisation, to provide community support to stroke survivors and their families (Stroke Association, 2023a). The acute care, rehabilitation, and long-term support phases of the UK stroke pathway delivered through ISDNs *(Figure 6.2*) advocate services which are aligned and collaborate to provide comprehensive personalised care for stroke survivors. In this example, the Stroke Association provides services which the NHS does not have the capacity to provide, but which the NHS commissions the Stroke Association locally to carry out, although provision can vary across the UK. Types of support provided by the Stroke Association include communication, emotional, and long-term needs. This collaboration is only effective because of networking and communication between these two organisations, with NHS stroke services signposting or referring patients to the Stroke Association.

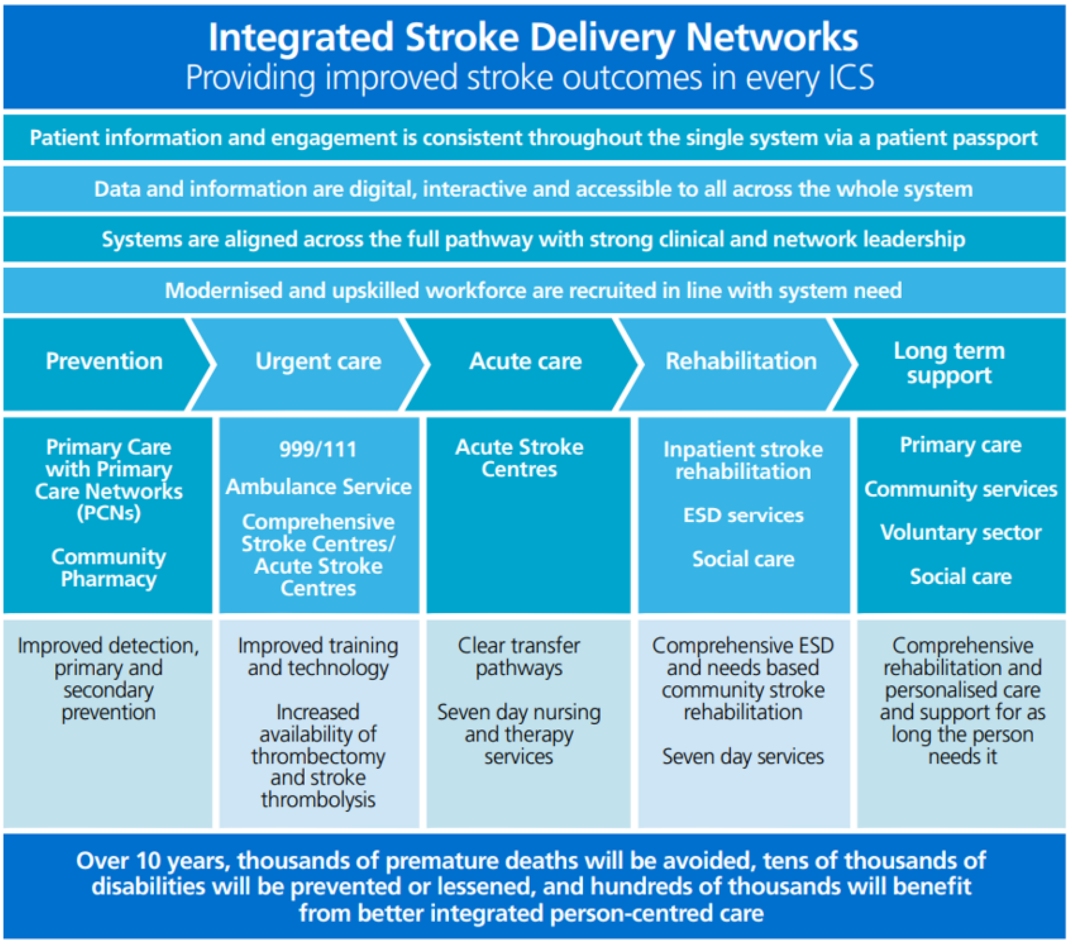

Figure 6.2. Integrated Stroke Delivery Network (ISDN) infographic (NHS England, 2021)

In the literature, Best et al.'s (2012) survey of community Exercise after Stroke services in Scotland reported that NHS health professionals were often the referrers to these services, most of which were delivered by charity collaborations or leisure centres. In terms of skill-sharing, physiotherapists have been involved with training and supporting exercise professionals to provide exercise programmes for people with neurological conditions in a collaboration between healthcare and recreation centres in Canada (Merali et al., 2016). Furthermore, Condon and Guidon (2018) advise that further exploration of partnership models, such as between physiotherapists and exercise professionals, which aim to facilitate exercise professionals to provide exercise programmes for stroke survivors is warranted. However, sustaining partnerships between healthcare and recreation or leisure providers can be challenging and require joint efforts to maintain engagement (Salbach et al., 2018).

6.5.3 Inner setting domain

Local NHS services, including acute stroke units, rehabilitation centres, CR programmes, and neuro-outpatient clinics, and community-based exercise providers, such as leisure and fitness centres, private and public gyms, and charities delivering exercise programmes, are defined as the *Inner setting.* Study findings were coded to a total of eight constructs within the *Inner setting* domain.

6.5.3.1 Structural characteristics

The factors coded to this construct were from staff perspectives only. Staff identified that the way stroke services and their staffing were organised, the services they provided, and the geographical areas that they covered, influenced implementation of this intervention. Stroke services across the UK vary for numerous reasons, including the complexity of the healthcare service, funding of services, resources, and population needs. Mapping existing service provision across the stroke pathway within defined footprints at a regional or local level, such as ISDNs or hospital trusts and sites, may enable identification of the nuances within local services and the opportunities for engaging stroke survivors with aerobic exercise. For example, this activity could identify an opportunity to provide secondary prevention information, including exercise and signposting to community exercise-based services, to those with TIA or mild stroke within the pathway. Any service changes should address local stroke survivor needs, which could be identified through engagement with patients, carers, and members of the public.

6.5.3.2 Relational connections and communications

Communication and collaboration between professionals within organisations were identified as facilitators by staff under the *Relational connections* construct. This overlaps with, and is expanded by, facilitators in the *Communications* construct, namely communication within organisations, and knowledge-sharing between professionals and services. These findings were all from a staff perspective and emphasise the importance staff placed on effective communication and collaborative working for successful implementation.

Collaboration is present in the wider implementation literature, where the relational aspect of implementation involved in building relationships and mutual trust amongst stakeholders is already being examined (Rapport et al., 2022). These factors are also reflected within the UK stroke clinical guidelines, where collaboration with other services providing exercise-based services, such as CR and pulmonary rehabilitation, is encouraged to facilitate delivery of exercise interventions by sharing resources (Intercollegiate Stroke Working Party, 2023). In Canada, having expert support from staff working in exercise-based rehabilitation services has been shown to improve self-efficacy in implementing aerobic exercise amongst stroke rehabilitation physiotherapists (Inness et al., 2022). Professionals working in these services have skills in cardiovascular training and are well-placed to support and advise stroke rehabilitation staff who are implementing exercise in their practice. Furthermore, the system study identified that additional comorbidities are associated with stroke survivors' engagement with CR, some of which may require specific adaptations to exercise on which professionals from other areas of healthcare could advise.

6.5.3.3 Culture

Cultural factors were raised only by staff as influencing implementation, whereas social factors were a point of convergence as they were identified by staff, stroke survivors, and the system. Staff were aware that social factors influenced implementation, with stroke survivors citing a lack of support as a barrier to participation in aerobic exercise. The system study found a positive association with both uptake and completion of CR amongst stroke survivors who had a partner. Stroke survivors have previously identified support from family, friends, peers, and professionals as social facilitators of exercise (Clague-Baker et al., 2017, Dam and Rhind, 2020). People who had experienced TIA and minor stroke in the UK (n = 12) identified informal sources of support, including family and friends for practical and emotional support, and self-management for fatigue and cognition, and formal sources such as support services and charities such as the UK's Stroke Association (Turner et al., 2019). As discussed in section 5.7.7, this finding and the literature highlight how important social support is to stroke survivors in encouraging them to participate in exercise. It is also worth noting that not all staff may be fully aware of social or cultural barriers faced by stroke survivors (Clague-Baker et al., 2020). Discussions with the PCPI group involved with the stroke survivor perspectives study (Study 3) indicated that cultural influences and social circumstances also influence engagement with exercise. They suggested engaging with community centres and groups to ascertain local exercise delivery preferences, and then conducting a trial of the intervention in a small geographical area before wider roll-out. This data could be used to inform decisions on the most appropriate format of aerobic exercise provision, thereby maximising uptake, and engagement with aerobic exercise.

6.5.3.4 Compatibility

There were two factors in this construct, both solely from a staff perspective. The first was implementation fit within the individuals' role, responsibility, and workflow, and the second was the process for onward referral of stroke survivors to other healthcare or exercise professionals or services. Provision of aerobic exercise is not always perceived by staff as a routine part of practice. This was reported as a barrier to the implementation of aerobic exercise by Doyle and MacKay-Lyons (2013) in their survey of physiotherapists working in neurological rehabilitation settings in Canada. More recently it has been described in relation to aerobic exercise testing, where just 55% of survey participants (n=29) agreed that testing formed part of their physiotherapy role (Legasto-Mulvale, Inness and Salbach, 2024). Challenges to incorporating exercise prescription and delivery into workflows have been identified (Axelson et al., 2014), and this can be related to lack of time to implement (Doyle and MacKay-Lyons, 2013, Otterman et al., 2012).

The process for onward referral to other professionals or services could be viewed as a barrier or a facilitator, depending on whether the process exists, is clear, and has been shared with staff. As processes and pathways are often specific to organisations, and even to sites or departments within organisations such as the NHS, they should be identified and mapped out locally. For example, Physical Activity Referral Schemes, to which GPs can refer those with long-term conditions, are offered in some, but not all, areas of the UK, and inclusion criteria may vary. A knowledge of referral processes within an organisation links with the factor on communication and collaboration between professionals within organisations, as this is necessary for the referral process to be carried out effectively. It also overlaps with the factor relating to networking and skill-sharing between organisations. The ability to refer or signpost stroke survivors to community-based exercise programmes or support, relies on a knowledge of locally available services or agencies. The UK stroke clinical guidelines recommend that stroke rehabilitation services create connections with community-based exercise facilities to encourage long-term engagement with physical activity and exercise for stroke survivors (Intercollegiate Stroke Working Party, 2023). Therefore, greater communication can reap benefits for stroke survivors, staff, and organisations, by increasing awareness of available services and facilitating collaborative working.

6.5.3.5 Incentive systems, available resources, and access to knowledge and information

The factors within these three constructs are interrelated and are therefore discussed together. The only point of convergence was in the *Available Resources* construct where findings from the staff and system studies converged on factors relating to staffing and resources.

Staff believed that having access to sufficient resources such as physical space, equipment, and training would help implementation, but that lack of time was a barrier. In the system study, increased staff hours were associated with increased likelihood of completion of CR in people with comorbid stroke. Interestingly, the proportion of patients with comorbid stroke in a programme was associated negatively with uptake, but positively with completion, and the overall number in a service was negatively associated with both uptake and completion. This could be related to the recommended ratio of staff to patients comprehensively stated within the UK CR standards, which is based on risk stratification and the level of supervision each patient requires due to coexisting disabilities (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). In a UK feasibility study for adapted CR after mild-to-moderate stroke, a decision was made, based on stroke severity and the levels of supervision required, to limit the number of stroke survivors included in the CR classes to three out of 14 participants for safety reasons (Clague-Baker et al., 2022). A limited staff-to-patient ratio was identified by CR coordinators as one of the main barriers to stroke survivors attending CR in Australia (Howes, Mahenderan and Freene, 2020). However, although these findings and the literature highlight the need for adequate staffing, other practical factors also need to be taken into account.

Availability of, and accessibility to, appropriate physical space to conduct aerobic exercise training is another consideration. Lack of adequate physical space in which to conduct exercise classes for people with balance and mobility limitations, including stroke, and store equipment hindered delivery in Canadian recreation centres (Salbach et al., 2018). Lighting, access, toileting facilities and room temperature, as well as availability of suitable equipment are important, regardless of whether exercise is being delivered in a healthcare or community setting. The ACPICR (2023) standards for exercise for the cardiovascular population include guidelines for risk assessment of the exercise venue in terms of space, temperature and equipment. In a hospital setting, staff may need to think creatively in terms of how they use available space or consider what other appropriate spaces are accessible and available. Liaising with other services delivering exercise interventions may enable sharing of exercise space and equipment, as suggested within the UK stroke clinical guidelines (2023), through the innovative use of existing resources and creation of more efficient ways of working and collaborating.

This collaborative approach may also be useful in acquiring resources for screening and exercise testing, access to which staff cited as a facilitator for implementation. Screening stroke survivors for exercise is recommended in the UK stroke clinical guidelines (2023), which also state that equipment such as treadmills, ECG machines, and blood-pressure monitors should be available for screening, monitoring, and exercise prescription after stroke. However, challenges around the availability of equipment for both screening and exercise delivery have been reported widely in the North American literature (Salbach et al., 2018, Prout et al., 2016, Billinger et al., 2014, Legasto-Mulvale, Inness and Salbach, 2024), with physiotherapists in Canada citing lack of knowledge and lack of equipment as some of the main barriers to conducting inpatient aerobic exercise testing with stroke survivors (Legasto-Mulvale, Inness and Salbach, 2024). Unfortunately, this is unlikely to be less of a problem in the UK. However, it should be noted that these types of equipment are used relatively routinely within CR in the UK to screen, prescribe and monitor exercise. Therefore, collaboration with professionals within these exercise-based rehabilitation services may, again, provide a solution.

One facilitator coded to the *Inner setting* domain, specific to a staff perspective, was funding for training. Exercise professionals were interested in stroke-specific training on safety, the physical and cognitive aspects of stroke, adaptive exercise and equipment, and communication (Condon and Guidon, 2018), whereas physiotherapists wanted to improve their skills in incorporating aerobic exercise into their practice (Prout et al., 2016). Funding was perceived as an incentive amongst exercise professionals in Ireland to undertake appropriate training to work with stroke survivors (Condon and Guidon, 2018). Any type of training generally requires funding in one form or other, whether for conferences, courses, or consultancy fees, backfilling a staff member's hours whilst receiving or providing training, or through provision of time for regular continuing professional development. Training and funding were both identified by staff as facilitators of implementation, but are challenging to provide or acquire in the current NHS climate of high pressure on resources, and increasing cost pressures in publicly-funded leisure services (Local Government Association, 2024, Dunn, Ewbank and Alderwick, 2023). Lack of funding for training may also be a challenge within exercise and fitness settings, where exercise professionals may need to self-fund or seek support from charitable organisations. Perhaps in some areas there could be an opportunity for reciprocal training, for example, where physiotherapists provide stroke-specific training to exercise professionals, and in return the exercise professionals provide training on aerobic exercise prescription and delivery to the physiotherapists. This approach would simultaneously facilitate collaboration and address staffs' lack of knowledge in a cost-effective way.

6.5.4 Individuals domain

This domain is divided into two subdomains, *Roles,* and *Characteristics*. The subjects of the *Roles* subdomain were defined as staff, who were the deliverers of the intervention, and stroke survivors, who were the recipients. Staff included healthcare and exercise professionals from the systematic review and survey, and multidisciplinary healthcare professionals delivering CR from the observational study. In the systematic review, stroke survivors were recipients of the intervention that staff perspectives were being sought on. Stroke survivors were participants in the survey and were the population of interest in the observational study.

The subject of the *Characteristics* domain was defined simply as the characteristics of healthcare, exercise, and fitness staff, and of stroke survivors. Constructs to which data were coded were *Capability, Opportunity,* and *Motivation.*

6.5.4.1 Capability

This CFIR defines the *Capability* construct as “the degree to which the individual(s) has interpersonal competence, knowledge, and skills to fulfil role” (Damschroder et al., 2022). The integration revealed several convergent factors in this construct which were knowledge, fear, and confidence, identified by both staff and stroke survivors.

Knowledge of aerobic exercise was an important point of convergence for staff and stroke survivors. Staff reported a lack of knowledge of the intervention, and stroke survivors a lack of knowledge on how to exercise, as barriers to delivery and participation, respectively. In addition, stroke survivors wanted information on how to exercise safely. In the *Innovation* domain, staff believed that the intervention could be adapted to suit stroke survivors’ needs, but in the *Inner setting* domain they expressed a need for funding for training in the delivery of exercise post-stroke. The latter aligns with the finding in the staff study that not all exercise professionals or physiotherapists possessed factual knowledge about the intervention in relation to screening, prescription and guidelines (Boyne et al., 2017a, Doyle and MacKay-Lyons, 2013, Wiles et al., 2008). In a UK study on adapted CR after stroke, stroke rehabilitation staff expressed lack of knowledge about cardiovascular training, as well as CR and healthy lifestyles (Clague-Baker et al., 2024). In Canada, physiotherapists in two studies (n=37 and n = 137) identified knowledge and skills as barriers to aerobic exercise testing (Legasto-Mulvale, Inness and Salbach, 2024, Foster et al., 2019). Furthermore, Legasto-Mulvale, Inness and Salbach (2024) reported that although around half of 31 participants’ physiotherapy training had included learning how to carry out exercise testing, only 50% (n=14/28) felt confident about their ability to carry out a field test, and less than half believed that physiotherapists are experts in exercise testing after stroke. Additionally, even when they did have access to exercise test results, just 45% or less knew how to use these to guide the exercise prescription (Legasto-Mulvale, Inness and Salbach, 2024).

Stroke survivor perspectives were that lack of knowledge on how to exercise was a barrier, but information on exercising safely, as well as information on the beneficial effects of exercise, would facilitate their participation. This suggests that stroke survivors are either not being provided with, or signposted to, information about exercise, or that information is not being provided at an appropriate time for that stroke survivor. The timing of advice for stroke survivors about healthy lifestyles has been identified as important by stroke staff (Clague-Baker, 2020). Some tailored information is currently available, such as the guide published by the Stroke Association (2022) entitled “Getting Active after Stroke” which provides practical information for stroke survivors about incorporating activity and exercise into daily routines, but stroke survivors may need to be signposted to resources such as this. Health literacy, the ability to access, understand, and use information, can be impacted by the characteristics of stroke, but provision of information by health professionals can improve this (Flink et al., 2023, Bogaert, 2020). As health literacy is potentially associated with rehabilitation outcomes, it is important to consider how and when information about aerobic exercise is offered. The components of stroke rehabilitation may vary depending on the needs of the stroke survivor, and the local contexts and settings in which it is delivered. Therefore, points of opportunity for teaching and learning about aerobic exercise may be identifiable throughout a stroke survivor’s journey of recovery, with long-term engagement in exercise essential for secondary prevention. Teachable moments have been described in the literature as the time at which people are most open to significantly changing their behaviours and lifestyle following a major event such as stroke (Hall et al., 2020, Ing et al., 2015). Hall et al. (2020) reported that the timing varies depending on the stroke survivor’s recovery and related capabilities. This suggests that a ‘drip-feed’ approach may be advantageous, whereby staff provide accessible appropriate information at multiple time-points throughout a person’s rehabilitation journey. The Stroke Association’s guide to getting active suggests seeking advice from health professionals if people are unsure of what activities are safe for them to do (Stroke Association, 2022), but staff need to know what that advice should be. Therefore, if staff’s knowledge of aerobic exercise after stroke could be increased through training and support, they would be well-positioned to educate stroke survivors about the effects and benefits of aerobic exercise, and advise them on safe exercise participation.

Staff expressed a willingness to improve their knowledge and skills so they could implement aerobic exercise after stroke. This should ideally be undertaken with managerial or organisational support, and could include formal or informal training, peer discussion, support from staff experienced with this intervention, learning from publications and clinical guidelines, as has been reported for other stroke rehabilitation interventions (Weerakkody et al., 2023). In the UK, formal training courses on exercise after stroke, such as the validated Exercise and Fitness Training after Stroke Instructor course previously delivered by Later Life Training, or the Functional Rehabilitation & Exercise Training after Stroke (FRETS) course delivered by the ARNI programme, may be appropriate. In Canada, an online training course, e-AEROBICS, has been developed for physiotherapists and includes behaviour management, exercise physiology, assessment, screening, and prescription of aerobic exercise (Thornton et al., 2021). This was designed to facilitate the translation of the AEROBICS recommendations to clinical practice. The updated UK stroke clinical guidelines (2023) provide more detail around delivery of aerobic exercise than the previous (2016) version of the guidelines, but focus mainly on actual interventions rather than how to implement these.

Fear, a convergent factor, was a barrier to implementation for staff and stroke survivors, although for different reasons. Fear of injury was identified as a barrier by stroke survivors, whereas staff reported a fear of liability and of making the patient worse. Stroke can affect cognition, communication, balance, and movement, so fear of injury or falling is a real concern for many stroke survivors, and has been identified as a barrier to exercise participation (Aguiar et al., 2022, Prout et al., 2017). However, a Cochrane review did not find any evidence of injuries being caused by fitness training, and exercise participation can reduce this risk and improve balance (Regan et al., 2021b, Saunders et al., 2020). Steps can also be taken during participation in exercise to mitigate the risk of falling, for example by using equipment such as a cycle ergometer where available (Aguiar et al., 2022). Risk of injury can be addressed through education about exercise technique and modes such as stretching (Billinger et al., 2014). The UK stroke clinical guidelines (2023) have a number of recommendations in relation to falls, one of which is twice weekly participation in exercise that includes balance and coordination work.

For healthcare staff, fear of making a patient worse is not always a negative, as it indicates the importance they attach to delivering good clinical care, and can also reveal any uncertainties staff have around particular interventions (Bogaert, 2020). In the context of aerobic exercise after stroke, fear is arguably linked with lack of knowledge, which then impacts confidence. Condon and Guidon (2018) found that exercise professionals who had undergone stroke-specific training were less likely to be fearful of worsening a stroke survivor’s condition. Fear and lack of confidence were reported in a UK feasibility study on adapted CR for stroke survivors (Clague-Baker et al., 2020). In this study, stroke and CR staff expressed concerns that exercise could have negative effects on a stroke survivors’ tone, although no evidence of this effect was found, and some stroke survivors with increased tone reported that exercise had helped with reducing tightness in their limbs (Clague-Baker, 2020). For reasons of safety, there are some stroke-specific physiological factors that need to be considered and adjusted for when conducting exercise testing and prescribing exercise for stroke survivors, such as changes to cerebral circulation and early onset of muscle and general fatigue (Marzolini et al., 2019, Liguori, 2020). Staff’s concerns around making the patient worse overlap with ‘safety and perceived risk’, a factor which was coded to the *Assessing needs* construct in the *Implementation Process* domain, and is discussed under that domain.

Confidence was a point of convergence, as it was a factor in both the staff and stroke survivor studies. Staff had variable levels of confidence regarding prescribing exercise, described as a barrier to implementation, whereas being confident about participation was a facilitator for stroke survivors. According to Boyne et al. (2017a), particular areas of uncertainty for staff were exercise intensity (99/416), and strategies for increasing motivation (109/416) and self-efficacy (96/416) amongst stroke survivors. Staff’s lack of confidence could be linked to fear and lack of knowledge, and it has been noted that education and support can increase confidence (Inness et al., 2022). A link between staffs’ confidence and their knowledge and skills regarding an intervention has been reported in the stroke rehabilitation literature in relation to aerobic exercise and constraint-induced movement therapy (Weerakkody et al., 2023, Inness et al., 2022). Training and skills development lead to improvements in capability and self-efficacy amongst physiotherapists implementing aerobic exercise after stroke (Inness et al., 2022), again highlighting the links between knowledge, skills and confidence.

In CR, one of the reasons for encouraging people to engage with individualised exercise, is to facilitate learning about exercising safely and effectively whilst under supervision, so they become confident in their own ability to exercise appropriately and independently (Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). This learning enables them to apply the same principles to exercising outside the sessions, with the aim of enabling them to continue to exercise long-term as part of secondary prevention, thereby reducing the likelihood of a further event. If staff are well-trained and knowledgeable about aerobic exercise after stroke, they can confidently educate and advise stroke survivors. Indeed, the UK stroke clinical guidelines instruct staff to use methods such as physical activity platforms or social networking apps to build confidence amongst stroke survivors and encourage adherence to exercise (Intercollegiate Stroke Working Party, 2023).

6.5.4.2 Opportunity

Accessibility of services emerged as a factor from a staff perspective only. Staff reported variations in accessibility and inclusivity of services, particularly for stroke survivors with more complex needs or who are less ambulatory (Best et al., 2012). This is reflected in the literature, where most research around exercise after stroke has focussed on people with mild to moderate stroke, although research involving those with more severe stroke is emerging (Valkenborghs et al., 2019, Lloyd et al., 2018). However, the UK stroke clinical guidelines (2023) state that aerobic exercise should still be offered, regardless of the severity of the person's impairments. The GIRFT review of NHS stroke services reported a lack of equity in access to inpatient and community stroke rehabilitation in the UK (Hargroves and Lowe, 2022). It recommended that seven-day integrated community stroke services could support community rehabilitation to help address this inequity. Provision of community exercise after stroke programmes or services has previously been reported as insufficient (Best et al., 2012, Fullerton et al., 2008), with stroke survivors currently advised by the Stroke Association to contact their GP or stroke team regarding the availability of exercise programmes in their local area (Stroke Association, 2024b). Alternatives to face-to-face exercise programmes include online resources such as the '12-week Stroke-Specific Exercise Video Programme' produced by the Stroke Association and Stroke of Luck charities, which are available free-of-charge and accessible from home (Stroke Association, 2021). Telerehabilitation services are also an option in some areas, one example of which is the NROL service (Ackerley et al., 2023). Telerehabilitation is recommended in the UK stroke clinical guidelines (2023) for augmentation of in-person stroke rehabilitation, provided the stroke survivor has sufficient access to, and support with, the appropriate technology. Having a broader menu of offers may provide the opportunity to access exercise services to a greater number of stroke survivors. However, care must be taken not to inadvertently widen inequity of access.

6.5.4.3 Motivation

Staff and stroke survivor perspectives converged around motivation. Stroke survivors identified that lack of interest or motivation to exercise was a barrier to participation, and staff were concerned about stroke survivors' lack of motivation to exercise. A lack of knowledge of strategies to improve stroke survivors' motivation was reported by 109/416 physiotherapists in a US study (Boyne et al., 2017a). However, as described previously in sections 3.5.4.2, 5.2.2, and 5.6.6, the evidence around stroke survivors' motivation is mixed, with less than one third (9/32) of inpatient stroke survivor participants in a Canadian study reporting that people were unmotivated to take part in exercise early after stroke (Prout et al., 2017). Staff taking part in focus groups as part of a UK CR after stroke study believed that stroke survivors were mostly motivated to be physically active (Clague-Baker et al., 2020). Furthermore, mild, moderate, and severe stroke has not been differentiated between in this thesis, so there is a possibility that stroke severity may also be an influencing factor.

Understanding the benefits of aerobic exercise can be motivational for stroke survivors, with information about aerobic exercise perceived as a facilitator by participants in the stroke survivor study. Although this factor relates to stroke survivor motivation, there is a question over staff's motivation to discuss and prescribe aerobic exercise with stroke survivors when exercise is given less priority than other interventions. In Canada, a lack of resources led to a need to prioritise improving function over aerobic exercise participation during inpatient rehabilitation to facilitate discharge home, even though staff viewed aerobic exercise as best practice (Inness et al., 2022). This highlights that staff often feel they have restricted choice over what they include in rehabilitation sessions, due to factors outside their control, even where evidence and guidelines support an intervention. However, facilitators for implementation identified in the staff perspectives study were that aerobic exercise after stroke was a desirable intervention, and that staff were willing to facilitate its implementation through training. Therefore, it may be that provision of training could influence motivation for exercise prescription and delivery by staff.

In summary, the factors in this domain are linked to the likelihood of stroke survivors engaging initially with aerobic exercise and with sustaining their engagement in the longer term. This is essential if improving cardiorespiratory fitness is to be addressed as part of secondary prevention of further stroke or cardiac events.

6.5.5 Implementation process

The subject of this domain was usual practice within healthcare and/or exercise settings within the UK. The factors coded to this domain were under the *Assessing needs* construct.

6.5.5.1 Assessing needs

In the *Implementation Process* domain, findings from all three studies converged around stroke survivor needs and characteristics. Staff's concerns around the impact of comorbidities, and physical and cognitive needs, were reflected in the system perspective where additional comorbidities had variable associations with uptake and completion of CR. Stroke survivors' identified exercise preferences, in terms of timing and format, as facilitators for participation. Safety and perceived risk to the patient was a factor from a staff perspective only.

The UK stroke clinical guidelines (2023) recommend that exercise programmes should be individualised according to the stroke survivor's goals and take into account any comorbidities the person may have. Globally, people are increasingly presenting with multi-morbidities (two or more comorbidities), as demonstrated by both the literature (Forman et al., 2018, Chowdhury et al., 2023, NACR, 2019), and the additional comorbidities reported in the system study. Additional comorbidities bring more complex needs, so prescription and delivery of exercise after stroke will need to be tailored appropriately, with modifications made as necessary.

In the survey (Study 3) stroke survivors' expressed preferences for starting aerobic exercise during the inpatient stay. This aligns with a finding in a Canadian study, where most stroke survivor participants (28/32) expressed a willingness to commence aerobic exercise as inpatients, although the study was conducted in an inpatient setting (Prout et al., 2017). It may be helpful to introduce the concept of aerobic exercise to stroke survivors whilst they are inpatients, depending on the individual. Although in the survey (Study 3) most participants were already engaged in exercise pre-stroke, this was a small self-selecting sample (n =51), and the reality is that many stroke survivors are deconditioned before their stroke occurs, so exercise participation may be unfamiliar to them (Billinger et al., 2014). The inpatient stay may provide an opportunity to begin the process of education about aerobic exercise and its beneficial effects in relation to quality of life and secondary prevention.

Supervision by an exercise professional or personal trainer was viewed by stroke survivors as a facilitator for participation. A Norwegian study found that stroke survivors (n = 135) who received coaching sessions, delivered by physiotherapists over an 18-month period, maintained adherence to weekly exercise sessions (Gunnes et al., 2018). In relation to physical activity participation more than six months post-stroke, health professionals were seen as a positive influence by stroke survivors (n = 38) although lack of self-management advice or individualisation of exercises was a frustration to some participants (Morris et al., 2017). Conversely, interviews with 13 stroke survivors in the UK found that lack of professional support hindered participation in physical activity following discharge from healthcare services (Nicholson et al., 2014). The literature confirms that health professionals have an important role to play in facilitating stroke survivors' engagement with exercise.

The option of group exercise was identified by stroke survivors as a facilitator for exercise participation. This preference has previously been reported by Banks et al. (2012) in an Australian study using the Exercise Preference Questionnaire, and by Aguiar et al. (2022) in a study regarding aerobic exercise after stroke in Brazil. Group exercise has certain advantages for both stroke survivors and staff. It can provide peer support, motivation, and some accountability to attendees, as well as obvious benefits related to staff capacity and skill-mix. Peer support has been identified as a benefit of group exercise by stroke survivors (Nicholson et al., 2013). Within CR, exercise classes are often delivered by a multidisciplinary team with a variety of staff types such as nurses, health care assistants, occupational therapists, physiotherapists, or exercise specialists (NACR, 2023). The increasing complexity that accompanies comorbidities means a wider mix of staff skills could facilitate individualised exercise prescription. In leisure centres and gyms, personal trainers are generally available to provide support with exercise programmes, with some stroke survivors preferring to exercise away from healthcare settings (Norris et al., 2013). However, not all staff believe that they are skilled in delivering group exercise to stroke survivors, with one survey in Ireland reporting that just 16/76 (21%) of exercise professionals rated their group exercise skills as good or very good (Condon and Guidon, 2018). The exercise professionals commented that difficulties can arise with supervising group sessions where stroke survivors have varying abilities and require different levels of supervision, so one-to-one sessions may be preferable (Condon and Guidon, 2018). Furthermore, greater need for one-to-one supervision can increase the cost of providing and attending exercise sessions. In Canada, the Stroke Recovery in Motion Implementation Planner was developed to guide the planning, implementation, and maintenance of stroke-specific community-based exercise programmes (Reszel et al., 2022b), to increase the availability of, and access to, exercise programmes for stroke survivors in community settings.

Staff had concerns around safety and perceived risk to the patient, which could influence the implementation of aerobic exercise after stroke. This finding overlaps with other factors, previously discussed within the *Individuals* domain, of fear of making the patient worse, and knowledge on how to prescribe and deliver exercise to this group. A lack of knowledge around actual risk to the patient versus the perceived risk may exist, which could be addressed through appropriate education. A Cochrane review found a lack of evidence of serious adverse events during physical fitness training post-stroke, although few studies reported these events, so this is not generalisable to the wider stroke population (Saunders et al., 2016). Furthermore, few adverse events related to the intervention were reported in Lloyd et al.'s (2018) systematic review on physical fitness training for non-ambulatory stroke survivors. It has been reported that exercise testing post-stroke is safe for most people with mild to moderately severe stroke (Machado et al., 2023), with no serious adverse events during sub-maximal exercise testing reported in a recent scoping review (Legasto-Mulvale et al., 2023). Furthermore, 19/26 (73%) physiotherapist participants in a Canadian survey believed it was safe for stroke survivors (Legasto-Mulvale, Inness and Salbach, 2024). Despite this evidence, therapists are still concerned about adverse cardiovascular events during exercise testing and delivery (Norris et al., 2013). However, the UK stroke clinical guidelines (2023) stipulate that exercise should be offered to all stroke survivors, once they are medically stable, regardless of stroke severity, so these concerns need to be addressed through training and support to enable staff to knowledgeably and confidently prescribe and deliver aerobic exercise post-stroke.

6.5.6 Summary of convergent factors

To summarise, main areas of convergence in the integrated findings were as follows:

- The positive views of aerobic exercise expressed by stroke survivors and staff, and the importance of social support in facilitating participation.
- The availability of resources such as staffing, training, and equipment were factors from staff and system perspectives. To address resource issues, it may be necessary to investigate more efficient ways of working, as well as identify collaborative approaches to delivery of aerobic exercise in practice.
- Knowledge, fear, and confidence amongst staff and stroke survivors. These factors are modifiable and could be addressed through staff training, education, and with support from other exercise-based rehabilitation services.
- Staff should be aware that some stroke survivors may lack of motivation to participate in exercise and explore ways to address this, including with technology.
- The needs and characteristics of stroke survivors, including comorbidities, safety during exercise, and exercise preferences, are factors that can inform activities and strategies to increase implementation.

6.6 Stakeholder engagement

To contextualise and validate the integrated findings, the author held virtual meetings with over 28 allied health professionals and assistant practitioners from four NHS hospital trusts in the North West and Midland regions of England, as well as four private practitioner physiotherapists from one private practice in the Midlands region during late 2023 and early 2024.

The NHS staff who attended the meetings held a variety of clinical roles at differing levels of seniority, such as neurological rehabilitation physiotherapist, consultant stroke physiotherapist, ISDN facilitators, occupational therapists, speech and language therapists and assistant practitioners. The NHS staff worked in services across the stroke pathway, including acute inpatient stroke rehabilitation, stroke rehabilitation, early supported discharge (ESD) in two adjacent geographical areas with very different local populations, outpatient neuro-rehabilitation, and within an Integrated Stroke Delivery Network (ISDN). The private practitioners worked within a neurological rehabilitation practice which provided a community-based physiotherapy service and group exercise classes, one remote and two in-person, which stroke survivors could attend. All staff had experience within stroke rehabilitation, although local patient populations were varied due to the differences in the geographical footprints covered by both the NHS and private services.

A total of seven meetings were conducted, during which a brief overview of the thesis was given, and the integrated findings presented in table and diagram formats (*Appendix 6.2)* as described in section 6.4.2.2. This generated discussion around staff's views of the thesis findings, their knowledge of aerobic exercise for stroke survivors and the current stroke clinical guidelines, ways in which they could incorporate, or were incorporating, aerobic exercise into their clinical practice, and what they would find helpful to increase implementation going forward.

6.6.1 Stakeholder views

Overall, the integrated findings presented at the stakeholder meetings were not surprising to staff working in relevant clinical settings, indicating both validity and credibility of the factors identified in this thesis. Notes were taken by the author during and after these meetings and the key topics that arose from the discussions are described below.

6.6.1.1 Process

The availability of resources for exercise screening, testing, and delivery, and staffs' skills and knowledge, were key thesis findings. In terms of implementing aerobic exercise, staff at the stakeholder meetings discussed their current practice around screening and monitoring, their access to, and use of, equipment, the referral process, and the timing for delivery of aerobic exercise to stroke patients. The topics of their discussions resonated with what was found in the thesis.

Regarding screening and monitoring tests, staff said they used the 6-minute walk test (6MWT) occasionally in practice, and the shuttle test rarely, but did not use either for screening prior to cardiorespiratory exercise. Most did not use the rating of perceived exertion (RPE) to prescribe or monitor exercise, although staff agreed that there were potential opportunities to use this during rehabilitation sessions. They agreed with the thesis finding around stroke survivor needs and characteristics influencing implementation saying, for example, that patients generally wouldn't manage either test due to the severity of their impairments. Staff could readily access blood pressure machines, but used these to monitor haemodynamic stability rather than exercise, and some had access to treadmills which they would use with an overhead hoist to support the patient, but did not have access to ECG machines. These tests and equipment are recommended in the UK stroke clinical guidelines (2023) for exercise screening, prescription and monitoring, but staffs' discussions further validated the findings around lack of skills, knowledge and resources limiting implementation of these recommendations and therefore aerobic exercise.

In agreement with the thesis findings, staff were unsure of the referral process for exercise, who the referrer should be, and who should make the decision on whether exercise participation was safe and appropriate. Timing of the offer or commencement of aerobic exercise was seen as important, also in line with the findings, with some suggesting this should begin during the inpatient stay so that it is seen as part of routine rehabilitation, others recommending 6 – 12 months post-stroke as an appropriate time, and also that the offer should be repeated if not taken up initially.

6.6.1.2 Knowledge and resources

In this thesis, the knowledge and resources that staff possessed to prescribe and deliver aerobic exercise to stroke patients were reported as some of the barriers to implementation. These factors were also raised during the stakeholder meetings, which suggested that these are ongoing issues, therefore validating these thesis findings.

The NHS staff supported the thesis finding that aerobic exercise was generally less of a priority than interventions targeting function, balance work, and management of muscle tone, as they rarely prescribed or delivered aerobic exercise. In contrast, the private practitioners provided exercise classes which were open to stroke survivors, although they still faced issues around accessing appropriate training on exercise delivery, as per another thesis finding. Staff agreed that lack of time was a barrier to implementing aerobic exercise, sometimes due to the pace at which patients were moved from one part of a stroke service to another. Many lacked knowledge and confidence to prescribe aerobic exercise, and expressed safety concerns around shoulder subluxation, increasing tone, or causing adverse events through exercise. They strongly supported the challenges of accessing training on exercise prescription and delivery in the UK, although were keen to improve their knowledge and skills in this area, as found in the thesis.

6.6.1.3 Stroke survivor needs and characteristics

This thesis identified stroke survivors' motivation and social support, and the accessibility of services, as factors that influenced implementation. In the stakeholder meetings, staff expressed concerns about these same barriers, which are described below, indicating their agreement with the thesis findings.

Stroke survivors' lack of motivation was noted at several meetings. Staff believed this could be due to stroke survivors still processing what had happened, or because aerobic exercise was not routinely discussed or recommended as part of secondary prevention by doctors. Their discussions supported the thesis finding that stroke survivors often focussed on goals unrelated to cardiorespiratory fitness. Staff agreed that family and carer support during rehabilitation was valuable and important, with some staff actively encouraging family involvement to support rehabilitation outside formal therapy sessions. They also agreed that there were challenges to accessing services, which included transport and parking issues, financial barriers, and stroke survivors' physical and cognitive abilities.

6.6.1.4 Collaboration

Collaboration between and within organisations and professionals was a key thesis finding. Furthermore, as discussed previously, the UK stroke clinical guidelines (2023) recommend collaboration with other exercise-based services, such as CR or pulmonary rehabilitation for exercise screening, equipment, and support with exercise delivery for stroke survivors.

Collaboration was a point of discussion at all stakeholder meetings, which adds credibility to this thesis finding.

Staff agreed that collaboration was important, but could be challenging, with stroke rehabilitation staff generally not working with, or knowing, the staff that delivered other exercise-based rehabilitation at their site, such as CR. Often within healthcare, services and staff work in silos, based in different buildings or locations within the same hospital trust Furthermore, prior to the meeting, most had not considered initiating a collaboration to share knowledge and resources around aerobic exercise. Not all staff were aware of local community-based exercise services available to stroke survivors following discharge from their care. However, some positive examples of collaboration between healthcare and community exercise services which benefitted stroke survivors were shared. This supports the thesis finding that collaboration between professionals and services is feasible and would facilitate implementation of aerobic exercise, although stroke staff may need to actively plan and facilitate this. Some were aware that staff delivering other exercise-based services may not be familiar with the changes to the UK stroke clinical guidelines (2023) in relation to aerobic exercise, and that collaboration should be approached with this in mind, particularly given the general resource and capacity challenges within health and care services. Furthermore, the resource-sharing recommended in the UK stroke clinical guidelines may be challenging depending on the location of equipment or space within sites.

6.6.1.5 Summary and implications

Discussions with staff confirmed many of the factors identified in this thesis. Aerobic exercise was not a priority for most staff, who generally focused on function, balance, and tone management. Barriers such as lack of time, resources, and knowledge, hindered implementation. Many agreed that stroke survivors' lack of motivation was a challenge, and that timing of when aerobic exercise was offered was important. Examples of successful collaboration between healthcare and exercise services, and between one stroke and CR service, were shared, but collaboration could be challenging. Most staff were not familiar with the updated UK stroke clinical guidelines around exercise after stroke.

During the stakeholder meetings, potential solutions to these challenges were discussed. They supported the prioritisation of addressing knowledge, fear, and confidence amongst staff as an initial step. Proposals around staff education included a one-day course comprising the evidence for aerobic exercise after stroke, 'myth-busting', and a how-to guide to exercise prescription. Another popular suggestion was a guideline or toolkit, similar to those developed for CR, containing information on the evidence for, and benefits of, aerobic exercise, together with a practical guide to exercise prescription and delivery following stroke. The establishment of links with other exercise-based rehabilitation teams within organisations, or with community-based exercise services to share knowledge and skills, and equipment or physical space, could also be considered. Staff working in exercise and fitness settings were not involved in these stakeholder discussions but should be involved in any future discussions or plans, particularly as long-term engagement with exercise needs to be facilitated.

Although the UK stroke clinical guidelines (2023) provide recommendations around cardiorespiratory training, there is clearly a gap between what is recommended and what is delivered in practice, which is the implementation gap. The complexity of implementation is reflected in the range of influencing factors identified in this thesis. These ongoing challenges lead to questions around whether implementation science, borne of a need to facilitate the translation of research knowledge into practice, has actually been successful in its aim.

6.7 Additional discussion points

6.7.1 Methodology

Mixed methods research is usually conducted with two studies, one qualitative and one quantitative (Creswell and Plano Clark, 2017). However, as this thesis explored three perspectives on aerobic exercise implementation, three studies were conducted using different study designs, one for each perspective. The author directly influenced how and what data were collected in the systematic review and survey studies, whereas with the retrospective observational study, this was not possible as the data had been collected for an alternative primary purpose. Using the CFIR helped to identify common concepts across the findings, and where there was convergence, but also highlighted findings that were unique to one study, which did not have directly comparable findings in any other study. This was particularly the case with the system findings, from which no factors were coded to the *innovation* domain or *individual characteristics* subdomain, compared to the findings from the staff and stroke survivor studies which were coded to all five domains. This could be a reflection of the use of secondary data analysis for one study, or of the differences between individuals' perspectives and a system perspective. Some CFIR constructs therefore only contained data from one study. Furthermore, the convergent mixed methods design involves developing side-by-side comparisons of the qualitative and quantitative data, but there is limited guidance available on developing joint displays using multiple data sources. However, the juxtaposing of the quantitative and qualitative data using the CFIR as a comprehensive structure facilitated the generation of new insights into what influences the implementation of aerobic exercise after stroke.

6.7.2 Implementation science

Implementation and its theories, models and frameworks are not intuitively understood by clinicians as suggested by Lynch et al. (2018), who, in response, created a simplified guide to implementation with the intention of facilitating understanding and use. Despite this guide, however, the implementation of evidence-based interventions and guidelines remains challenging. The CFIR was developed to assist implementation and was chosen for use in this thesis based on its comprehensibility. However, the author was mindful that the language used in the CFIR needed to be simplified during stakeholder meetings for the purposes of clarity of understanding, and avoiding distraction from the findings, which were the intended main focus of the meetings. Therefore, the domains were described as categories, the constructs as sub-categories, and the entire framework as a means for organising the factors identified.

Implementation science aims to reduce the evidence-to-practice gap, and consists of two components, implementation research and implementation practice. The research component aims to identify the best approaches for translating knowledge into practice, whereas the practice component focusses on how to adapt and apply these approaches in different contexts to achieve sustainable outcomes (Ramaswamy et al., 2019). Despite development within the field of implementation science, a perceived gap between implementation research and implementation practice has been recognised (Metz et al., 2022, Rapport et al., 2022), and is being reflected upon by implementation researchers and implementation practitioners (Beidas et al., 2022, Moore and Khan, 2023). The concept that these should form a cycle has been conceived, whereby the implementation research component informs the implementation practice component and vice versa (Ramaswamy et al., 2019). This process requires implementation researchers and practitioners to engage with each other and with other stakeholders, such as patients and the public, using a shared language to foster relationships and build mutual trust (Rapport et al., 2022). Collaborative working, together with choosing flexible implementation methods which can be used in real-world settings, may be beneficial for creating a bi-directional bridge between implementation research and implementation practice, and therefore translating evidence into practice (Rapport et al., 2022, Moore and Khan, 2023).

6.7.3 Collaboration between researchers and practitioners

The conversations during stakeholder engagement meetings about the thesis findings highlighted a need for more collaboration between researchers and practitioners, to establish a space where co-learning can occur in the context of shared principles and the common goal of improving healthcare outcomes for stroke survivors. Stroke survivors, their families, and carers are experts by experience and need to be included in any plans and decisions around services which involve stroke care. Implementation is often taking place within complex contexts and limited capacity, such as within the UK's NHS, and is therefore incredibly challenging. Additionally, stroke itself is a complex condition, requiring a multi-faceted approach to rehabilitation and secondary prevention (NHS, 2022). To address these issues, research should focus on adapting implementation strategies which are responsive to stakeholder needs and can be delivered in a supportive environment by fostering relationships and trust amongst all stakeholders, including service users, as well as sharing knowledge and experience. The findings from this thesis could be used to inform the development of these implementation strategies to improve the rate at which aerobic exercise is prescribed and delivered in practice.

6.7.4 Multimorbidity exercise rehabilitation

Traditionally healthcare has focussed on the treatment of single diseases, with clinical guidelines often based on evidence for single health conditions in the absence of multimorbidity (National Institute for Health and Care Excellence, 2016). This means that people with multimorbidity are being treated under multiple sets of guidelines, which may not be appropriate given the overall treatment burden and potential interaction between single disease medications and treatments (National Institute for Health and Care Excellence, 2016). Rehabilitation is also delivered in disease-specific silos. Given that CR, stroke, and pulmonary rehabilitation guidelines recommend the individualisation of exercise programmes, accounting for co-existing diseases, this raises a question about alternative modes of delivery. Would a multimorbidity or function-led rehabilitation model of delivery be more appropriate for those with multiple comorbidities? A pilot RCT in Australia evaluated the feasibility of multimorbidity rehabilitation, and compared outcomes of those attending disease-specific rehabilitation (n = 8) and multimorbidity rehabilitation (n = 9) consisting of education and exercise components (Barker et al., 2018). They found that multimorbidity rehabilitation programmes are feasible, but that a larger RCT would be needed to determine the effects on clinical outcomes. In the UK, one example of ongoing collaborative research exploring individualised exercise for people with multimorbidity is the PERFORM trial, plans for which involves a multicentre RCT (National Institute for Health and Care Research, 2022).

6.7.5 Implementation of clinical guidelines

The focus of this thesis was the implementation of aerobic exercise after stroke. Aerobic exercise is one of the interventions recommended for implementation within the UK stroke clinical guidelines. It is recognised that clinical guidelines form an important part of evidence-based best practice, but challenges to implementing these into healthcare practice have been widely reported in the literature globally (Otterman et al., 2012, Overington et al., 2014, Spallek et al., 2010). There are similarities between the factors influencing the implementation of clinical guidelines and those identified in this thesis. Barriers to implementation have included time constraints, lack of trust in the evidence, and lack of knowledge and skills (Spallek et al., 2010, Wang et al., 2023, Correa et al., 2020). Cormican, Hirani and McKeown (2023) conducted a systematic review of factors that staff perceive as influencing the implementation of stroke clinical guidelines into practice. This included 22 studies with a total of 1576 participants, of whom 1297 were physiotherapists, occupational therapists, and speech and language therapists. They found that the main barriers were time, resources such as equipment, physical space and funding, skills and knowledge, and lack of organisational processes such as protocols. Training on recommended interventions, organised dissemination of guidelines, and support from management and leadership in prioritising implementation were facilitators for implementation. An earlier qualitative study with 28 health professionals in Australia investigated the implementation of multiple stroke guidelines (McCluskey, Vratsistas-Curto and Schurr, 2013). The authors reported that beliefs about capabilities and consequences, in addition to reminders to implement were the main factors, but that staff's motivation and skills were also influential. This literature indicates that many of the factors that influence the implementation of clinical guidelines are the same as, or similar to, those which influence aerobic exercise after stroke. Furthermore, the clinical guideline literature offers some insight into the importance of managerial support for staff, and of organisational processes which can help or hinder implementation. Currently, UK staff working in stroke rehabilitation are grappling with the updated stroke clinical guidelines (2023) and what these mean for their services and practice in a high-pressure, under-resourced environment. Every effort should be made to provide them with the support and resources they need to deliver best clinical practice for stroke survivors, and researchers can contribute to this by working collaboratively with staff.

6.7.6 Strengths and limitations

The strengths and limitations of the three individual studies conducted for this thesis have been described in their respective chapters (see sections 3.7.6, 4.6.5, and 5.7.10). The strengths and limitations of the thesis are described here.

This thesis used a mixed methods approach to explore the factors influencing the implementation of aerobic exercise after stroke from multiple perspectives. The advantages of this approach are that it provides a more comprehensive understanding of the research topic than using a quantitative or qualitative approach alone, and can generate new insights via the integration of the findings from different sources (Creswell and Plano Clark, 2017), as was the case with this thesis. The convergent mixed method design chosen facilitated the use of data collection methods and analysis which were appropriate for each type of data sought. There are limited examples of use of the CFIR, an implementation framework, in previous mixed method studies (Adamu et al., 2020, Barwick et al., 2019), and so the successful use of it in this thesis was another strength. This choice was justified due to the focus on the determinants of implementation and the multiple perspectives being explored. It provided a comprehensive structure for the creation of the joint display, helped to organise the integrated factors, and facilitate their interpretation and discussion, whilst its novel use has added to the mixed-methods literature.

Each of the three studies investigated three separate, but important, views of the factors influencing implementation of aerobic exercise after stroke, so it was important to consider both the similarities and differences between these three views. However, one limitation to the convergent mixed method approach is that disparities between the three thesis studies and their data sources are effectively hidden by the joint display. For example, the data for the system perspectives study was from cardiac rehabilitation rather than stroke, although justifiably so as no existing stroke database collects information on exercise post-stroke, whereas the staff perspectives study focused on stroke and aerobic exercise, though it did include the perspectives of some cardiac rehabilitation staff, and the survey data in the stroke survivor perspectives study solely focused on stroke and aerobic exercise. Also, the joint display does not indicate that the perspectives of managers and commissioners, whose roles in implementation are described in the literature, are missing from the integration. This was a limitation given the important roles they play within healthcare implementation (Birken et al., 2018a). They can provide support to staff around training, resources, and the organisational processes involved in the implementation of evidence-based practice and clinical guidelines, thereby influencing prioritisation of implementation (Birken et al., 2018a, Cormican, Hirani and McKeown, 2023). They are also involved in decision-making around the financing and commissioning of services (Birken et al., 2018a, Cilenti et al., 2012), so their views should ideally also be investigated and included in future implementation research and planning.

Another strength of this thesis was the inclusion of PCPI. Discussions with people with lived experience of stroke guided the direction of the research following the systematic review, and, in the case of the survey, ensured the research was relevant to stroke survivors. Involving patients, carers, and the public in research is now regarded as best practice, but limited guidance exists on the role of PCPI in implementation research (Gray-Burrows et al., 2018), and it can be quite challenging to conduct within doctoral studies due to funding and time constraints (Coupe and Mathieson, 2020). Furthermore, PCPI is not always reported consistently, meaning learning is lost (Staniszewska et al., 2017). The author made every effort to ensure PCPI within this thesis was meaningful and conducted appropriately. Contributions to the survey (Study 3) made by the PCPI group were acted upon as described in Chapter 5. Their involvement was reflected upon by the author and reported using an appropriate tool, the GRIPP2 (*Appendix 5.12),* which has contributed towards improving the transparency, quality, and consistency of the evidence base around PCPI in research.

Similarly, involving other stakeholder perspectives is also important. The stakeholder engagement meetings involving over 28 healthcare staff, working in range of stroke rehabilitation settings, was a strength. The discussions in these meetings validated and added credibility to the integrated findings within the context of current practice. In future, it would be advantageous to also conduct stakeholder engagement meetings with staff working in exercise and fitness settings, to ascertain their level of agreement with the factors identified in this thesis as their experiences could differ to those of healthcare staff.

6.8 Conclusion

Four objectives were set for this thesis, with three studies and an integration conducted to meet these objectives. **Thesis Objective 1** was to establish what was already known about the factors influencing delivery of aerobic exercise after stroke from a staff perspective. This was fulfilled via the systematic review of the perspectives of staff working within healthcare, exercise, and fitness settings. **Thesis Objective 2** involved exploring the factors associated with the uptake and completion of cardiac rehabilitation by people with comorbid stroke in the UK at a system-level. The retrospective observational study conducted with data selected from the NACR database met this objective. **Thesis Objective 3** was to investigate stroke survivors' perspectives of aerobic exercise in the UK and was fulfilled via the online survey conducted on adult stroke survivors' views. **Thesis Objective 4**, the final thesis objective, was to generate a more complete understanding of the factors influencing the implementation of aerobic exercise after stroke in the UK. This was done by integrating and interpreting the thesis findings, discussing the factors in the context of the literature and the UK clinical guidelines for stroke (2023), and conducting stakeholder engagement meetings to validate the findings. By fulfilling all four objectives, the overall aim of the thesis was addressed, and the research question, *What influences the implementation of aerobic exercise after stroke in the UK?,* was answered.

6.8.1 Implications for research and practice

During the process of conducting this PhD, the author grew in their recognition of the need for greater alignment of research with practice. Research should be guided by practice, and practice guided by research, using a collaborative bi-directional approach towards improving healthcare processes and outcomes. The increasing emphasis on meaningful patient and public involvement in research, and in implementation research and planning, is to be welcomed, although this needs to be reported more consistently in studies (Gray-Burrows et al., 2018).

The thesis findings, together with discussions during the staff engagement meetings, highlighted the challenges and complexities around the implementation of aerobic exercise after stroke, particularly in the context of vast variation of everchanging service provision and organisation. The findings from this thesis could be used to inform practice and the direction of future research.

The implications for research and practice of this thesis broadly align with the components of the COM-B framework (Michie, van Stralen and West, 2011), and are therefore described under the COM-B categories of capability, opportunity, and motivation.

6.8.1.1 Capability

Some of the key thesis findings related to knowledge and skills, fear, and confidence amongst staff and stroke survivors, and there are many elements to consider around this. Provision of accessible education for staff could be a first step towards improving implementation of aerobic exercise after stroke which could be delivered in a variety of formats such as face-to-face, online platforms, via peer discussion, and expert support.

Some formal training is currently available in the UK, but staff may need to be signposted to this, and be supported with time and funding to enable them to attend. As advised by stakeholders in this project, educational resources could include the evidence for, and benefits of, aerobic exercise testing and prescription, with accurate information or 'myth-busting' around risk and safety of aerobic exercise participation post-stroke, as well as a summary of the relevant sections of the current UK stroke clinical guidelines. A practical how-to guide on screening, assessment, and adaptation of exercise in the context of their local stroke population's needs, with advice on building collaborations with local teams, such as those delivering other exercise-based rehabilitation, gaining managerial support for implementation, and building cases for presentation to commissioners could be developed. There is a need to raise awareness amongst staff of the benefits of aerobic exercise, not just around outcomes such as cardiorespiratory fitness and function, but also about how these outcomes, and stroke survivors' participation in aerobic exercise, can support them in rebuilding their lives after stroke. This could include areas such as family life, employment, leisure activities, lifestyle, and wellbeing. Discussions around how staff can be supported to incorporate aerobic exercise for stroke survivors into their routine clinical practice should be encouraged. Addressing the lack of knowledge amongst staff could contribute to reducing their fear around making the patient worse and increase their confidence and self-efficacy in exercise prescription. However, to implement changes based on knowledge and skills, a wider team approach involving clinical staff, managers, and experts by experience, is needed.

Factors identified from stroke survivor perspectives included knowledge, fear, and confidence. Knowledgeable staff could educate stroke survivors on what aerobic exercise is, its benefits, how to participate safely, and signpost them to support and services to encourage long-term adherence from a secondary prevention perspective.

6.8.1.2 Opportunity

Opportunity can be viewed in different ways from different perspectives. Staff may benefit from identifying opportunities throughout a stroke survivor's rehabilitative journey at which to introduce the concept of aerobic exercise, or to provide education or prescribe or deliver aerobic exercise. Stroke survivors may need to be provided with opportunities and support to participate in aerobic exercise.

Mapping local stroke pathways and services within these could facilitate staff in the identification of 'teachable moments' to introduce aerobic exercise to stroke survivors and their families or carers. The timing of the offer is important and may need to be repeated at various points, possibly by different staff, throughout the individuals' rehabilitative journey. It is also important to raise awareness amongst staff of social and cultural factors, such as family support, or cultural beliefs, values, or practices, which influence participation. Engagement with local community groups could help to inform development of culturally sensitive services. Care must be taken to avoid widening inequity of access to aerobic exercise. Another key finding was the availability of resources to conduct exercise testing, prescription, and delivery. This is challenging given the current constraints on staffing, space, and equipment, and may require alternative ways of thinking and collaborative working to share skills and resources within and between organisations.

Identifying and maintaining up-to-date information on locally available community-based exercise and support services would be beneficial for the referral of stroke survivors to post-discharge from healthcare services. Consideration should be given to how to build sustainable links and partnerships with community-based services, as this could widen the opportunities for stroke survivors to engage with exercise in the longer term.

6.8.1.3 Motivation

In this thesis, stroke survivors' lack of motivation to exercise was identified as a potential barrier. However, it is important to note that there are conflicting views in the literature around stroke survivors' motivation. If lack of motivation is a factor, a variety of strategies could be trialled by staff to address this. These could include provision of information about exercise to stroke survivors, their families, and carers, identifying exercise activities that fit into their daily routine and become habits, or identifying sources of peer or other support. The Stroke Association provides suggestions on their website for strategies to stay motivated to exercise, which stroke survivors could be signposted to if motivation is challenging (Stroke Association, 2022).

Stroke survivors' exercise preferences were also a factor in the thesis findings, and some of these overlap with providing opportunities to engage with exercise. It is worth remembering that in this case, one size does not fit all, and that it may be necessary to provide a menu of options tailored to different preferences, such as group or individual exercise sessions, female-only, and clinical or community settings. Consultation with local stroke survivors and carers is vital to maximise the uptake and success of exercise programmes. The importance stroke survivors place on exercising under the supervision of health or exercise professionals should also be recognised.

Another thesis finding related to whose role or responsibility it is to implement aerobic exercise after stroke, as this is not always viewed as part of routine practice. The identification of onward referral processes and pathways may go some way to clarifying staff's roles within implementation. Furthermore, it must be seen as an organisational priority so that staff are supported in their implementation efforts, which will also lead to increased motivation amongst staff to include and deliver aerobic exercise within their practice.

6.8.1.4 Potential avenues for future research

Future research is needed to develop and test a practical resource to begin to address some of the factors identified by this thesis, particularly around staff knowledge and skills in the delivery of aerobic exercise after stroke, as part of an implementation strategy. This could be similar to the UK ACPICR standards developed for CR, or the AEROBICS guidelines for clinicians developed in Canada, and the e-AEROBICS online course covering behaviour management, exercise physiology, assessment, screening, and prescription of aerobic exercise (Thornton et al., 2021, MacKay-Lyons et al., 2019, Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, 2023). An online training package could be added to the Stroke Specific Education Framework (SSEF) course library to aid accessibility for stroke health and care staff (www.stroke-education.org.uk/). Effective methods of providing accessible training needs to be investigated, but implementation will not be improved by training alone, as illustrated by the range of influencing factors identified in this thesis. The different elements influencing implementation could be addressed in the format of a UK-specific toolkit or strategy encompassing evidence, protocols and standards for testing, prescription and delivery, mapping of processes, collaboration, and team and stroke survivor engagement, which can be adapted to different contexts, and be monitored, evaluated, and refined. One similar example, currently under development in Canada, is the Stroke Aerobic Exercise Implementation Toolkit (START) which will support implementation of aerobic exercise in stroke rehabilitation settings (Inness, [In progress]). Community-based exercise services should also be considered, but it would be essential to collaborate with UK exercise and fitness professionals around service design and delivery. This is especially important as exercise professionals were not involved in the stakeholder engagement meetings about the integrated thesis findings. A Canadian collaboration has designed an implementation guide to developing community-based exercise programmes for people with stroke (Reszel et al., 2022a, Reszel et al., 2022b). Input from other stakeholders, such as managers and commissioners, may also be advisable, to support service design, development, and implementation plans.

A further study could explore the delivery of aerobic exercise after stroke within current UK practice, with the aim of identifying examples of best practice within these services from which learning could occur. As part of this study, it would be important to aim to collect data about stroke severity and time since stroke and investigate how these factors also influence the implementation of aerobic exercise for this population, as this information was lacking to various degrees within the three studies undertaken for this thesis. This could help to tease out any differences between these sub-populations of stroke survivors, such as levels of motivation, specific support required, or the optimal timing of delivery of the intervention. Whatever approach is taken, it is vital to involve a range of stakeholders and researchers, including experts by experience, to maximise likelihood of success in increasing the implementation of aerobic exercise after stroke in the UK.

6.8.2 Original contribution to knowledge

The research completed for this PhD comprises a substantial body of work which has made an original contribution in multiple ways. In addition to the novel use of methods in studies 1,2, and 3, and the previously described contributions made by each study, the integration of findings from these three studies generated the first comprehensive integration of the influencing factors for this intervention from multiple perspectives. The integration enabled identification of factors common to two or three perspectives, as well as those specific to one perspective, providing unique insight into how targeting one modifiable factor could, in fact, simultaneously address others. This thesis thereby contributed towards filling the gap within the existing knowledge around what factors influence the implementation of aerobic exercise after stroke in the UK and provides a springboard from which plans to address these factors can be developed.

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APPENDICES

Appendix 2.1. A copy of the updated Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2022)

Framework Guidance:
The CFIR is intended to be used to collect data from individuals who have power and/or influence over implementation outcomes. See the CFIR Outcomes Addendum for guidance on identifying these individuals and selecting outcomes.
The CFIR must be fully operationalized prior to use in a project:
1) Define the subject of each domain for the project (see guidance for each domain below).
2) Replace broad construct language with project-specific language if needed.
3) Add constructs to capture salient themes not included in the updated CFIR.

I. INNOVATION DOMAIN
Innovation: The "thing" being implemented, e.g., a new clinical treatment, educational program, or city service.
[Document the innovation being implemented, e.g., innovation type, innovation core vs. adaptable components, using a published reporting guideline. Distinguish the innovation (the "thing" that continues when implementation is complete) from the implementation process and strategies used to implement the innovation (activities that end after implementation is complete).]

Construct Name	**Construct Definition** *The degree to which:*
A. Innovation Source	The group that developed and/or visibly sponsored use of the innovation is reputable, credible, and/or trustable.
B. Innovation Evidence-Base	The innovation has robust evidence supporting its effectiveness.
C. Innovation Relative Advantage	The innovation is better than other available innovations or current practice.
D. Innovation Adaptability	The innovation can be modified, tailored, or refined to fit local context or needs.
E. Innovation Trialability	The innovation can be tested or piloted on a small scale and undone.
F. Innovation Complexity	The innovation is complicated, which may be reflected by its scope and/or the nature and number of connections and steps.
G. Innovation Design	The innovation is well designed and packaged, including how it is assembled, bundled, and presented.
H. Innovation Cost	The innovation purchase and operating costs are affordable.

II. OUTER SETTING DOMAIN Outer Setting: The setting in which the Inner Setting exists, e.g., hospital system, school district, state. There may be multiple Outer Settings and/or multiple levels within the Outer Setting (e.g., community, system, state). Project Outer Setting(s): [Document the actual Outer Setting in the project, e.g., type, location, and the boundary between the Outer Setting and the Inner Setting.]	
Construct Name	**Construct Definition** *The degree to which:*
A. Critical Incidents	Large-scale and/or unanticipated events disrupt implementation and/or delivery of the innovation.
B. Local Attitudes	Sociocultural values (e.g., shared responsibility in helping recipients) and beliefs (e.g., convictions about the worthiness of recipients) encourage the Outer Setting to support implementation and/or delivery of the innovation.
C. Local Conditions	Economic, environmental, political, and/or technological conditions enable the Outer Setting to support implementation and/or delivery of the innovation.
D. Partnerships & Connections	The Inner Setting is networked with external entities, including referral networks, academic affiliations, and professional organization networks.
E. Policies & Laws	Legislation, regulations, professional group guidelines and recommendations, or accreditation standards support implementation and/or delivery of the innovation.
F. Financing	Funding from external entities (e.g., grants, reimbursement) is available to implement and/or deliver the innovation.
G. External Pressure	External pressures drive implementation and/or delivery of the innovation. Note: Use this construct to capture themes related to External Pressures that are not included in the subconstructs below.
1. Societal Pressure	Mass media campaigns, advocacy groups, or social movements or protests drive implementation and/or delivery of the innovation.
2. Market Pressure	Competing with and/or imitating peer entities drives implementation and/or delivery of the innovation.
3. Performance-Measurement Pressure	Quality or benchmarking metrics or established service goals drive implementation and/or delivery of the innovation.

III. INNER SETTING DOMAIN **Inner Setting: The setting in which the innovation is implemented, e.g., hospital, school, city. There may be multiple Inner Settings and/or multiple levels within the Inner Setting, e.g., unit, classroom, team.** **Project Inner Setting(s): [Document the actual Inner Setting in the project, e.g., type, location, and the boundary between the Outer Setting and the Inner Setting.]**	
Construct Name	**Construct Definition** *The degree to which:*
Note:	*Constructs A – D exist in the Inner Setting regardless of implementation and/or delivery of the innovation, i.e., they are persistent general characteristics of the Inner Setting.*
A. Structural Characteristics	Infrastructure components support functional performance of the Inner Setting. Note: Use this construct to capture themes related to Structural Characteristics that are not included in the subconstructs below.
1. Physical Infrastructure	Layout and configuration of space and other tangible material features support functional performance of the Inner Setting.
2. Information Technology Infrastructure	Technological systems for tele-communication, electronic documentation, and data storage, management, reporting, and analysis support functional performance of the Inner Setting.
3. Work Infrastructure	Organization of tasks and responsibilities within and between individuals and teams, and general staffing levels, support functional performance of the Inner Setting.
B. Relational Connections	There are high quality formal and informal relationships, networks, and teams within and across Inner Setting boundaries (e.g., structural, professional).
C. Communications	There are high quality formal and informal information sharing practices within and across Inner Setting boundaries (e.g., structural, professional).
D. Culture	There are shared values, beliefs, and norms across the Inner Setting. Note: Use this construct to capture themes related to Culture that are not included in the subconstructs below.
1. Human Equality-Centeredness	There are shared values, beliefs, and norms about the inherent equal worth and value of all human beings.
2. Recipient-Centeredness	There are shared values, beliefs, and norms around caring, supporting, and addressing the needs and welfare of recipients.
3. Deliverer-Centeredness	There are shared values, beliefs, and norms around caring, supporting, and addressing the needs and welfare of deliverers.

4. Learning-Centeredness	There are shared values, beliefs, and norms around psychological safety, continual improvement, and using data to inform practice.
Note:	*Constructs E – K are specific to the implementation and/or delivery of the innovation.*
E. Tension for Change	The current situation is intolerable and needs to change.
F. Compatibility	The innovation fits with workflows, systems, and processes.
G. Relative Priority	Implementing and delivering the innovation is important compared to other initiatives.
H. Incentive Systems	Tangible and/or intangible incentives and rewards and/or disincentives and punishments support implementation and delivery of the innovation.
I. Mission Alignment	Implementing and delivering the innovation is in line with the overarching commitment, purpose, or goals in the Inner Setting.
J. Available Resources	Resources are available to implement and deliver the innovation. Note: Use this construct to capture themes related to Available Resources that are not included in the subconstructs below.
1. Funding	Funding is available to implement and deliver the innovation.
2. Space	Physical space is available to implement and deliver the innovation.
3. Materials & Equipment	Supplies are available to implement and deliver the innovation.
K. Access to Knowledge & Information	Guidance and/or training is accessible to implement and deliver the innovation.
IV. INDIVIDUALS DOMAIN **Individuals: The roles and characteristics of individuals.**	
ROLES SUBDOMAIN **Project Roles: [Document the roles applicable to the project and their location in the Inner or Outer Setting.]**	
Construct Name	**Construct Definition**
A. High-level Leaders	Individuals with a high level of authority, including key decision-makers, executive leaders, or directors.
B. Mid-level Leaders	Individuals with a moderate level of authority, including leaders supervised by a high-level leader and who supervise others.
C. Opinion Leaders	Individuals with informal influence on the attitudes and behaviors of others.
D. Implementation Facilitators	Individuals with subject matter expertise who assist, coach, or support implementation.

E. Implementation Leads	Individuals who lead efforts to implement the innovation.
F. Implementation Team Members	Individuals who collaborate with and support the Implementation Leads to implement the innovation, ideally including Innovation Deliverers and Recipients.
G. Other Implementation Support	Individuals who support the Implementation Leads and/or Implementation Team Members to implement the innovation.
H. Innovation Deliverers	Individuals who are directly or indirectly delivering the innovation.
I. Innovation Recipients	Individuals who are directly or indirectly receiving the innovation.
CHARACTERISTICS SUBDOMAIN **Project Characteristics: [Document the characteristics applicable to the roles in the project based on the COM-B system or role-specific theories.]**	
Construct Name	**Construct Definition:** *The degree to which:*
A. Need	The individual(s) has deficits related to survival, well-being, or personal fulfilment, which will be addressed by implementation and/or delivery of the innovation.
B. Capability	The individual(s) has interpersonal competence, knowledge, and skills to fulfil Role.
C. Opportunity	The individual(s) has availability, scope, and power to fulfil Role.
D. Motivation	The individual(s) is committed to fulfilling Role.
V. IMPLEMENTATION PROCESS DOMAIN **Implementation Process: The activities and strategies used to implement the innovation.** **Project Implementation Process: [Document the implementation process framework and/or activities and strategies being used to implement the innovation. Distinguish the implementation process used to implement the innovation (activities that end after implementation is complete) from the innovation (the “thing” that continues when implementation is complete).]**	
Construct Name	**Construct Definition:** *The degree to which individuals:*
A. Teaming	Join together, intentionally coordinating and collaborating on interdependent tasks, to implement the innovation.
B. Assessing Needs	Collect information about priorities, preferences, and needs of people. Note: Use this construct to capture themes related to Assessing Needs that are not included in the subconstructs below.

1. Innovation Deliverers	Collect information about the priorities, preferences, and needs of deliverers to guide implementation and delivery of the innovation.
2. Innovation Recipients	Collect information about the priorities, preferences, and needs of recipients to guide implementation and delivery of the innovation.
C. Assessing Context	Collect information to identify and appraise barriers and facilitators to implementation and delivery of the innovation.
D. Planning	Identify roles and responsibilities, outline specific steps and milestones, and define goals and measures for implementation success in advance.
E. Tailoring Strategies	Choose and operationalize implementation strategies to address barriers, leverage facilitators, and fit context.
F. Engaging	Attract and encourage participation in implementation and/or the innovation. Note: Use this construct to capture themes related to Engaging that are not included in the subconstructs below.
1. Innovation Deliverers	Attract and encourage deliverers to serve on the implementation team and/or to deliver the innovation.
2. Innovation Recipients	Attract and encourage recipients to serve on the implementation team and/or participate in the innovation.
G. Doing	Implement in small steps, tests, or cycles of change to trial and cumulatively optimize delivery of the innovation.
H. Reflecting & Evaluating	Collect and discuss quantitative and qualitative information about the success of implementation. Note: Use this construct to capture themes related to Reflecting & Evaluating that are not included in the subconstructs below.
1. Implementation	Collect and discuss quantitative and qualitive information about the success of implementation.
2. Innovation	Collect and discuss quantitative and qualitative information about the success of the innovation.
I. Adapting	Modify the innovation and/or the Inner Setting for optimal fit and integration into work processes.
CFIR OUTCOMES ADDENDUM	
I. ANTECEDENT ASSESSMENTS	
Name	**Definition**
A. Acceptability	The extent to which an innovation is perceived as “agreeable, palatable, or satisfactory" (Proctor, 2009).
B. Appropriateness	The “perceived fit, relevance, or compatibility of the innovation […] for a given practice setting, provider, or consumer; and/or perceived fit of the innovation to address a particular issue or problem" (Proctor, 2009).

C. Feasibility	The extent to which an innovation “can be successfully used or carried out within a given agency or setting" (Proctor, 2009).
D. Implementation Climate	The extent to which the Inner Setting has an implementation climate.
E. Implementation Readiness	The extent to which the Inner Setting is ready for implementation.
II. IMPLEMENTATION OUTCOMES	
Name	**Definition**
A. Anticipated Implementation Outcomes	Outcomes based on perceptions or measures of the likelihood of future implementation success or failure, i.e., implementation outcomes that have not yet occurred. These outcomes are forward-looking; constellations of CFIR determinants across domains predict these outcomes.
1. Adoptability	The likelihood key decision-makers will decide to put the innovation in place/innovation deliverers will decide to deliver to innovation.
2. Implementability	The likelihood the innovation will be put in place or delivered.
3. Sustainability	The likelihood the innovation will be put in place or delivered over the long-term.
B. Actual Implementation Outcomes	Outcomes based on perceptions or measures of current (or past) implementation success or failure, i.e., implementation outcomes that have occurred. These outcomes are backward-looking; constellations of CFIR determinants across domains explain these outcomes.
1. Adoption	The extent key decision-makers decide to put the innovation in place/innovation deliverers decide to deliver the innovation.
2. Implementation	The extent the innovation is in place or being delivered.
3. Sustainment	The extent the innovation is in place or being delivered over the long-term.
III. INNOVATION OUTCOMES	Outcomes that capture the success or failure of the innovation, based on the impact of the innovation on three important constituents: Innovation Recipients, Innovation Deliverers, and Key Decision-Makers. Impact is defined by: Reach ("The absolute number, proportion, and representativeness of individuals who are willing to participate in a given initiative, intervention, or program.”) x Innovation Effectiveness ("The impact of an intervention on important outcomes, including potential negative effects, quality of life, and economic outcomes.”
Name	**Definition**

A. Innovation Recipient Impact	Recipient Reach x Innovation Effectiveness
B. Innovation Deliverer Impact	Deliverer Reach x Innovation Effectiveness
C. Key-Decision Maker (or System) Impact	Key-Decision Maker Reach x Innovation Effectiveness

Appendix 2.2. Ethical approval for the stroke survivor survey from the Health Ethics Review Panel at the University of Central Lancashire

University of Central Lancashire
UCLan

University of Central Lancashire
Preston PR1 2HE
01772 201201
uclan.ac.uk

11th May 2022

Louise Connell / Nicola Gaskins
School of Sport and Health Sciences
University of Central Lancashire

Dear Louise and Nicola,

Re: Health Ethics Review Panel Application
Unique Reference Number: HEALTH 0310

The Health Ethics Review Panel has granted approval of your proposal application 'Stroke Survivors' Views of Aerobic Exercise in the United Kingdom'. Approval is granted up to the end of project date*.

It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by the Ethics Review Panel
- you notify EthicsInfo@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to the Ethics Review Panel
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purpose e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Pro forma).

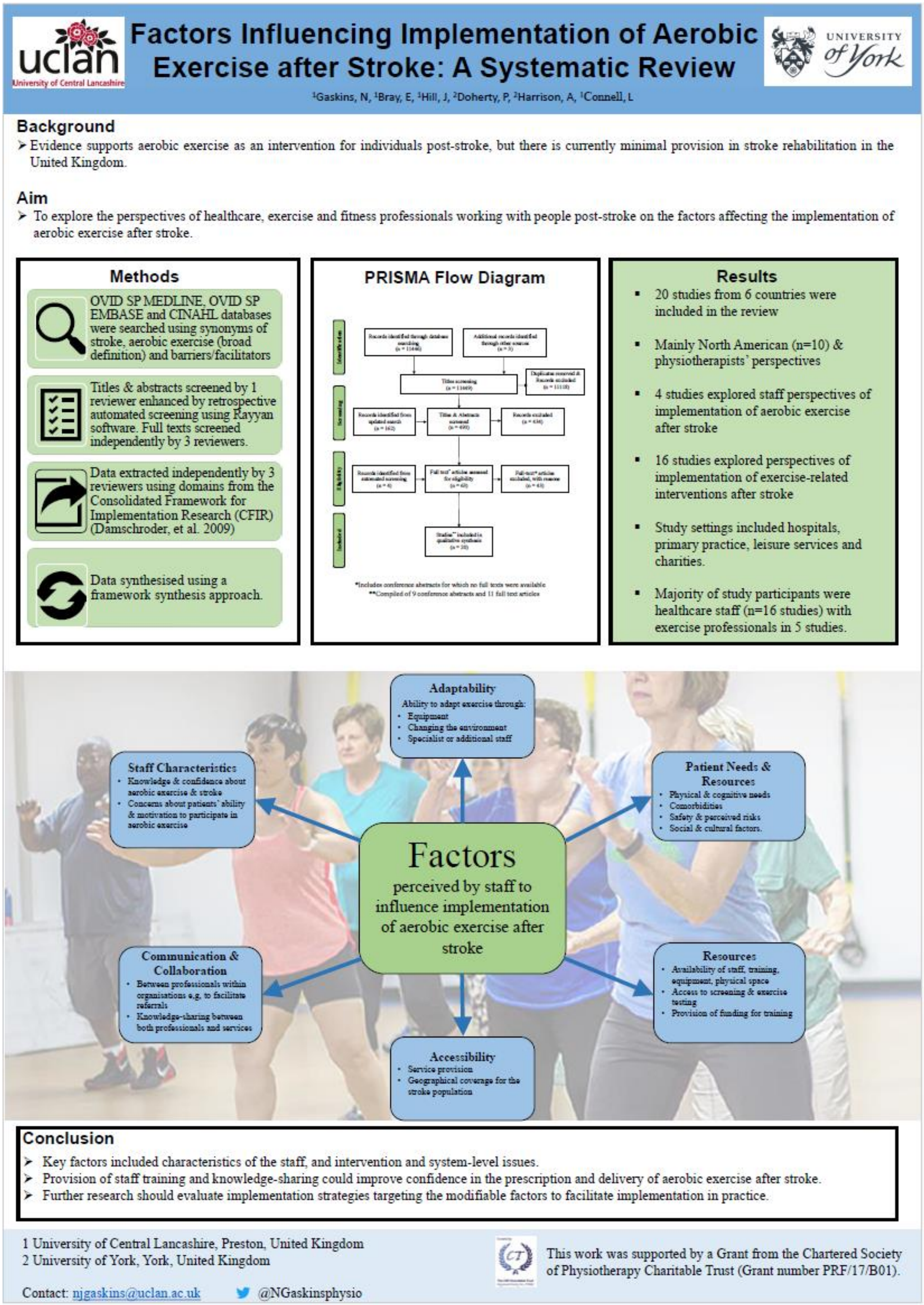
Yours sincerely

Lucy Hives, Deputy Vice-Chair
Health Ethics Review Panel

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals gained.

Appendix 3.1. A copy of poster on the systematic review findings presented at the poster at the National Physiotherapy UK Conference 2019, the Society for Research in Rehabilitation Winter Conference 2019, and the Research @ UCLan Event in 2020



Appendix 3.2. PRISMA checklist for the systematic review

Section/topic	#	Checklist item	Reported on section #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Chapter 3
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	3.4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3.2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3.3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3.4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3.4.2
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3.4.1
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	*Appendix 3.2*
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	3.4.3 and 3.4.4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3.4.5

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	3.4.5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Not applicable
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Not applicable
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	3.4.5
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	3.4.6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	3.4.6
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	3.5.1 Figure 3.1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table 3.1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Not applicable
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 3.1 and 3.5.3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Not applicable
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Not applicable
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	3.5.2
DISCUSSION			

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	3.5.4 and Table 3.2
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	3.6.6
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	3.6
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Grant number PRF/17/B01 (page 17)

Appendix 3.3. Search terms used in the systematic review

1) Aerobic exercise search terms

Aerobic exercise search terms were selected from four Cochrane reviews which were:

- Bidonde J, Busch AJ, Schachter CL, Overend TJ, Kim SY, Góes SM, Boden C, Foulds HJA. Aerobic exercise training for adults with fibromyalgia. Cochrane Database of Systematic Reviews 2017, Issue 6. Art. No.: CD012700. DOI: 10.1002/14651858.CD012700.
- Voet NBM, van der Kooi EL, Riphagen II, Lindeman E, van Engelen BGM, Geurts ACH. Strength training and aerobic exercise training for muscle disease. Cochrane Database of Systematic Reviews 2013, Issue 7. Art. No.: CD003907. DOI: 10.1002/14651858.CD003907.pub4.
- Andriolo RB, El Dib RP, Ramos L, Atallah ÁN, da Silva EMK. Aerobic exercise training programmes for improving physical and psychosocial health in adults with Down syndrome. Cochrane Database of Systematic Reviews 2010, Issue 5. Art. No.: CD005176. DOI: 10.1002/14651858.CD005176.pub4.
- Hassett L, Moseley AM, Harmer AR. Fitness training for cardiorespiratory conditioning after traumatic brain injury. Cochrane Database of Systematic Reviews 2017, Issue 12. Art. No.: CD006123. DOI: 10.1002/14651858.CD006123.pub3

Aerobic exercise search terms – all selected and searched with ‘OR’, searched for title and abstract only	
Exercise/	training program$.tw.
exercis$.tw.	endurance exercis$.tw.
cardioresp$.tw.	cardiorespiratory fitness training.tw.
exercise therap$.tw.	Physical Exertion/
aerobic exercis$.tw.	Physical Fitness/
exercise program$.tw.	physical endurance/
exercise training.tw.	exertion$.tw.
aerobic training.tw.	cardiovascular exercis$.tw.

2) Barriers and facilitators search terms

Barriers and facilitators search terms were selected from the following paper:

- Nathan, N., Elton, B., Babic, M., McCarthy, N., Sutherland, R., Presseau, J., ... & Wolfenden, L. (2017). Barriers and facilitators to the implementation of physical activity policies in schools: A systematic review. Preventive medicine.

The terms 'enable' and 'factor' were added by NG.

Barriers and facilitators search terms – all selected and searched with 'OR'	
barrier*.mp.	facilitat*.mp.
(impede* or impediment*).mp.	opportunit*.mp.
hurdle*.mp.	adher*.mp.
challenge*.mp.	enable*.mp.
(hindrance* or hinder*).mp.	factor*.mp.
obstacle*.mp.	

3) Stroke search terms

Stroke search terms were provided by an information specialist in the Stroke Research Team based at the University of Central Lancashire, Janet Reed.

Stroke search terms – all selected and searched with 'OR'	
(anterior circulation adj5 emboli$).ab,ti.	(basilar art$ adj5 arterioscleros$).ab,ti.
(anterior circulation adj5 hypox$).ab,ti.	(basilar art$ adj5 atheroscleros$).ab,ti.
(anterior circulation adj5 infarct$).ab,ti.	(basilar art$ adj5 insufficiency).ab,ti.
(anterior circulation adj5 isch?emi$).ab,ti.	(basilar art$ adj5 isch?emia).ab,ti.
(anterior circulation adj5 obstruction).ab,ti.	(basilar art$ adj5 occlus$).ab,ti.
(anterior circulation adj5 occlus$).ab,ti.	(basilar art$ adj5 stenosis).ab,ti.
(anterior circulation adj5 thrombo$).ab,ti.	(berry adj5 aneurysm$).ab,ti.
(anterior circulation adj5 vasculopathy).ab,ti.	(brain adj5 (vascular adj5 accident)).ab,ti.
(anterior circulation adj5 vasospasm).ab,ti.	(brain adj5 (vascular adj5 disease$)).ab,ti.
(apoplectic adj5 attack$).ab,ti.	(brain adj5 (vascular adj5 disorder)).ab,ti.
Cerebrovascular Disorders.af.	(brain adj5 (vascular adj5 event)).ab,ti.
exp basal ganglia cerebrovascular disease/	(brain adj5 (vascular adj5 injur$)).ab,ti.
exp brain ischemia/	(brain adj5 (vascular adj5 insult)).ab,ti.

exp carotid artery diseases/	(brain adj5 (vascular adj5 trauma$)).ab,ti.
Stroke/	(brain adj5 aneurysm$).ab,ti.
exp brain infarction/	(brain adj5 angioma$).ab,ti.
exp cerebrovascular trauma/	(brain adj5 haemangioma$).ab,ti.
Hypoxia-Ischemia, Brain/	(brain adj5 hemangioma$).ab,ti.
exp intracranial arterial diseases/	(brain vasc$ adj5 malformation$).ab,ti.
exp "Intracranial Embolism and Thrombosis"/	(brain$ adj5 bleed$).ab,ti.
exp intracranial arteriovenous malformations/	(brain$ adj5 emboli$).ab,ti.
(apoplectic adj5 event).ab,ti.	(brain$ adj5 haematoma$).ab,ti.
(apoplectic adj5 events).ab,ti.	(brain$ adj5 haemorrhage$).ab,ti.
(apoplectic adj5 insult).ab,ti.	(brain$ adj5 hematoma$).ab,ti.
(arteriovenous adj5 malformation$).ab,ti.	(brain$ adj5 hemorrhage$).ab,ti.
(attentional adj5 neglect).ab,ti.	(brain$ adj5 hypox$).ab,ti.
(basal gangli$ adj5 bleed$).ab,ti.	(brain$ adj5 infarct$).ab,ti.
(basal gangli$ adj5 haematoma$).ab,ti.	(brain$ adj5 isch?emi$).ab,ti.
(basal gangli$ adj5 haemorrhage$).ab,ti.	(brain$ adj5 obstruction).ab,ti.
(basal gangli$ adj5 hematoma$).ab,ti.	(brain$ adj5 occlus$).ab,ti.
(basal gangli$ adj5 hemorrhage$).ab,ti.	(brain$ adj5 thrombo$).ab,ti.
(basal ganglia adj5 (vascular adj5 accident)).ab,ti.	(brain$ adj5 vasculopathy).ab,ti.
(basal ganglia adj5 (vascular adj5 disease$)).ab,ti.	(brain$ adj5 vasospasm).ab,ti.
(basal ganglia adj5 (vascular adj5 disorder)).ab,ti.	(cerebell$ adj5 bleed$).ab,ti.
(basal ganglia adj5 (vascular adj5 event)).ab,ti.	(cerebell$ adj5 emboli$).ab,ti.
(basal ganglia adj5 (vascular adj5 injur$)).ab,ti.	(cerebell$ adj5 haematoma$).ab,ti.
(basal ganglia adj5 (vascular adj5 insult)).ab,ti.	(cerebell$ adj5 haemorrhage$).ab,ti.
(basal ganglia adj5 (vascular adj5 trauma$)).ab,ti.	(cerebell$ adj5 hematoma$).ab,ti.
(basal ganglia adj5 emboli$).ab,ti.	(cerebell$ adj5 hemorrhage$).ab,ti.
(basal ganglia adj5 hypox$).ab,ti.	(cerebell$ adj5 hypox$).ab,ti.
(basal ganglia adj5 infarct$).ab,ti.	(cerebell$ adj5 infarct$).ab,ti.
(basal ganglia adj5 isch?emi$).ab,ti.	(cerebell$ adj5 isch?emi$).ab,ti.
(basal ganglia adj5 obstruction).ab,ti.	(cerebell$ adj5 obstruction).ab,ti.
(basal ganglia adj5 occlus$).ab,ti.	(cerebell$ adj5 occlus$).ab,ti.

(basal ganglia adj5 thrombo$).ab,ti.	(cerebell$ adj5 thrombo$).ab,ti.
(basal ganglia adj5 vasculopathy).ab,ti.	(cerebell$ adj5 vasculopathy).ab,ti.
(basal ganglia adj5 vasospasm).ab,ti.	(cerebell$ adj5 vasospasm).ab,ti.
(basilar adj5 aneurysm$).ab,ti.	(cerebr$ adj5 bleed$).ab,ti.
(cerebr$ adj5 haemorrhage$).ab,ti.	(cerebr$ adj5 emboli$).ab,ti.
(cerebr$ adj5 hematoma$).ab,ti.	(cerebr$ adj5 haematoma$).ab,ti.
(cerebr$ adj5 hemorrhage$).ab,ti.	(infratentorial adj5 hypox$).ab,ti.
(cerebr$ adj5 hypox$).ab,ti.	(infratentorial adj5 infarct$).ab,ti.
(cerebr$ adj5 infarct$).ab,ti.	(infratentorial adj5 isch?emi$).ab,ti.
(cerebr$ adj5 isch?emi$).ab,ti.	(infratentorial adj5 obstruction).ab,ti.
(cerebr$ adj5 obstruction).ab,ti.	(infratentorial adj5 occlus$).ab,ti.
(cerebr$ adj5 occlus$).ab,ti.	(infratentorial adj5 thrombo$).ab,ti.
(cerebr$ adj5 thrombo$).ab,ti.	(infratentorial adj5 vasculopathy).ab,ti.
(cerebr$ adj5 vasculopathy).ab,ti.	(infratentorial adj5 vasospasm).ab,ti.
(cerebr$ adj5 vasospasm).ab,ti.	(intracerebral adj5 bleed$).ab,ti.
(cerebral adj5 aneurysm$).ab,ti.	(intracerebral adj5 emboli$).ab,ti.
(cerebral adj5 angioma$).ab,ti.	(intracerebral adj5 haematoma$).ab,ti.
(cerebral adj5 haemangioma$).ab,ti.	(intracerebral adj5 haemorrhage$).ab,ti.
(cerebral adj5 hemangioma$).ab,ti.	(intracerebral adj5 hematoma$).ab,ti.
(cerebral art$ adj5 arteriosclero$).ab,ti.	(intracerebral adj5 hemorrhage$).ab,ti.
(cerebral art$ adj5 atherosclero$).ab,ti.	(intracerebral adj5 hypox$).ab,ti.
(cerebral art$ adj5 insufficiency).ab,ti.	(intracerebral adj5 infarct$).ab,ti.
(cerebral art$ adj5 isch?emia).ab,ti.	(intracerebral adj5 isch?emi$).ab,ti.
(cerebral art$ adj5 occlus$).ab,ti.	(intracerebral adj5 obstruction).ab,ti.
(cerebral art$ adj5 stenosis).ab,ti.	(intracerebral adj5 occlus$).ab,ti.
(cerebral vein adj5 thrombo$).ab,ti.	(intracerebral adj5 thrombo$).ab,ti.
(cerebral venous adj5 thrombo$).ab,ti.	(intracerebral adj5 vasculopathy).ab,ti.
(communicating adj5 aneurysm$).ab,ti.	(intracerebral adj5 vasospasm).ab,ti.
(cortical adj5 emboli$).ab,ti.	(intracran$ adj5 bleed$).ab,ti.
(cortical adj5 hypox$).tw.	(intracran$ adj5 emboli$).ab,ti.
(cortical adj5 infarct$).ab,ti.	(intracran$ adj5 haematoma$).ab,ti.
(cortical adj5 isch?emi$).ab,ti.	(intracran$ adj5 haemorrhage$).ab,ti.
(cortical adj5 obstruction).ab,ti.	(intracran$ adj5 hematoma$).ab,ti.
(cortical adj5 occlus$).ab,ti.	(intracran$ adj5 hemorrhage$).ab,ti.
(cortical adj5 thrombo$).ab,ti.	(intracran$ adj5 hypox$).ab,ti.
(cortical adj5 vasculopathy).ab,ti.	(intracran$ adj5 infarct$).ab,ti.
(cortical adj5 vasospasm).ab,ti.	(intracran$ adj5 isch?emi$).ab,ti.
(giant adj5 aneurysm$).ab,ti.	(intracran$ adj5 obstruction).ab,ti.

(hemispatial adj5 neglect).ab,ti.	(intracran$ adj5 occlus$).ab,ti.
(hemispher$ adj5 emboli$).ab,ti.	(intracran$ adj5 thrombo$).ab,ti.
(hemispher$ adj5 hypox$).ab,ti.	(intracran$ adj5 vasculopathy).ab,ti.
(hemispher$ adj5 infarct$).ab,ti.	(intracran$ adj5 vasospasm).ab,ti.
(hemispher$ adj5 isch?emi$).ab,ti.	(intracranial adj5 (vascular adj5 accident)).ab,ti.
(hemispher$ adj5 obstruction).ab,ti.	(intracranial adj5 (vascular adj5 disease$)).ab,ti.
(hemispher$ adj5 occlus$).ab,ti.	(intracranial adj5 (vascular adj5 disorder)).ab,ti.
(hemispher$ adj5 thrombo$).ab,ti.	(intracranial adj5 (vascular adj5 event)).ab,ti.
(hemispher$ adj5 vasculopathy).ab,ti.	(intracranial adj5 (vascular adj5 injur$)).ab,ti.
(hemispher$ adj5 vasospasm).ab,ti.	(intracranial adj5 (vascular adj5 insult)).ab,ti.
(infratentorial adj5 bleed$).ab,ti.	(intracranial adj5 (vascular adj5 trauma$)).ab,ti.
(infratentorial adj5 emboli$).ab,ti.	(intracranial adj5 aneurysm$).ab,ti.
(infratentorial adj5 haematoma$).ab,ti.	(intracranial adj5 arterioscleros$).ab,ti.
(infratentorial adj5 haemorrhage$).ab,ti.	(intracranial adj5 atheroscleros$).ab,ti.
(infratentorial adj5 hematoma$).ab,ti.	(intracranial adj5 insufficiency).ab,ti.
(infratentorial adj5 hemorrhage$).ab,ti.	(intracranial adj5 isch?emia).ab,ti.
(infratentorial adj5 hypox$).ab,ti.	(intracranial adj5 aneurysm$).ab,ti.
(infratentorial adj5 infarct$).ab,ti.	(intracranial adj5 arterioscleros$).ab,ti.
(infratentorial adj5 isch?emi$).ab,ti.	(intracranial adj5 atheroscleros$).ab,ti.
(infratentorial adj5 obstruction).ab,ti.	(intracranial adj5 insufficiency).ab,ti.
(infratentorial adj5 occlus$).ab,ti.	(intracranial adj5 isch?emia).ab,ti.
(infratentorial adj5 thrombo$).ab,ti.	(intracranial adj5 occlus$).ab,ti.
(infratentorial adj5 vasculopathy).ab,ti.	(intracranial adj5 stenosis).ab,ti.
(infratentorial adj5 vasospasm).ab,ti.	(intraventricular adj5 bleed$).ab,ti.
(intracerebral adj5 bleed$).ab,ti.	(intraventricular adj5 haematoma$).ab,ti.
(intracerebral adj5 emboli$).ab,ti.	(intraventricular adj5 haemorrhage$).ab,ti.
(intracerebral adj5 haematoma$).ab,ti.	(intraventricular adj5 hematoma$).ab,ti.
(intracerebral adj5 haemorrhage$).ab,ti.	(intraventricular adj5 hemorrhage$).ab,ti.
(intracerebral adj5 hematoma$).ab,ti.	(isch?emic adj5 attack$).ab,ti.
(intracerebral adj5 hemorrhage$).ab,ti.	(isch?emic adj5 event).ab,ti.
(intracerebral adj5 hypox$).ab,ti.	(isch?emic adj5 events).ab,ti.
(intracerebral adj5 infarct$).ab,ti.	(isch?emic adj5 insult).ab,ti.
(intracerebral adj5 isch?emi$).ab,ti.	(lacunar adj5 infarct$).ab,ti.

(intracerebral adj5 obstruction).ab,ti.	(lenticulostriate adj5 (vascular adj5 accident)).ab,ti.
(intracerebral adj5 occlus$).ab,ti.	(lenticulostriate adj5 (vascular adj5 disease$)).ab,ti.
(intracerebral adj5 thrombo$).ab,ti.	(lenticulostriate adj5 (vascular adj5 disorder)).ab,ti.
(intracerebral adj5 vasculopathy).ab,ti.	(lenticulostriate adj5 (vascular adj5 event)).ab,ti.
(intracerebral adj5 vasospasm).ab,ti.	(lenticulostriate adj5 (vascular adj5 injur$)).ab,ti.
(intracran$ adj5 bleed$).ab,ti.	(lenticulostriate adj5 (vascular adj5 insult)).ab,ti.
(intracran$ adj5 emboli$).ab,ti.	(lenticulostriate adj5 (vascular adj5 trauma$)).ab,ti.
(intracran$ adj5 haematoma$).ab,ti.	(MCA adj5 emboli$).ab,ti.
(intracran$ adj5 haemorrhage$).ab,ti.	(MCA adj5 hypox$).ab,ti.
(intracran$ adj5 hematoma$).ab,ti.	(MCA adj5 infarct$).ab,ti.
(intracran$ adj5 hemorrhage$).ab,ti.	(MCA adj5 isch?emi$).ab,ti.
(intracran$ adj5 hypox$).ab,ti.	(MCA adj5 obstruction).ab,ti.
(intracran$ adj5 infarct$).ab,ti.	(MCA adj5 occlus$).ab,ti.
(intracran$ adj5 isch?emi$).ab,ti.	(MCA adj5 thrombo$).ab,ti.
(intracran$ adj5 obstruction).ab,ti.	(MCA adj5 vasculopathy).ab,ti.
(intracran$ adj5 occlus$).ab,ti.	(MCA adj5 vasospasm).ab,ti.
(intracran$ adj5 thrombo$).ab,ti.	(parenchymal adj5 bleed$).ab,ti.
(intracran$ adj5 vasculopathy).ab,ti.	(parenchymal adj5 haematoma$).ab,ti.
(intracran$ adj5 vasospasm).ab,ti.	(parenchymal adj5 haemorrhage$).ab,ti.
(intracranial adj5 (vascular adj5 accident)).ab,ti.	(parenchymal adj5 hematoma$).ab,ti.
(intracranial adj5 (vascular adj5 disease$)).ab,ti.	(parenchymal adj5 hemorrhage$).ab,ti.
(intracranial adj5 (vascular adj5 disorder)).ab,ti.	(posterior circulation adj5 emboli$).ab,ti.
(intracranial adj5 (vascular adj5 event)).ab,ti.	(posterior circulation adj5 hypox$).ab,ti.
(intracranial adj5 (vascular adj5 injur$)).ab,ti.	(posterior circulation adj5 obstruction).ab,ti.
(intracranial adj5 (vascular adj5 insult)).ab,ti.	(posterior circulation adj5 thrombo$).ab,ti.
(intracranial adj5 (vascular adj5 trauma$)).ab,ti.	(posterior circulation adj5 vasculopathy).ab,ti.
(intracranial adj5 aneurysm$).ab,ti.	(posterior circulation adj5 vasospasm).ab,ti.

(intracranial adj5 arterioscleros$).ab,ti.	(posterior fossa adj5 bleed$).ab,ti.
(intracranial adj5 atheroscleros$).ab,ti.	(posterior fossa adj5 haematoma$).ab,ti.
(intracranial adj5 insufficiency).ab,ti.	(posterior fossa adj5 haemorrhage$).ab,ti.
(intracranial adj5 isch?emia).ab,ti.	(posterior fossa adj5 hematoma$).ab,ti.
(intracranial adj5 occlus$).ab,ti.	(posterior fossa adj5 hemorrhage$).ab,ti.
(intracranial adj5 stenosis).ab,ti.	(putamen adj5 bleed$).ab,ti.
(intraventricular adj5 bleed$).ab,ti.	(putamen adj5 haematoma$).ab,ti.
(intraventricular adj5 haematoma$).ab,ti.	(putamen adj5 haemorrhage$).ab,ti.
(intraventricular adj5 haemorrhage$).ab,ti.	(putamen adj5 hematoma$).ab,ti.
(intraventricular adj5 hematoma$).ab,ti.	(putamen adj5 hemorrhage$).ab,ti.
(intraventricular adj5 hemorrhage$).ab,ti.	(putaminal adj5 bleed$).ab,ti.
(isch?emic adj5 attack$).ab,ti.	(putaminal adj5 haematoma$).ab,ti.
(isch?emic adj5 event).ab,ti.	(putaminal adj5 haemorrhage$).ab,ti.
(isch?emic adj5 events).ab,ti.	(putaminal adj5 hematoma$).ab,ti.
(isch?emic adj5 insult).ab,ti.	(putaminal adj5 hemorrhage$).ab,ti.
(lacunar adj5 infarct$).ab,ti.	(ruptured adj5 aneurysm$).ab,ti.
(lenticulostriate adj5 (vascular adj5 accident)).ab,ti.	(saccular adj5 aneurysm$).ab,ti.
(lenticulostriate adj5 (vascular adj5 disease$)).ab,ti.	(sagittal adj5 thrombo$).ab,ti.
(lenticulostriate adj5 (vascular adj5 disorder)).ab,ti.	(sinus adj5 thrombo$).ab,ti.
(lenticulostriate adj5 (vascular adj5 event)).ab,ti.	(spatial adj5 neglect).ab,ti.
(lenticulostriate adj5 (vascular adj5 injur$)).ab,ti.	(subarachnoid adj5 bleed$).ab,ti.
(lenticulostriate adj5 (vascular adj5 insult)).ab,ti.	(subarachnoid adj5 haematoma$).ab,ti.
(lenticulostriate adj5 (vascular adj5 trauma$)).ab,ti.	(subarachnoid adj5 haemorrhage$).ab,ti.
(MCA adj5 emboli$).ab,ti.	(subarachnoid adj5 hematoma$).ab,ti.
(MCA adj5 hypox$).ab,ti.	(subarachnoid adj5 hemorrhage$).ab,ti.
(MCA adj5 infarct$).ab,ti.	(supratentorial adj5 bleed$).ab,ti.
(MCA adj5 isch?emi$).ab,ti.	(supratentorial adj5 emboli$).ab,ti.
(MCA adj5 obstruction).ab,ti.	(supratentorial adj5 haematoma$).ab,ti.
(MCA adj5 occlus$).ab,ti.	(supratentorial adj5 haemorrhage$).ab,ti.
(MCA adj5 thrombo$).ab,ti.	(supratentorial adj5 hematoma$).ab,ti.
(MCA adj5 vasculopathy).ab,ti.	(supratentorial adj5 hemorrhage$).ab,ti.
(MCA adj5 vasospasm).ab,ti.	(parenchymal adj5 hemorrhage$).ab,ti.
(parenchymal adj5 bleed$).ab,ti.	(posterior circulation adj5 emboli$).ab,ti.

(parenchymal adj5 haematoma$).ab,ti.	(posterior circulation adj5 hypox$).ab,ti.
(parenchymal adj5 haemorrhage$).ab,ti.	(posterior circulation adj5 infarct$).ab,ti.
(parenchymal adj5 hematoma$).ab,ti.	(posterior circulation adj5 isch?emi$).ab,ti.
(parenchymal adj5 hemorrhage$).ab,ti.	(unilateral adj5 neglect).ab,ti.
(posterior circulation adj5 emboli$).ab,ti.	(venous adj5 malformation$).ab,ti.
(posterior circulation adj5 hypox$).ab,ti.	(vertebral art$ adj5 arteriosclero$).ab,ti.
(posterior circulation adj5 infarct$).ab,ti.	(vertebral art$ adj5 atherosclero$).ab,ti.
(posterior circulation adj5 isch?emi$).ab,ti.	(vertebral art$ adj5 insufficiency).ab,ti.
(posterior circulation adj5 obstruction).ab,ti.	(vertebral art$ adj5 isch?emia).ab,ti.
(posterior circulation adj5 thrombo$).ab,ti.	(vertebral art$ adj5 occlus$).ab,ti.
(posterior circulation adj5 vasculopathy).ab,ti.	(vertebral art$ adj5 stenosis).ab,ti.
(posterior circulation adj5 vasospasm).ab,ti.	(vertebral artery adj5 aneurysm$).ab,ti.
(posterior fossa adj5 bleed$).ab,ti.	(vertebral basilar adj5 arteriosclero$).ab,ti.
(posterior fossa adj5 haematoma$).ab,ti.	(vertebral basilar adj5 atherosclero$).ab,ti.
(posterior fossa adj5 haemorrhage$).ab,ti.	(vertebral basilar adj5 insufficiency).ab,ti.
(posterior fossa adj5 hematoma$).ab,ti.	(vertebral basilar adj5 isch?emia).ab,ti.
(posterior fossa adj5 hemorrhage$).ab,ti.	(vertebral basilar adj5 occlus$).ab,ti.
(putamen adj5 bleed$).ab,ti.	(vertebral basilar adj5 stenosis).ab,ti.
(putamen adj5 haematoma$).ab,ti.	(vertebrobasilar adj5 arteriosclero$).ab,ti.
(putamen adj5 haemorrhage$).ab,ti.	(vertebrobasilar adj5 atherosclero$).ab,ti.
(putamen adj5 hematoma$).ab,ti.	(vertebrobasilar adj5 emboli$).ab,ti.
(putamen adj5 hemorrhage$).ab,ti.	(vertebrobasilar adj5 hypox$).ab,ti.
(putaminal adj5 bleed$).ab,ti.	(vertebrobasilar adj5 infarct$).ab,ti.
(putaminal adj5 haematoma$).ab,ti.	(vertebrobasilar adj5 insufficiency).ab,ti.
(putaminal adj5 haemorrhage$).ab,ti.	(vertebrobasilar adj5 isch?emi$).ab,ti.
(putaminal adj5 hematoma$).ab,ti.	(vertebrobasilar adj5 isch?emia).ab,ti.
(putaminal adj5 hemorrhage$).ab,ti.	(vertebrobasilar adj5 obstruction).ab,ti.
(ruptured adj5 aneurysm$).ab,ti.	(vertebrobasilar adj5 occlus$).ab,ti.
(saccular adj5 aneurysm$).ab,ti.	(vertebrobasilar adj5 occlus$).ab,ti.
(sagittal adj5 thrombo$).ab,ti.	(vertebrobasilar adj5 stenosis).ab,ti.
(sinus adj5 thrombo$).ab,ti.	(vertebrobasilar adj5 thrombo$).ab,ti.
(spatial adj5 neglect).ab,ti.	(vertebrobasilar adj5 vasculopathy).ab,ti.
(subarachnoid adj5 bleed$).ab,ti.	(vertebrobasilar adj5 vasospasm).ab,ti.
(subarachnoid adj5 haematoma$).ab,ti.	(visual adj5 neglect).ab,ti.
(subarachnoid adj5 haemorrhage$).ab,ti.	acquired brain injur$.ab,ti.
(subarachnoid adj5 hematoma$).ab,ti.	aneurysm, ruptured/ and exp brain/

(subarachnoid adj5 hemorrhage$).ab,ti.	anomi$.ab,ti.
(supratentorial adj5 bleed$).ab,ti.	aphasi$.ab,ti.
(supratentorial adj5 emboli$).ab,ti.	apoplex$.mp.
(supratentorial adj5 haematoma$).ab,ti.	apraxi$.ab,ti.
(supratentorial adj5 haemorrhage$).ab,ti.	asymptomatic cervical bruit.ab,ti.
(supratentorial adj5 hematoma$).ab,ti.	AVM.mp.
(supratentorial adj5 hemorrhage$).ab,ti.	Brain Injuries/
(supratentorial adj5 hypox$).ab,ti.	Brain Injury, Chronic/
(supratentorial adj5 infarct$).ab,ti.	carotid$.ab,ti.
(supratentorial adj5 isch?emi$).ab,ti.	cerebral art$ disease$.ab,ti.
(supratentorial adj5 obstruction).ab,ti.	cerebrovasc$.mp.
(supratentorial adj5 occlus$).ab,ti.	cva$.mp.
(supratentorial adj5 thrombo$).ab,ti.	CVDST.ab,ti.
(supratentorial adj5 vasculopathy).ab,ti.	CVT.ab,ti.
(supratentorial adj5 vasospasm).ab,ti.	deglutition disorder$.ab,ti.
dysphagi$.ab,ti.	dysarthri$.ab,ti.
dysphasi$.ab,ti.	dysnomi$.ab,ti.
Endarterectomy, Carotid/	vertebral artery dissection.ab,ti.
exp anomia/	hemianop$.ab,ti.
exp aphasia/	hemiball$.ab,ti.
exp carotid arteries/	hemineglect.ab,ti.
exp deglutition disorders/	hemipar$.ab,ti.
exp dysarthria/	hemipleg$.ab,ti.
exp Heart Septal Defects, Atrial/	isch?emi$ attack$.mp.
exp hemianopsia/	neurologic$ deficit$.mp.
exp hemiplegia/	paresis.ab,ti.
exp intracranial hemorrhages/	paretic.ab,ti.
exp paresis/	patent foramen ovale.ab,ti.
foramen ovale, patent/	PFO.ab,ti.
swallow$ disorder$.ab,ti.	post stroke.ab,ti.
tia$1.mp.	poststroke.ab,ti.
Vasospasm, Intracranial/	SAH.mp.
vertebral artery dissection.ab,ti.	spasticity.ab,ti.
SAH.mp.	foramen ovale, patent/
dysphagi$.ab,ti.	hemianop$.ab,ti.
dysphasi$.ab,ti.	hemiball$.ab,ti.
Endarterectomy, Carotid/	hemineglect.ab,ti.
exp anomia/	hemipar$.ab,ti.

exp aphasia/	hemipleg$.ab,ti.
exp carotid arteries/	isch?emi$ attack$.mp.
exp deglutition disorders/	neurologic$ deficit$.mp.
exp dysarthria/	paresis.ab,ti.
exp Heart Septal Defects, Atrial/	paretic.ab,ti.
exp hemianopsia/	patent foramen ovale.ab,ti.
exp hemiplegia/	PFO.ab,ti.
exp intracranial hemorrhages/	post stroke.ab,ti.
exp paresis/	poststroke.ab,ti.
spasticity.ab,ti.	Vasospasm, Intracranial/
swallow$ disorder$.ab,ti.	vertebral artery dissection.ab,ti.
tia$1.mp.	vertebral artery dissection.ab,ti.

Appendix 3.4. A copy of the original Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2009)

Consolidated Framework for Implementation Research (CFIR) constructs		
CFIR website		
Construct		**Short Description**
I. INTERVENTION CHARACTERISTICS		
A	Intervention Source	Perception of key stakeholders about whether the intervention is externally or internally developed.
B	Evidence Strength & Quality	Stakeholders' perceptions of the quality and validity of evidence supporting the belief that the intervention will have desired outcomes.
C	Relative Advantage	Stakeholders' perception of the advantage of implementing the intervention versus an alternative solution.
D	Adaptability	The degree to which an intervention can be adapted, tailored, refined, or reinvented to meet local needs.
E	Trialability	The ability to test the intervention on a small scale in the organization, and to be able to reverse course (undo implementation) if warranted.
F	Complexity	Perceived difficulty of implementation, reflected by duration, scope, radicalness, disruptiveness, centrality, and intricacy and number of steps required to implement.
G	Design Quality & Packaging	Perceived excellence in how the intervention is bundled, presented, and assembled.
H	Cost	Costs of the intervention and costs associated with implementing the intervention including investment, supply, and opportunity costs.
II. OUTER SETTING		
A	Patient Needs & Resources	The extent to which patient needs, as well as barriers and facilitators to meet those needs, are accurately known and prioritized by the organization.
B	Cosmopolitanism	The degree to which an organization is networked with other external organizations.
C	Peer Pressure	Mimetic or competitive pressure to implement an intervention; typically because most or other key peer or competing organizations have already implemented or are in a bid for a competitive edge.
D	External Policy & Incentives	A broad construct that includes external strategies to spread interventions, including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting.
III. INNER SETTING		
A	Structural Characteristics	The social architecture, age, maturity, and size of an organization.

B	Networks & Communications	The nature and quality of webs of social networks and the nature and quality of formal and informal communications within an organization.
C	Culture	Norms, values, and basic assumptions of a given organization.
D	Implementation Climate	The absorptive capacity for change, shared receptivity of involved individuals to an intervention, and the extent to which use of that intervention will be rewarded, supported, and expected within their organization.
1	Tension for Change	The degree to which stakeholders perceive the current situation as intolerable or needing change.
2	Compatibility	The degree of tangible fit between meaning and values attached to the intervention by involved individuals, how those align with individuals' own norms, values, and perceived risks and needs, and how the intervention fits with existing workflows and systems.
3	Relative Priority	Individuals' shared perception of the importance of the implementation within the organization.
4	Organizational Incentives & Rewards	Extrinsic incentives such as goal-sharing awards, performance reviews, promotions, and raises in salary, and less tangible incentives such as increased stature or respect.
5	Goals and Feedback	The degree to which goals are clearly communicated, acted upon, and fed back to staff, and alignment of that feedback with goals.
6	Learning Climate	A climate in which: a) leaders express their own fallibility and need for team members' assistance and input; b) team members feel that they are essential, valued, and knowledgeable partners in the change process; c) individuals feel psychologically safe to try new methods; and d) there is sufficient time and space for reflective thinking and evaluation.
E	Readiness for Implementation	Tangible and immediate indicators of organizational commitment to its decision to implement an intervention.
1	Leadership Engagement	Commitment, involvement, and accountability of leaders and managers with the implementation.
2	Available Resources	The level of resources dedicated for implementation and on-going operations, including money, training, education, physical space, and time.
3	Access to Knowledge & Information	Ease of access to digestible information and knowledge about the intervention and how to incorporate it into work tasks.
IV. CHARACTERISTICS OF INDIVIDUALS		
A	Knowledge & Beliefs about the Intervention	Individuals' attitudes toward and value placed on the intervention as well as familiarity with facts, truths, and principles related to the intervention.

B	Self-efficacy	Individual belief in their own capabilities to execute courses of action to achieve implementation goals.
C	Individual Stage of Change	Characterization of the phase an individual is in, as he or she progresses toward skilled, enthusiastic, and sustained use of the intervention.
D	Individual Identification with Organization	A broad construct related to how individuals perceive the organization, and their relationship and degree of commitment with that organization.
E	Other Personal Attributes	A broad construct to include other personal traits such as tolerance of ambiguity, intellectual ability, motivation, values, competence, capacity, and learning style.
V. PROCESS		
A	Planning	The degree to which a scheme or method of behavior and tasks for implementing an intervention are developed in advance, and the quality of those schemes or methods.
B	Engaging	Attracting and involving appropriate individuals in the implementation and use of the intervention through a combined strategy of social marketing, education, role modeling, training, and other similar activities.
1	Opinion Leaders	Individuals in an organization who have formal or informal influence on the attitudes and beliefs of their colleagues with respect to implementing the intervention.
2	Formally Appointed Internal Implementation Leaders	Individuals from within the organization who have been formally appointed with responsibility for implementing an intervention as coordinator, project manager, team leader, or other similar role.
3	Champions	"Individuals who dedicate themselves to supporting, marketing, and 'driving through' an [implementation]" [101] (p. 182), overcoming indifference or resistance that the intervention may provoke in an organization.
4	External Change Agents	Individuals who are affiliated with an outside entity who formally influence or facilitate intervention decisions in a desirable direction.
C	Executing	Carrying out or accomplishing the implementation according to plan.
D	Reflecting & Evaluating	Quantitative and qualitative feedback about the progress and quality of implementation accompanied with regular personal and team debriefing about progress and experience.

Appendix 4.1. STROBE checklist for observational study

	Item No	Recommendation	Section
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Chapter 4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Not applicable
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	4.2
Objectives	3	State specific objectives, including any prespecified hypotheses	4.3
Methods			
Study design	4	Present key elements of study design early in the paper	4.4.1
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4.4.2 and 4.4.3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4.4.5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4.4.7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4.4.2
Bias	9	Describe any efforts to address potential sources of bias	4.4.8
Study size	10	Explain how the study size was arrived at	4.4.5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4.4.7 and Table 4.1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4.4.8
		(*b*) Describe any methods used to examine subgroups and interactions	4.4.8
		(*c*) Explain how missing data were addressed	4.4.4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable

Results			**Page**
Participants	13 *	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4.5.1 and 4.5.2
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Figure 4.3 and Figure 4.4
Descriptive data	14 *	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 4.2 and Table 4.6
		(b) Indicate number of participants with missing data for each variable of interest	4.4.4
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not applicable
Outcome data	15 *	*Cohort study*—Report numbers of outcome events or summary measures over time	Table 4.2 and Table 4.6
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Not applicable
		Cross-sectional study—Report numbers of outcome events or summary measures	Not applicable
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 4.5 and Table 4.4.8
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Table 4.9
Discussion			
Key results	18	Summarise key results with reference to study objectives	4.6
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	4.6.5
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	4.6
Generalisability	21	Discuss the generalisability (external validity) of the study results	4.6.5
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable

Appendix 5.1. Feedback from PCPI meetings

PCPI group feedback from meeting on 11th February 2022

Section	Feedback	Changes made
Advertisement	Remove the word 'aerobic' from the title as it may not be understood by potential participants	'Aerobic exercise after stroke' changed to 'Exercise after stroke'
	Change font colour to black on white background to ease access for those with visual problems	Well-spaced Black font on white background used throughout all participant-facing documents
Initial information and screening questions	Positive comments about the inclusion of the initial information as this saves time for people who are then screened out through ineligibility	No changes needed
	Change end-of-survey message for screen-out to include appreciation for their willingness to contribute	End of survey message amended to include suggested wording
Participant information sheet (PIS)	Repeat sources of support at the end of the PIS	Sources of support added to end of PIS
	Advantages of taking part: • Place these before disadvantages • Add option to request summary of findings so the person can see what they have contributed to	• Reordered advantages to come before disadvantages • Option to request summary of findings added at end of survey
Survey	Demographic questions not numbered originally but advised to number every question	All questions numbered
	Change description of aerobic exercise to make it 'gentle exercise'	Decided against this change as the definition of aerobic exercise does not include 'gentle exercise'
	Ensure wording around how long it takes to complete the survey is accurate and not too specific	Asked for feedback from pilot on time to complete and then gave a range for time to complete
	For specific questions change to multiple choice, add a free text option	Changes made to specific questions as suggested
Dissemination of survey	Consider contacting mental health charities such as MIND and McPin as well as stroke groups such as Stroke	Contacted MIND and McPin but they were unable to assist with circulation of the advertisement.

	Association. Certain group members offered to disseminate the advertisement to their contacts	The Stroke Association replied to say they currently do not have a member of staff to deal with research enquiries.

PCPI group feedback from meeting on 27th July 2022*

Section	Feedback	Reflection/Future Considerations
Survey	• Was open for 4 weeks, but should have been open for longer (6 – 8 weeks)	• In future, consider length of time surveys are open for
Survey Findings Gender	• Positive that number of male (n=24)/female (n=27) respondents was fairly even	
Aerobic exercise pre/post-stroke	• People who did aerobic exercise before and after stroke shows the 'rehabilitation worked' • This links with quality of life • Levels of activity – by how much has this increased for some • Decreases burden on services (secondary prevention)	• PCPI: some respondents may have self-initiated exercise outside of rehab provided by HCPs. • Secondary prevention - consider potential decrease in burden on health services
Exercise preferences	• Those with mental health issues usually prefer not to exercise in groups • Cultural sensitivity, e.g. Muslim women do not want to exercise with men • Understanding why people will/will not exercise • Services say they don't have the resources to adapt to those with stroke	• PCPI: Could conduct a follow-on study – e.g. Primary Care Networks on availability and uptake of support services; could look at certain geographies using local authority data, GP data and do a study in that area that could then be rolled out nationally • PCPI: Can be challenging to engage with all communities in the UK so start with a small geographical area, e.g. London, Birmingham, and conduct survey/research at community centres/facilities to learn lessons for rolling out the intervention

Plan for next steps Consensus event to share systematic review and survey findings	• Stakeholder seminar session would help to get the message out • Communicate to a wider community • funders, charities, organisations, health economics especially – benefits • People not accessing rehabilitation or exercise leads to a higher mortality rate and more NHS resources being used	• PCPI: Need to understand why people are not in rehabilitation • PCPI: Provide targeted support for people • PCPI: Professionals and service users – create a video about the study, PPI involvement in the design and include service providers
PCPI in this study Positives Negatives	• Kept updated on what was required from the group with good communication from the researcher • Felt engaged throughout the study • Meetings were respectful, open and honest • Able to pilot test the survey • Able to contribute to the survey and reflect on own condition • Given feedback on survey findings which included some surprising results • Timeline for the whole involvement – would have been helpful to know how long the whole project would take • Felt he was being rushed – better to give more notice of at least 2 -3 weeks for meetings (*Note: arranging the second meeting was a bit rushed but I used Doodle poll*) • Expressed disappointment with other group members when they did not engage / contribute to meetings / have cameras on / join meetings when they had accepted the invite	• Always maintain communication with the group • I had stated at the beginning that there would be 2 meetings over a 5-month period. • Aim to give at least 2-3 weeks' notice of any confirmed meeting dates in future • PCPI: consider process for recruiting to future PCPI groups. May wish to include a 10-minute interview to check the opportunity suits the person and ask how they feel about engaging in a group, having their camera on (for virtual meetings). Advised me to pay pro-rata for meeting attendance

*only one member of the group attended this meeting

Appendix 5.2. Feedback from pilot surveys – with three stroke survivors and two members of the public

Section	Feedback	Changes made
Advertisement	Remove the word 'aerobic' from the title as it may not be understood by potential participants	'Aerobic exercise after stroke' changed to 'Exercise after stroke'
	Change font colour to black on white background to ease access for those with visual problems	Well-spaced Black font on white background used throughout all participant-facing documents
Initial information and screening questions	Positive comments about the inclusion of the initial information as this saves time for people who are then screened out through ineligibility	No changes needed
	Change end-of-survey message for screen-out to include appreciation for their willingness to contribute	End of survey message amended to include suggested wording
Participant information sheet (PIS)	Repeat sources of support at the end of the PIS	Sources of support added to end of PIS
	Advantages of taking part: • Place these before disadvantages • Add option to request summary of findings so the person can see what they have contributed to	• Reordered advantages to come before disadvantages • Option to request summary of findings added at end of survey
Survey	Demographic questions not numbered originally but advised to number every question	All questions numbered
	Change description of aerobic exercise to make it 'gentle exercise'	Decided against this change as the definition of aerobic exercise does not include 'gentle exercise'
	Ensure wording around how long it takes to complete the survey is accurate and not too specific	Asked for feedback from pilot on time to complete and then gave a range for time to complete
	For specific questions change to multiple choice, add a free text option	Changes made to specific questions as suggested
Dissemination of survey	Consider contacting mental health charities such as MIND and McPin as well as stroke groups such as Stroke	Contacted MIND and McPin but they were unable to assist with circulation of the advertisement.

	Association. Certain group members offered to disseminate the advertisement to their contacts	The Stroke Association replied to say they currently do not have a member of staff to deal with research enquiries.

Appendix 5.3. A copy of the full questionnaire

Section 1

These questions are about yourself.
Please answer the questions honestly - all information that is collected is strictly confidential and anonymous.

1.1 What **age** are you?

18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65-74 ☐

75-84 ☐ 85 or over ☐ Prefer not to say ☐

1.2 What is your **gender**?

Male ☐ Female ☐ Other ☐ (please specify) ________ Prefer not to say ☐

1.3 What is your **ethnic group**?

White☐ Mixed or multiple ethnic groups ☐ Asian or Asian British ☐

Black, African, Caribbean or Black British ☐

Other ethnic group ☐ (please specify) _______ Prefer not to say ☐

1.4 What **country in the UK** do you currently live in?

England ☐ Northern Ireland ☐ Scotland ☐ Wales ☐

1.5 What is the **first part** of your **postcode?** (e.g. LA8, SE12) ………………………………………….

1.6 What best describes **your living situation**?

I live alone ☐ I live with other people ☐

If 'I live with other people', then:

1.6.1 Do you **live**

☐ with a partner or family

☐ in supported accommodation (eg. care home)

☐ Other, please specify ………………………………………………………………….

1.7 **How long** is it since you had your most recent **stroke**?

Less than 6 weeks ☐ 6 weeks to 3 months ☐ 4 - 6 months ☐ 7 months – 1 year ☐ 1- 2 years ☐ 2-3 years ☐ over 3 years ☐

1.8 Thinking about **your mobility**, do you

☐ walk on your own **without** a walking aid (e.g., a stick or a walking frame

☐walk on your own **with** a walking aid (e.g., a stick or a walking frame)

☐ walk with assistance from someone **without** a walking aid (e.g., a stick or a walking frame)

☐ walk with assistance from someone **and** a walking aid (e.g., a stick or a walking frame)

☐ use a wheelchair

Other, please specify …………………………………………………….

****

Section 2

The following questions ask about your personal views of aerobic exercise, and about exercise in the time before your stroke.

2.1 In your opinion, **what** is aerobic exercise? (Please select all that apply)

☐ Exercise that improves your balance using activities such as standing on one foot

☐ Exercise that makes your muscles stronger using activities such as lifting weights or carrying shopping

☐ Exercise that improves your heart and lungs and makes you fitter, such as brisk walking or dancing

☐ Exercise that makes your body more flexible using activities such as stretching

☐ None of the above

Here is a definition of **aerobic exercise:**

Aerobic exercise **improves your heart and lungs** and **makes you fitter**. It is the type of exercise which raises your heart rate, makes you breathe faster and feel warmer. It **involves moving continuously for at least 10 minutes** and using larger muscle groups, such as our leg muscles. Some examples of aerobic exercise are **brisk walking, cycling, climbing stairs, running, swimming, dancing, or rowing.**

Now please think about the time **before** you had your stroke.

2.2 Before your stroke, how important was aerobic exercise to you?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

2.3 Before your stroke, did you do any aerobic exercise?

☐ Yes ☐ No

If 'No', skip to Q2.3a

If 'Yes', go to 2.3.1

2.3.1 **Before your stroke**, what **type** of aerobic exercise(s) did you do? (Please select all that apply)

Walking ☐ Cycling ☐ Swimming ☐ Rowing ☐ Dancing ☐

Exercise class ☐ Other ☐ (please specify) ………………………………………………………

2.3.2 **Before your stroke**, how many times **per week in total** did you do these exercises?

[*Type of exercise(s) will be pulled through from 2.3.1 to a matrix table*]

Less than once a week ☐ Once a week ☐ 2-3 times a week ☐

4-5 times a week ☐ 6-7 times a week ☐ 8 times or more a week ☐

2.3.3 Before your stroke, how long did you exercise for each time?

[*Type of exercise(s) pulled through from 2.3.1 to a matrix table*]

Up to 15 mins ☐ 16-30 mins ☐ 31- 45 mins ☐ 46-60 mins ☐ more than 60 mins ☐

2.3a What were the **reasons** why you did not do aerobic exercise before your stroke? (Please select all that apply)

☐ It was not a priority for me

☐ There was nowhere for me to do aerobic exercise

☐ It did not fit with my lifestyle

☐ I did not enjoy exercise

☐ I was unable to due to health problems

☐ Other, please specify ……………………………………………………………….

2.3b Which of these is the **main reason** you did not do aerobic exercise?

[Answers pulled through from 2.3a for participant to click on main reason]

Now please think about the time **since your stroke**.

2.4 Since your stroke, how important is aerobic exercise to you?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

2.5 Since your stroke, have you been doing any aerobic exercise?

Yes ☐ No ☐

If 'No' skip to Q2.5a

If 'Yes', continue to 2.5.1

2.5.1 **How soon after your stroke** did you start this exercise?

☐ Less than one week

☐ 1 - 4 weeks

☐ 1 - 3 months

☐ 3 - 6 months

☐ 6 months - 1 year

☐ 1 year or more

2.5.2 What **type** of aerobic exercise(s) have you been doing?

(Please select all that apply)

Walking ☐ Cycling ☐ Swimming ☐ Rowing ☐ Dancing ☐ Upper body bike ☐ Exercise bike ☐ Stair exercise ☐ Circuits ☐ Other ☐ (please specify) __________

2.5.3 Since your stroke, how many **times per week in total** have you been doing aerobic exercise(s)?

[*Answers pulled through from 2.5.2 to a matrix table*]

Less than once per week ☐ Once per week ☐ 2-3 times ☐

4-5 times ☐ 6-7 times ☐ 8 or more times ☐

2.5.4 **How long** do you exercise for each time?

[*Answers pulled through from 2.5.2 to a matrix table*]

0-15 minutes ☐ 15-30 minutes ☐ 30-45 minutes ☐

45-60 minutes ☐ more than 60 minutes ☐

2.5.5 Since your stroke, do you exercise

on your own ☐ in a group or with others☐

on your own **and** with others ☐

2.5.6 Since your stroke, do you **prefer** exercising

in a group or with others ☐

on your own ☐

on your own **and** with others ☐

2.5.7 How **confident** do you feel about doing aerobic exercise?

☐ Completely confident

☐ Fairly confident

☐ Somewhat confident

☐ Slightly confident

☐ Not confident at all

2.5a What are the **reasons** why you have not done any aerobic exercise **since your stroke**?

(Please select all that apply)

☐ I am afraid that it may bring on another stroke

☐ I do not know how to exercise safely

☐ I do not feel confident about doing aerobic exercise

☐ I do not have enough support from friends or family to exercise

☐ I feel too tired to exercise

☐ I am not motivated to exercise

☐ Other health problems prevent me from exercising

☐ I have nowhere to exercise

☐ I do not have transport to get to a place where I can exercise

☐ I am concentrating on other areas of recovery from my stroke

☐ It is not a priority for me

☐ Other, please specify ……………………………………………………………………………………

[*If more than one option is selected in 2.5a, 2.5b will be the next question; If just one option is selected in 2.5a, 2.6 will be the next questions*]

2.5b Which of these is the **main reason** you have not done aerobic exercise since your stroke?

(Answers pulled through from 2.5a)

2.6 Do you think that doing aerobic exercise might help **prevent** having another stroke?

Yes ☐ No ☐ Don't know ☐

2.7 Do you think that **aerobic exercise can help** with any of the following?

(Please select all that apply)

☐ Getting fitter

☐ Improving balance

☐ Improving walking

☐ Making everyday activities easier

☐ Improving mental activities such as understanding or thinking

☐ Improving mood

☐ Other, please specify…………………………….

☐ None of these

2.8 Do you think that **aerobic exercise is recommended** for people who have had a stroke?

Yes ☐ No ☐ Don't know ☐

2.9 Please indicate your agreement with the following stated outcomes or benefits of exercising.

Exercise:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Is enjoyable	○	○	○	○	○
Makes me feel better	○	○	○	○	○
Improves my mood	○	○	○	○	○
Improves alertness	○	○	○	○	○
Improves endurance	○	○	○	○	○

Section 3

The following questions ask about the rehabilitation after your stroke, either in hospital or at home.

After your stroke you may have been contacted by **healthcare professionals** (e.g., a speech therapist, occupational therapist, nurse, doctor, physiotherapist or other) about **your rehabilitation**. This may have been in hospital, at a community centre, gym, your home, via phone or video call or a combination of these. **Rehabilitation after stroke** aims to enable you recover to the best of your ability and improve your quality of life.

3.1 Did you have any of the rehabilitation described above? Yes ☐ No ☐

If 'No', skip to 3.4

If 'Yes', continue to 3.1.1

3.1.1 **Where** did this rehabilitation take place? (Please select all that apply)

☐ in hospital

☐ in your home

☐ at a community centre

☐ at a gym

☐ via phone or video call

☐ Other, please specify ………………………………………….

3.1.2 Please remember that **aerobic exercise** is an activity that **raises your heart rate or make you breathe faster for a continuous period of time**.

During your rehabilitation, did anyone from **your healthcare team** speak to you about **aerobic exercise**?

Yes ☐ No ☐

If 'No' skip to 3.1a

If 'Yes', continue to 3.1.3

3.1.3 **Who** spoke with you about aerobic exercise? (Please select all that apply)

nurse☐ doctor ☐ physiotherapist ☐ occupational therapist ☐ speech and language therapist ☐ other ☐(please specify) ……………… don't know who ☐

3.1.4 **What** did the [*member of healthcare team*] speak with you about? (Please select all that apply)

☐ The benefits of aerobic exercise

☐ What type of aerobic exercise you could do safely

☐ How long you should do this aerobic exercise for, e.g., 10 minutes, 20 minutes, etc

☐ How many times per week you should exercise

☐ Where you could get more information about doing aerobic exercise

☐ Where you could get more support for doing aerobic exercise

☐ Local gyms or leisure centres

☐ They advised against doing aerobic exercise

☐ Other, please specify ……………………………………………

[Now skips to 3.2]

3.1a Would you have liked some **information** about aerobic exercise?

Yes ☐ No ☐

If 'No', skips to 3.2

If 'Yes' continues to 3.1b

3.1b **What** would you have liked to know about aerobic exercise?

(Please select all that apply)

☐ The benefits of aerobic exercise

☐ What type of aerobic exercise you could do safely

☐ How long you should do this aerobic exercise for, e.g., 10 minutes, 20 minutes, etc

☐ How many times per week you should exercise

☐ Where you could get more information about doing aerobic exercise

☐ Where you could get more support for doing aerobic exercise

☐ Local gyms or leisure centres

☐ Whether you should do aerobic exercise

☐ Other, please specify ………………………………………….

3.2 Did you do, or were you offered, any **aerobic exercise during your stroke rehabilitation**, in hospital or when your healthcare team visited you at home or spoke with you via phone or video call?

Yes ☐ Don't know ☐ No ☐

If 'Yes', continues to 3.2.1

If 'No' skips to 3.2a

3.2.1 **Where** did this take place?

☐ In hospital

☐ During your rehabilitation at home

☐ Somewhere else, please specify……………………………………….

3.2.2 **During your rehabilitation**, what **type(s)** of aerobic exercise did you do?

☐ Exercise bike

☐ Upper body bike

☐ Walking

☐ Treadmill

☐ Stair exercise

☐ Circuits

☐ Dancing

☐ Swimming

☐ Rowing

☐ Other, please specify …………………………………………………………

3.2.3 **How long** did you exercise for each time?

[*Answers pulled through from 3.2.2 to a matrix table*]

0-15 mins☐ 16-30 mins☐ 31-45 mins ☐

46-60 mins ☐ more than 60 minutes ☐

3.2.4 In total, how many **times per week** did you do the aerobic exercise(s)?

[*Answers pulled through from 3.2.2 to a matrix table*]

Less than once a week ☐ Once a week ☐ 2-3times ☐

4-5 times ☐ 6-7 times ☐ 8 or more times ☐

3.2.5 **During your rehabilitation**, did you exercise

(Please select all that apply)

on your own ☐ with your healthcare professional ☐

with family, carers or friends ☐

as part of a group, including with other stroke survivors ☐

Other, please specify ☐ ……………………………….

Now skip to 3.3

3.2a **Would you have liked** to have done some **aerobic exercise** during your rehabilitation (whether in hospital or at home)?

Yes ☐ No ☐

3.3 When you were **leaving hospital or finishing your rehabilitation**, were you given any **advice** about where you could find out **more information** about aerobic exercise?

Yes ☐ No ☐ Don't know ☐

If 'Yes', continues to 3.3.1

If 'No' or 'Don't know', skips to 3.3a

3.3.1 **What information** about aerobic exercise were you given?

(Please select all that apply)

☐ Leaflets containing advice

☐ Websites

☐ Verbal advice about aerobic exercise

☐ Information about the stroke association or other support groups

☐ Information about sports centres or gyms

☐ Other, please specify ……………………………………………………………………….

3.3a **Would you have liked** to have been given **advice** about aerobic exercise?

Yes☐ No ☐

If 'Yes', continues to 3.3b

If 'No', skips to 3.4

3.3b **What information** about aerobic exercise would you have liked?

(Please select all that apply)

☐ Leaflets containing advice

☐ Websites

☐ Verbal advice about aerobic exercise

☐ Information about the stroke association or other support groups

☐ Information about sports centres or gyms

☐ Other, please specify

……………………………………………………………………………….

3.4 What kinds of things **discourage or prevent** you from doing aerobic exercise?

(Please select all that apply)

☐ Fear of bringing on another stroke

☐ Fear of injuring myself

☐ Lack of knowledge about how to exercise since my stroke

☐ Lack of interest or motivation

☐ Lack of time

☐ Lack of support

☐ Cost

☐ Lack of transport

☐ No exercise facilities locally

☐ Other, please specify ……………………………………………………………………………….

☐ Nothing

[If more than one option has been selected, 3.4.1 will be the next question. If only one option or 'Nothing' has been selected, skips to 3.5]

3.4.1 Of the things that **discourage** you, which **one** is **most important** to you?

[Choices pulled forward from 3.4]

3.5 What kinds of things would **encourage or help** you to do aerobic exercise?

(Please select all that apply)

☐ More information about the benefits or effects of aerobic exercise after a stroke

☐ More information about how to do aerobic exercise safely after my stroke

☐ Knowing who I could ask for support with doing aerobic exercise

☐ Having the option to exercise with a group of other people including stroke survivors

☐ Supervision from a personal trainer or exercise professional

☐ Someone to accompany me during exercise or to get to and from exercise facilities

☐ Help with transport to a gym or sports centre

☐ Advice on sports equipment such as shoes, weights, bicycles

☐ Digital tools, such as apps or websites

☐Other, please specify……………………………………………………………………………………

☐ I do not need any further help or encouragement to do aerobic exercise

☐ Nothing – I do not wish to participate in aerobic exercise

[If more than one option has been selected, 3.5.1 will be the next question. If only one option or 'Nothing' has been selected, 3.6 will be the next question.]

3.5.1 Of the things that encourage you, which **one** is **most important** to you?

[Answers will be pulled forward from 3.5 to 3.5.1]

3.6 **If** your healthcare team **recommended** aerobic exercise after your stroke, **when** do you think would be the best time to **start** this exercise?

☐ During the person's stay in hospital

☐ At home with support from the community healthcare team

☐ After the person has been discharged from the rehabilitation or healthcare team

☐ Other, please specify ………………………………………………………………………………….

3.7 Do you have any other **comments** about aerobic exercise or this survey?

………

………

Optional

If you would like to **receive a summary of the findings** and/or are happy to be **contacted about taking part in further research** about aerobic exercise related to this doctoral research, please indicate this and provide your contact details below.

Otherwise please click **'Submit responses'**.

☐ I would like to receive a summary of the findings

☐ I am happy to be contacted about taking part in further research about aerobic exercise

*[If one or both of the above options are selected, participants will be taken to a separate second survey consisting of one question where they can provide their email address and indicate whether they would like a results summary and/or be contacted about further research. This ensures that their survey responses are completely anonymous and separate to their contact details. They will then be shown a summary of their responses and asked to scroll to the end and select '**Next**' to submit their responses.*

*If neither of the above options are selected, they can simply click '**Submit responses'** and they will see the end of survey message and a downloadable pdf version of their responses.]*

[End of survey message]

Thank you for completing this survey. Your responses have been submitted.

If you would like further information about exercise after stroke, please visit the Stroke Association's website (www.stroke.org.uk/life-after-stroke/exercising-after-stroke). You can also contact them by phone (0303 3033 100) or email (helpline@stroke.org.uk).

Other support can be found with organisations such as Headway (0808 800 2244) or MIND (0300 123 3393).

Appendix 5.4. A copy of the participant recruitment advert

Subject: Survey on UK Stroke Survivors' Views of Aerobic Exercise

Dear xxx,

I am/my student is conducting a research study about stroke survivors' views of aerobic exercise in the UK. This is part of my/her PhD and is being carried out using an electronic online survey.

The study has received ethical approval from the University of Central Lancashire. I am/she is seeking adult stroke survivors who are resident in the UK to consider taking part in this survey.

I have attached the advertisement which contains a link to further information and also copied it below. I would be very grateful if you could please circulate this via email or social media to anyone you think would be interested or who would be able to share with others.

You are welcome to help others to complete this survey or to ask a friend or relative to help you to complete this survey, if they/you are unable to complete it independently.

Thanks,

Nicola Gaskins

Appendix 5.5. Summary of study and screening

[*A link in the advertisement will bring the user to the following information*]

UK Stroke Survivors' Views of Aerobic Exercise: Can you help?

- We would like to invite you to take part in an online survey which is part of a Doctoral research project at the University of Central Lancashire.

What is the survey about?

- We are interested in the views of stroke survivors' living in the United Kingdom (UK) about a type of exercise called aerobic exercise.

Who can take part?

- If you are aged 18 or over, live in the UK and have had a stroke, we would be really interested to hear your views.
- **It does not matter whether or not you are interested in exercise, we still want to hear from you.**

How do I take part?

- Taking part is entirely voluntary.
- It may take around 20 – 30 minutes of your time to complete.
- Further information on the study can be found by clicking here *[downloadable long version PIS]*
- If you are interested in taking part, please complete three short questions to ensure the survey is right for you by clicking on '**Next**' below. You will then be given further information about the study to help you decide whether to take part.

  Thank you

'Next'

Screening questions *[compulsory]:*

To answer a question, please click on the answer(s) you wish to select.

Are you aged 18 or over? Yes ☐ No ☐

Have you had a stroke? Yes ☐ No ☐

Are you living in the United Kingdom (UK)? Yes ☐ No ☐

[Answering ***'Yes'*** *to all screening questions will automatically open the following participant information sheet and consent. Answering* ***'No'*** *to any screening question will automatically skip to the end of the survey and give this message:*

'Thank you very much for your interest in this survey and for your willingness to take part, which we really appreciate. However, for this study, participants need to be adult stroke survivors who are resident in the United Kingdom.

If you would like further information about exercise after stroke, please visit the Stroke Association's website (www.stroke.org.uk/life-after-stroke/exercising-after-stroke). You can also contact them by phone (0303 3033 100) or email (helpline@stroke.org.uk).']

Appendix 5.6. A copy of the long participant information sheet (PIS)

Participant Information Sheet - long version

Title of Study

- UK Stroke Survivors' Views of Aerobic Exercise

Invitation to Participate

- You are being invited to take part in a research study at the University of Central Lancashire (UCLan). This is being carried out by a doctoral research student supported by a team of experienced researchers.
- Before you decide whether to take part, it is important for you to understand why the research is being done and what it will involve.
- Please take time to read the following information carefully and ask us if you would like more information or if anything is not clear. Our contact details can be found below. Please talk to others about the study if you wish.
- We would like to stress that you do not have to accept this invitation and should only agree to take part if you would like to.

What is the purpose of this research?

- We want to find out what UK stroke survivors' views are of a type of exercise called aerobic exercise, as there is currently little research on this.
- **It does not matter whether you are interested in exercise or not, your opinions are still important to us.**

Who is invited to take part?

- You have been invited to take part because you have had a stroke, are aged 18 or over, and live in the UK.

Do I have to take part?

- No, it is up to you to decide to fill out the survey.

- If you do agree to take part, you will be able to skip any questions you do not wish to answer.

What will happen if I take part?

- If you agree to take part, we will ask you to confirm that you have read the information sheet and that you are giving your consent to take part in the survey. Then you will automatically be taken to the survey questions.
- You may wish to ask for support from a friend, relative or carer to complete the survey.
- It may take around 20 – 30 minutes to fill out the survey and there are 26 main questions. You will be able to see your progress on the bar at the top of each page.
- You will have one week to complete the survey, provided you keep your page (browser) open during this time. If you have not completed the survey within a week, any responses will be automatically deleted.
- First, there will be some questions about yourself, such as your age and how long it is since your stroke. This information will be used to compare the answers given by different groups of people when we are analysing the results of the survey. Then there will be questions about your personal views on aerobic exercise, both before and since you had your stroke.
- You will not be asked any questions which would enable us to work out who has answered the questions – your answers will remain anonymous.

Are there any benefits from taking part?

- Your feedback may help provide information to improve care and services for people after a stroke. You may find this rewarding on a personal level.
- You will have the option to request a brief summary of the study findings.

Are there any possible disadvantages or risks in taking part?

- The main disadvantage is that this will take up some of your time.
- You may find that just thinking about some issues can be upsetting or make you feel emotional. In these circumstances, we would advise you to discuss these with your GP or seek other support from organisations such as the Stroke Association (0303

3033 100), Headway (0808 800 2244) or Mind (0300 123 3393)

What will happen if I want to stop taking part?

- You are free to stop taking part in the survey at any point up until you click 'Submit responses' by closing your page (browser) at which point any responses will be deleted.
- You do not need to give a reason or explanation for stopping and this will not affect your care or rights in any way.
- Once you have clicked 'Submit responses', your answers will be automatically saved anonymously, so it will no longer be possible to remove or change your answers.
- If you provide your email address to receive a summary of the findings and later change your mind, you will need to contact the research student using the details below to have this deleted. You can do this at any point up until the summary is shared, after which your email will be deleted.
- If you provide your email address to be contacted about taking part in future research about aerobic exercise and later change your mind, you will need to contact the research student via email to have your email address deleted. You can do this at any point up until you are contacted about taking part in future research. After this, your email will be deleted.

How will my data be used?

- The University processes personal data as part of its research and teaching activities in accordance with the lawful basis of 'public task', and in accordance with the University's purpose of "advancing education, learning and research for the public benefit".
- Under UK data protection legislation, the University acts as the Data Controller for personal data collected as part of the University's research. The University privacy notice for research participants can be found on the attached link https://www.uclan.ac.uk/data_protection/privacy-notice-research-participants.php
- No personal data will be transferred outside the European Economic Area.
- We will only use information from you that we need for the research study. This information will include:

- **Your email address -** only if you have requested a summary of the study findings and/or if you have said you are interested in taking part in further research relating to this doctoral project.

How will my data be stored?

- We will keep all information about you safe and secure in line with the University Data Protection Code of Practice.
- All data that we collect will be transferred onto, and stored on, a secure UCLan drive.
- Physical copies of information will be stored in locked filing cabinets in locked UCLan rooms only accessible by the doctoral research student and her supervisory team.

Will my data be anonymised?

- People who do not need to know who you are will not be able to see your name or contact details (if you provide them, e.g., for receiving a summary of the findings etc). This information will be collected completely separately to your survey responses.
- Your data (survey responses) will be automatically anonymised when you click 'submit responses' and have a unique code number.
- No identifiable information will be included in any reports or publications about the study's findings so that no one can work out that you took part in the study.

How long will my data be stored for?

- Your data will be stored securely at UCLan for the duration of the doctoral project and an additional 5 years. Then, it will be fully anonymised and added to the UCLan data repository for future use in accordance with the Research Data Management Policy. At this time, all data that could identify you will be deleted or shredded.
- Anonymised research data will be made open access as appropriate.
- Your contact details will be destroyed once we no longer need to contact you.

What are my choices about how my information is used?

- We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

- You can stop being part of the study, without giving a reason, up until you click 'Submit responses' when your answers will be saved anonymously, and it will no longer be possible to remove your data from the results.
- You can find out more about how we use your information by contacting the doctoral research student or their Director of Studies using the details provided below.

Expenses and / or payments

- You will not receive any payment for taking part in this survey.

What will happen to the results of the study?

- Findings from this research will be shared widely using a range of methods, these will include:
    - Giving written feedback to people who took part in the study if they requested this
    - Presentations at conferences
    - Publication in journals
    - As part of the doctoral research student's (Nicola Gaskins) thesis.

Who has reviewed the study?

- The study has been reviewed and given a favourable opinion by UCLan's Health Ethics Review panel, to protect your safety, rights, wellbeing, and dignity.

What if I am unhappy or if there is a problem?

- If you are unhappy, or if there is a problem, please feel free to let us know by contacting the doctoral research student, Nicola Gaskins, or their Director of Studies, Professor Louise Connell, who will try to help.
- If you remain unhappy or would like to speak to someone outside of this study or have a complaint which you feel you cannot come to us with, then please contact the Research Governance Unit at OfficerForEthics@uclan.ac.uk .
- The University strives to maintain the highest standards of rigour in the processing of your data. However, if you have any concerns about the way in which the University

processes your personal data, it is important that you are aware of your right to lodge a complaint with the Information Commissioner's Office by calling 0303 123 1113.

Who can I contact if I have further questions?

- If you have any further questions, you can contact the doctoral research student or their Director of Studies for this project. Contact details are below.

Doctoral Research Student:

Name: Nicola Gaskins

Email address: njgaskins@uclan.ac.uk

Director of Studies:

Name: Professor Louise Connell

Email address: LAConnell@uclan.ac.uk

Thank you for reading this information sheet and for considering taking part in this research.

Appendix 5.7. A copy of the short participant information sheet (PIS)

Here is some further information about this research study. At the end you will be asked if you wish to consent to taking part in the survey.

Participant Information Sheet (short version)

UK Stroke Survivors' Views of Aerobic Exercise

The following summary gives you the key information about this doctoral research study. If you would like more detailed information, please click **here**.

What is this study about?

- We are interested in stroke survivors' personal views about a type of exercise called aerobic exercise, both from before and since their stroke.

What is involved?

- This will involve completing an online survey which has been approved by the University of Central Lancashire. This may take around 20-30 minutes.
- Taking part is completely voluntary.
  - You will be able to skip any questions you do not wish to answer.
  - You can stop taking part in the survey at any point up until you click 'Submit responses' by closing the page (your browser) without giving a reason or explanation and your answers will be automatically deleted.
  - If you start the survey and do not complete it within one week, any answers will be deleted.
  - Once you have clicked 'Submit responses', your answers will be automatically saved anonymously, and can no longer be removed or changed.

Are there any benefits or disadvantages to taking part?

- Your feedback may help to improve care and services for people after a stroke.
- You will be able to request a brief summary of the study findings if you wish.
- Completing the survey will take up some of your time.

- Thinking about some issues may be upsetting. If so, you could seek support from your GP or organisations such as the Stroke Association (0303 3033 100), Headway (0808 800 2244) or Mind (0300 123 3393)

How will my information be used?

- We will only use information which is given to us by you.
- Your answers to the survey will be saved anonymously and no identifiable information will be included in any reports or publications about the study's findings.
- We will keep all your information safe and secure, and we will not share it with anyone outside the PhD student's supervisory team. Anonymised research data will be made open access as appropriate. No personal data will be transferred outside the European Economic Area.

What happens next?

- More information can be found in the longer version of this participant information sheet by clicking here *[Downloadable file].*
- To find out more, or if there is a problem with the study, please contact the PhD research student, Nicola Gaskins (njgaskins@uclan.ac.uk), or their Director of Studies, Professor Louise Connell (LAConnell@uclan.ac.uk) who will try to help.
- If would like to speak to someone outside of this study or have a complaint which you feel you cannot come to us with, then please contact the Research Governance Unit at OfficerForEthics@uclan.ac.uk .

Thank you for reading this information sheet and for considering taking part in this research.

Please click **'Next question'** to continue

Appendix 5.8. Consent section of the survey

Please read the following statements and complete the question at the end of the section to confirm that you are giving your consent to take part in the survey.

- I confirm I have read and understood the study participant information sheet and had the chance to ask questions with the doctoral (PhD) research student via email
- I understand that I can stop taking part at any time by simply closing the page (my browser) without clicking 'Submit responses', at which point any responses I have given will be deleted.
- I understand that I do not need to give a reason or explanation for stopping and this will not affect my care or rights in any way.
- I understand that If I do not complete the survey within one week of starting it, my answers will be automatically deleted.
- I understand that once I click 'Submit responses' at the end of the survey my answers will be automatically saved anonymously, and I will no longer be able to stop taking part in the survey or withdraw my answers
- I understand that my data will be held in accordance with the University of Central Lancashire's Data Protection Code of Practice, General Data Protection Regulation (GDPR) and the Data Protection Act 2018
- I understand that my data (survey answers) will be used in the thesis of the named doctoral research student (Nicola Gaskins) and that in this instance my data would be anonymous, and I would not be identifiable either directly or indirectly
- I understand that my data (survey answers) may be published externally (in presentations, magazine, or journal articles) and that in this instance my data would be anonymous, and I would not be identifiable either directly or indirectly
- I understand that my anonymised data will be stored indefinitely in the University of Central Lancashire research repository according to University policies for further research or publications
- I have read and understand the above statements and hereby give consent to participate

  Yes☐ No ☐

[An answer is required for this question. If 'Yes' is selected, the survey will open automatically. Selecting 'No' will skip to the end of the survey and a thank you message].

Appendix 5.9. Opt-in to share contact details section of the survey

Please indicate whether you wish to receive a summary of the study findings and/or be contacted about taking part in further research about aerobic exercise. Then click 'Next'.

☐ I would like to receive a summary of the findings

☐ I am happy to be contacted about taking part in further research about aerobic exercise

Next

Please provide your email address to receive a summary of the findings and/or be contacted about taking part in further research about aerobic exercise as you have indicated. Then click **'Submit responses'.**

Email: ___________________________________

Submit responses

[End of survey message]

Thank you for completing this survey. Your responses have been submitted.

If you would like further information about exercise after stroke, please visit the Stroke Association's website (www.stroke.org.uk/life-after-stroke/exercising-after-stroke). You can also contact them by phone (0303 3033 100) or email (helpline@stroke.org.uk).

Other support can be found with organisations such as Headway (0808 800 2244) or MIND (0300 123 3393).

Appendix 5.10. A copy of the GRIPP2-SF (Staniszewska et al., 2017)

Table 2 GRIPP2 short form

Section and topic	Item	Reported on page No
1: Aim	Report the aim of PPI in the study	
2: Methods	Provide a clear description of the methods used for PPI in the study	
3: Study results	Outcomes—Report the results of PPI in the study, including both positive and negative outcomes	
4: Discussion and conclusions	Outcomes—Comment on the extent to which PPI influenced the study overall. Describe positive and negative effects	
5: Reflections/critical perspective	Comment critically on the study, reflecting on the things that went well and those that did not, so others can learn from this experience	

PPI=patient and public involvement

Appendix 5.11. Adverts for recruiting PCPI members

Patient, Carer and Public Involvement in a study about Aerobic Exercise After Stroke

What is the study about?
After a stroke it is important for people to improve their level of fitness. This can help with carrying out daily activities and to prevent another stroke.

Aerobic exercise is the type of exercise which improves your heart and lungs and makes you fitter. This is recommended for people who have had a stroke.

What is the aim of the study?
Although aerobic exercise is proven to be beneficial for people after stroke, little is known about what stroke survivors' think of, and know about, this type of exercise, particularly in the UK. This study aims to find out what those views and knowledge are so that this information can be used to shape what is offered to stroke survivors in terms of aerobic exercise.

How long will the study last?
This study will begin in January 2021 and finish in May 2022.

What do I have to do?
I would like you to advise on several aspects of the research. These will include helping with the study design and in the development of user-friendly written information which is relevant to the people taking part in the study. I would also like you to promote the study and the findings wherever possible, as well as helping to check that the conclusions are valid from a public perspective.

How often will meetings be held?
One meeting will take place at the beginning of the project (January/February 2022) with another at the end once the data has been analysed (May 2022).

Where will meetings be held?
Meetings will be held either via phone or video call.

How long will each meeting be?
One hour.

Who is in the group?
People who have had a stroke and carers of people who have had a stroke.

Will I be paid?
Advisors will be reimbursed for their time and some additional time reviewing documents in line with the NIHR guidance

You will be invited to actively participate and/or review outputs and publications (e.g. journal articles, conferences, newsletters, patient/carer information, websites, and other forms of social media) before they are delivered.

Response/ Further information

To respond to this invitation or for further information:
Please contact the Doctoral Student:

Nicola Gaskins
Faculty of Health and Wellbeing
University of Central Lancashire
Preston
PR1 2HE

Email address: njgaskins@uclan.ac.uk

People in Research Advertisement

Title:
Could you help with research about aerobic exercise after stroke?

Short description: (max 100 character)
We are looking for people with experience of stroke to contribute to a research study about exercise

Full description: (max 500 characters)
This opportunity is for people who have had a stroke or care for someone with a stroke.

This research is about aerobic exercise, the type of exercise that improves your level of fitness. It is recommended after a stroke. Your involvement in this research would include contributing to the study design and helping to review the meaning and relevance of the findings.

This would involve 2 discussions over the course of 5 months via video call.

Link to organisation:
www.uclan.ac.uk

Date for opportunity to be displayed: 07.01.2022
Date for opportunity to be removed: 21.01.2022

Organisation:

University of Central Lancashire (UCLan)

Description of organisation
A Doctoral student at UCLan under the supervision of experienced researchers is involved in this project. Their aim is to improve care and services for people who have had a stroke.

Topic:
Stroke or cardiovascular disease

Location:
North West

Involvement type
Designing and managing
Reviewing
Disseminating

Add document
You can upload documents that are relevant to the opportunity, for example role descriptions or information about the organisation.

Payment
An involvement fee to thank you for your time will be offered in line with NIHR guidance

Expenses:
All reasonable expenses will be covered.

What support is being offered?
All support needs will be considered, and wherever possible we will try to support those needs

Contact details
Name: Nicola Gaskins

Email: njgaskins@uclan.ac.uk

Telephone:
N/A

Website address:
www.uclan.ac.uk

Appendix 5.12. The completed GRIPP2-SF for the stroke survivor survey

Section and topic	Item
1. Aim	To ensure that this research was relevant and beneficial to stroke survivors
2. Methods	Five people with lived experience of stroke were recruited to a PCPI group via an advertisement on the NIHR People in Research website. Two meetings were conducted virtually, the first using MS Teams and the second using Zoom. The group members were involved in the development of the participant-facing documents for the survey which included the PIS and survey questions. They also advised on methods to disseminate the survey and recruit participants. Following data collection and some initial data analysis, one group member (a stroke survivor) attended the second meeting and gave their views on the study findings and whether these were representative and beneficial to the stroke community. They provided very useful suggestions on next steps for this research. The PCPI for this study was supported by a grant secured from the Research Design Service North West Coast.
3. Study Results	Survey development: Changes were made to all the participant-facing documents prior to submission for ethical approval. Pilot: One group member contributed to the piloting of the survey and provided further feedback. Recruitment: The researcher contacted other charitable groups to request assistance with dissemination of the advertisement as suggested by the group. Group members shared a link to the 'live' survey to help to recruit participants. Future plans: They were very positive about the researcher's plans to conduct a consensus event with stakeholders. It was helpfully suggested to include funders, charities, organisations, and a health economist in the planned consensus event with stakeholders. The group members gave permission for the researcher to keep their contact details on file so they could be contacted about future opportunities in relation to aerobic exercise after stroke. Future PCPI groups: The researcher was given useful practical advice on the process of recruitment and selection to a future PCPI group by one of the more experienced members of this PCPI group.

4. Discussion and conclusions	Patient and public involvement was effective, particularly in the development of the participant-facing documents in preparation for submission to ethics and in raising issues not considered by the researcher. It was encouraging that the initial survey results are also deemed beneficial to stroke survivors and the health service with regards to secondary prevention. Their advice regarding the consensus event were also valuable.
5. Reflections/critical perspective	Time was a limiting factor during meetings. Had smaller involvement fees been offered to the members or more funding been available it would have been beneficial for the first meeting to have been longer to enable full discussions of each section of the proposed survey. The researcher was developing skills around involving patients and members of the public in her research and therefore benefitted from the experience of setting up and running this group. The advice provided about the process of recruitment to PCPI groups, in relation to interviewing prospective group members, will be valuable in the future. Patient and public involvement in this research was discussed with the group member who attended the second meeting. The positives they reported included effective and timely communication by the researcher, meetings conducted respectfully, being able to contribute to the development of the survey, receiving feedback on some of the findings as well as reflect on their own lived experiences. The areas for improvement included giving very clear project timelines when advisers are first recruited and ensuring at least 2-3 weeks' notice in advance of all meetings. The effect that the non-attendance or lack of contribution of group members on those who did attend and contribute was also raised by the group member. They reported feelings of disappointment and lack of respect as a result of non-attendance despite accepting the meeting invitation. There is a possibility that conducting meetings remotely may have negatively influenced the rates of attendance and levels of contribution during meetings, e.g. people leaving their cameras off and remaining muted resulting in a lack of engagement; easier to decide last minute not to attend a meeting. In future, providing clear guidance on what is expected in terms of attendance and contribution during remote meetings may help. Remote meetings do have advantages in terms of removing geographical restrictions and travel costs for both attendees and researchers. However, lack of digital access can eliminate the possibility of contribution by others.

Appendix 6.1. A full version of the joint display

CFIR Domains	CFIR Constructs	Staff perspectives (Systematic review)	Stroke survivor perspectives (Survey)	System perspectives (Observational study)	Converge / diverge
I. INNOVATION DOMAIN **Aerobic exercise after stroke, process of its delivery (Initial referral → discharge or onward referral)**	Evidence-base	Importance of aerobic exercise (FLR) Should be prescribed (FLR)	Important (C-D) Recommended after stroke (FLR) Positive outcome expectation from participation (FLR)		*Convergence* Staff and stroke survivors shared similar views of aerobic exercise in terms of importance and benefits
	Adaptability	Adaptable for stroke survivors' needs using equipment, the environment, specialist/additional staff (FLR)			*Single perspective* Staff agreed aerobic exercise could be adapted and individualised for stroke survivors
	Complexity	Steps required prior to implementation such as screening and the potential number of professionals involved (B)			*Single perspective* Staff expressed concerns around the steps needed for implementation and the number professionals involved

II. OUTER SETTING DOMAIN **UK Politics, guidelines, COVID-19, healthcare system, community exercise settings**	Partnerships & connections	Networking and skill-sharing between organisations such as between healthcare staff and exercise professionals (FLR)			*Single perspective* Staff identified inter-organisational networking and skill-sharing as facilitators
FIII. INNER SETTING DOMAIN **NHS services, leisure centres, gyms, and other exercise providers**	Structural Characteristics	Service organisation (C-D) Staffing (C-D) Geographical coverage (C-D) Funding models (B) Stroke service provision (C-D)			*Single perspective* Factors around service organisation and stroke service provision, including geographical coverage and staffing, were important to staff. Funding models were identified as a barrier
	Relational Connections	Communication and collaboration between professionals within organisations (FLR)			*Single perspective* Interprofessional collaboration was identified as a facilitator by staff

	Communications	Communication within organisations (FLR) Knowledge-sharing between professionals and services (FLR)			*Single perspective* Communication and collaboration between professionals, services, and within organisations are facilitators
	Culture	Patients' social and cultural factors (C-D)	Lack of support (B)	Partnership status (partnered) • ↑ uptake (FLR) • ↑ completion (FLR)	*Converge* Staff, stroke survivor and system identified support as a factor. Staff were aware that stroke survivors' cultural factors also influenced implementation
	Compatibility	How implementation fits within the individuals' role, responsibility, and workflow (C-D) Process for onward referral to other			*Single perspective* The methods of referral to other services and how implementation would fit within a role and

		professionals or services (C-D)			responsibility was specific to staff perspectives
	Incentive Systems	Funding for training (FLR)			*Single perspective* Staff identified funding as a facilitator
	Available Resources	Staff, training, equipment, physical space, resources for screening & exercise testing (FLR) Lack of time to implement (B)		↑ Staff hours (Uptake FLR) % of stroke patients in CR programme (B) Overall number of patients in a service (B)	*Converge* Resources including staffing and equipment were facilitators in both the staff and system studies. Staff identified lack of time as a barrier, with the CR system study identifying service capacity as a barrier in terms of the proportion of stroke survivors in a CR programme and overall number of patients in a CR service

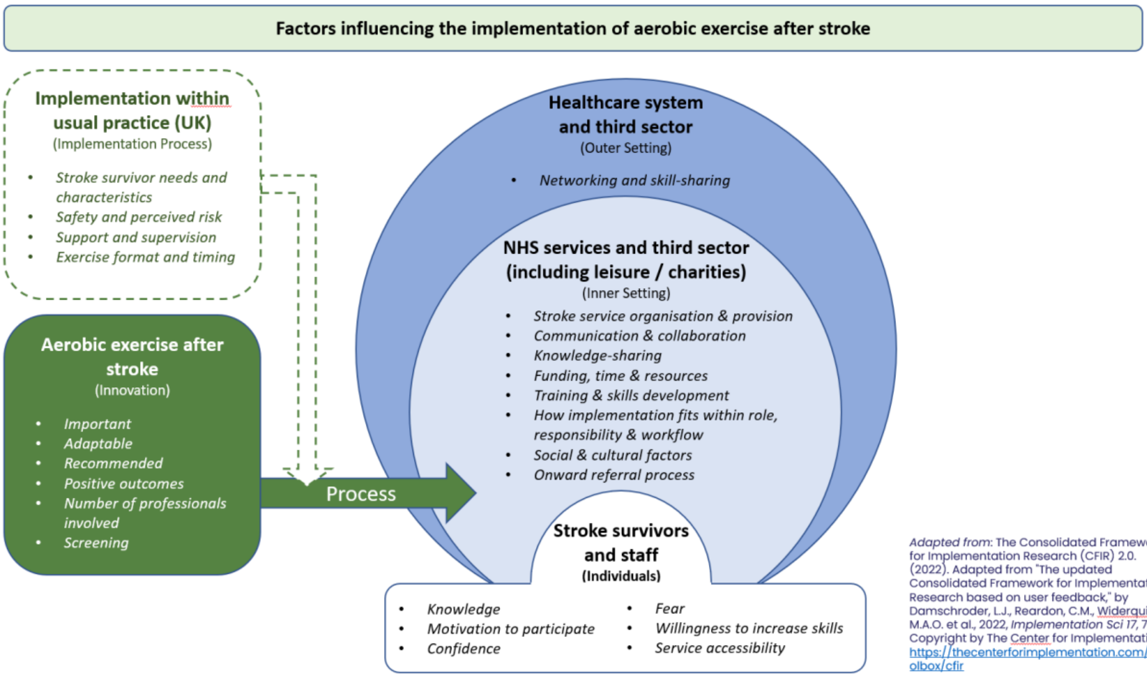
	Access to Knowledge & Information	Improve skills on incorporating the intervention (FLR) Training: safety, physical & cognitive aspects of stroke, communication, adaptive exercise & equipment (FLR)			*Single perspective* Staff said that undergoing training specific to delivering aerobic exercise after stroke and improving their skills to incorporate this into their practice were facilitators
IV. INDIVIDUALS DOMAIN – ROLES SUBDOMAIN **Staff; Stroke survivors**	Innovation Deliverers	Staff	Healthcare and exercise professionals	Staff delivering CR within the CR system	*Converge*
	Innovation Recipients	Stroke Survivors	Stroke survivors	People with comorbid stroke	*Converge*
IV. INDIVIDUALS DOMAIN – CHARACTERISTICS SUBDOMAIN **Characteristics of staff and stroke survivors**	Capability	Lack of knowledge about the intervention (B) Variable levels of confidence in exercise prescription (B) Fear of liability (B)	Lack of knowledge on how to exercise (B) Confident about participation (FLR) Fear of injury (B)		*Converge* Staff and stroke survivors shared characteristics around knowledge, fear, and confidence. Both groups wanted to learn about aerobic exercise to

		Fear of making patient worse (B) Willingness to upskill to implement intervention (FLR)	Information on exercising safely (FLR) Information on benefits/effects of aerobic exercise (FLR)		facilitate implementation.
	Opportunity	Service accessibility (C-D)			*Single perspective* Staff identified accessibility of services for stroke survivors as a factor
	Motivation	Concerned about patients' ability and motivation to participate (B) Intervention perceived as desirable (FLR) Willing to facilitate implementation via training (FLR)	Lack of interest/motivation (B)		*Converge* Concerns around motivation were raised by staff and stroke survivors. Staff perceived aerobic exercise as desirable and were willing to facilitate implementation via training

V. IMPLEMENTATION PROCESS DOMAIN **Usual practice within healthcare or exercise settings in the UK**	Assessing needs	Impact of patients' physical & cognitive needs, comorbidities on ability to participate (B) Safety & perceived risk to the patient (B)	Supervision from personal trainer or exercise professional (FLR) Group exercise option (FLR) Start aerobic exercise as inpatient (FLR)	Age (increasing) • ↓ uptake (B) • ↑ completion (FLR) Cardiac treatment • Any, ↑ uptake (FLR) • CABG only, ↑ completion (FLR) Previous cardiovascular disease event (Any) • ↑ completion (FLR) Deprivation (increasing) • ↓ uptake (B) • ↓ completion (B) Additional comorbidities • Musculoskeletal ↑ uptake (FLR) • Ischaemia ↓ uptake (B) • Metabolic ↓ completion (B) • Respiratory ↓ uptake (B) • Psychosocial ↑ uptake (FLR)	*Converge* Stroke survivor needs and characteristics were identified as factors in every study. The staff and system findings focussed on needs and comorbidities, with the stroke survivor study related to exercise preferences and support to participate in aerobic exercise

				↓ completion (B) • Erectile Dysfunction ↑ uptake (FLR)	

Appendix 6.2. Tables and diagrams presented at stakeholder meetings



Adapted from: The Consolidated Framework for Implementation Research (CFIR) 2.0. (2022). Adapted from "The updated Consolidated Framework for Implementation Research based on user feedback," by Damschroder, L.J., Reardon, C.M., Widerquist, M.A.O. et al., 2022, *Implementation Sci 17*, 75. Copyright by The Center for Implementation. https://thecenterforimplementation.com/toolbox/cfir

Factors influencing the implementation of aerobic exercise after stroke

CFIR Domains	Barriers	Facilitators	Factors
Aerobic exercise (Innovation)	• Screening • Professionals involved	• Important • Recommended • Adaptable and desirable • Positive outcomes	
Healthcare system and third sector (Outer setting)		• Interorganisational networking and skill-sharing	
NHS stroke services and third sector centres (Inner setting)	• Funding models • Lack of time • % of stroke survivors in programme (CR) • Overall numbers in a service (CR)	• Interprofessional communication and collaboration within organisations • Knowledge sharing between professionals and services • Training, funding, and resources • Improving skills to deliver aerobic exercise	• Stroke service organisation and provision • Geographical coverage of services • Fit of implementation within staff role, responsibility and workflow • Stroke survivor social and cultural factors • Onward referral process
Stroke survivors (Individuals)	• Lack of knowledge on how to exercise • Fear of injury • Lack of interest/motivation	• Information on exercising safely and effects of aerobic exercise • Confident about participation	
Staff (Individuals)	• Lack of knowledge • Fear of liability and making stroke survivor worse • Confidence to prescribe exercise varied • Concerns about stroke survivor motivation and ability to participate	• Willingness to undergo training to implement	• Service accessibility
UK usual practice (Implementation process)	• Impact of stroke survivor needs and comorbidities on ability to participate • Safety and perceived risk to stroke survivor • Lack of support	• Supervision from professionals • Group exercise option • Commence aerobic exercise during inpatient stay	• Stroke survivor characteristics – age, deprivation, additional comorbidities, cardiac treatment, and previous cardiovascular disease event