

# Using Intervention Mapping to Develop and Facilitate Implementation of a Multifaceted Behavioural Intervention Targeting Physical Activity and Sedentary Behaviour in Stroke Survivors: Physical Activity Routines After Stroke (PARAS)

**Sarah Moore**

Northumbria University - City Campus: Northumbria University

**Darren Flynn**

Teesside University School of Health and Life Sciences

**Christopher Price**

Newcastle University Faculty of Medical Sciences

**Leah Avery** (✉ [leah.avery@tees.ac.uk](mailto:leah.avery@tees.ac.uk))

Teesside University <https://orcid.org/0000-0003-3578-1209>

---

## Research

**Keywords:** Stroke, physical activity, sedentary behaviour, behavioural intervention, healthcare professional behaviour change, health behaviour change, intervention mapping

**Posted Date:** February 4th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-161430/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

## Background

The benefits of increased physical activity for stroke survivors include improved walking ability, balance and mood. However, less than 30% achieve recommended levels of physical activity, and high levels of sedentary behaviour are reported. We engaged stroke survivors, informal carers and healthcare professionals (HCPs) in a co-design process to develop an evidence-informed behavioural intervention targeting physical activity and sedentary behaviour for use by stroke rehabilitation teams.

## Methods

Intervention Mapping was used as a framework for intervention development. Step 1 involved a systematic review, focus group discussions and a review of existing care pathways. Step 2 involved identification of social cognitive determinants of behavioural change and behavioural outcomes of the intervention. Step 3 involved linking the determinants of behavioural outcomes with specific behaviour change techniques to target the behaviours of interest. Step 4 involved the development of the intervention informed by steps 1 to 3. Subsequently, an implementation plan was developed (Step 5) followed by an evaluation plan (Step 6).

## Results

Systematic review findings informed selection of nine 'promising' behaviour change techniques (e.g. goal setting-behaviour; problem-solving). Focus groups with stroke survivors (n=18) and HCPs (n=24) identified the need for an intervention that could be delivered at different time points within the rehabilitation pathway, tailored to individual needs and circumstances with training for HCPs delivering the intervention. Intervention delivery was considered feasible within local community stroke services. The target behaviours for the intervention were physical activity and sedentary behaviour of stroke survivors. Assessment of acceptability and usability with 11 HCPs and 21 stroke survivors/relatives identified issues around self-monitoring tools; the need for a repository of local services for physical activity; and the need for face-to-face feedback provision to HCPs following delivery of the intervention for optimisation purposes. Face-to-face training for HCPs was delivered to support faithful delivery of the intervention within community settings. A feasibility study protocol was designed to evaluate the intervention.

## Conclusions

A systematic development process using intervention mapping resulted in a multi-faceted evidence- and theory-informed intervention (Physical Activity Routines After Stroke - PARAS) for delivery by community stroke rehabilitation teams.

**Trial registration:** Trial identifier: ISRCTN35516780, date of registration: 24/10/2018, URL <http://www.isrctn.com/ISRCTN35516780>

# Contributions To The Literature

- There are recognised gaps in the literature and in practice on how to successfully support stroke survivors to engage in long-term physical activity and reduce sedentary behaviour.
- Current interventions are poorly described and target short-term improvements in physical activity without specific links to activities of daily living.
- Using intervention mapping, Physical Activity Routines After Stroke (PARAS) is an evidence- and theory informed co-designed intervention that addresses the limitations of existing interventions and incorporates training for healthcare professionals to facilitate delivery as part of routine care.

## Background

Low levels of physical activity (1) and high levels of time spent sedentary (2) are common after stroke, irrespective of post-stroke disability.(3) Both are associated with an increased risk of cardiovascular disease and type 2 diabetes, (4) reduced life expectancy (5) and impact negatively upon mental health and well-being.

A wealth of research demonstrates the short-term benefits of structured exercise interventions (commonly delivered in a group format) on cardiovascular risk factors (6) and function after stroke; (7) however, longer-term benefits are under-researched. Furthermore, structured exercise interventions for stroke survivors often have little or no emphasis on everyday habitual levels of physical activity and sedentary behaviour.(7) Stroke survivors express preferences for undertaking previous or new activities that are meaningful, promote independence, and can be incorporated into their everyday lives, such as gardening (8) or walking to the shops. Consequently, structured exercise interventions with prescribed activities are not appropriate for a proportion of stroke survivors. Moreover, structured exercise interventions often do not focus on developing stroke survivors' self-management skills, which inhibits them from making sustained changes in behaviour beyond the intervention period.(8)

The small number of randomised controlled trials (n=9) conducted that target long-term free-living physical activity after stroke show promise.(9) However, limitations in methodological quality and intervention design prevent any robust conclusions in this field.(9) Specifically, they lack adequate descriptions of intervention content(10) and fidelity assessment,(11) which restricts replicability and prevents successful implementation. There is also a dearth of interventions targeting reductions in sedentary behaviour alongside increasing physical activity of stroke survivors.

Furthermore, few interventions targeting physical activity and sedentary behaviour post-stroke have been developed with reference to theory, systematically developed or robustly evaluated. (9) The application of health behaviour change theory is critically important to gain a thorough understanding of the antecedents of the behaviours of interest, in order to develop targeted and effective interventions.(12-14) Intervention Mapping is a practical framework for systematic, evidence and theory-based planning for

behaviour change (15) and has been particularly effective in the context of healthcare,(16, 17) including informing the development of interventions targeting physical activity behaviour.(18)

Using Intervention Mapping, our aim was to systematically develop an evidence-and theory-informed behavioural intervention targeting long-term free-living physical activity and sedentary behaviour for integration into the stroke rehabilitation care pathway.

## Methods

### Overview of development process

Our intervention was developed with reference to the Medical Research Council Framework for the Development and Evaluation of Complex Interventions given the complexity of the target population (i.e. their complex needs) and type of intervention required (i.e. complex in terms of several intersecting components and factors influencing behaviour change presenting unique problems for evaluation).(19) We utilised Intervention Mapping as a framework to inform intervention content, delivery, implementation and evaluation.(20) The six steps of this intervention development approach described by Bartholomew *et al.* (2016) (20) were used to develop the intervention 'Physical Activity Routines After Stroke (PARAS)' and are summarised in Figure 1.

## Results

### Step 1: Needs assessment

To develop an intervention that could be tailored to effectively target physical activity and sedentary behaviour after stroke, and subsequently implement this intervention in to the stroke rehabilitation care pathway, we conducted a needs assessment. This involved: systematically reviewing the literature; consulting with healthcare professionals and stroke survivors and identifying local community stroke care pathways (where they existed) to determine how a new intervention could integrate with and/or complement what was already available.

### Systematic review

A systematic review of randomised controlled trials was undertaken to explore the characteristics and promise of existing intervention components targeting free-living physical activity and/or sedentary behaviour after stroke. (9)

### Key findings of systematic review

The findings of the systematic review have been published previously. (9) All nine studies (N=719 participants) included in the systematic review targeted physical activity behaviour, and none targeted sedentary behaviour. Six of the interventions evaluated were rated as promising – i.e. interventions with statistically significant between- or within-group improvements in outcomes greater than those of the

comparator group. (21) All of these interventions involved an element of supervised support that was tailored to individual needs. Both face-to-face and telephone contact were identified as promising modes of intervention delivery to engage stroke survivors in physical activity behaviour change. The number of contacts for promising interventions ranged from a single contact to 36 contacts, with the duration of interventions ranging from one single contact to twelve consecutive weeks. Nine promising behaviour change techniques were identified with reference to the BCT Taxonomy V1 (22) and considered for inclusion in our intervention: information about health consequences; information about social and environmental consequences; goal setting behaviour; problem-solving; action planning; feedback on behaviour; biofeedback; social support unspecified; and credible source.

### **Qualitative focus group discussions**

To complement and add context to the findings of our systematic review, a series of interactive focus group discussions were conducted with stroke survivors and healthcare professionals involved with their care. The overall aim of the focus groups was to identify determinants of behavioural change for both stroke survivors and healthcare professionals and to explore the barriers and enablers to engagement in long-term physical activity and reduction in sedentary behaviour post-stroke. Focus group discussions were conducted in person, audio-recorded and transcribed verbatim. Transcripts were read, re-read and analysed following the conduct of each focus group discussion and any unsubstantiated issues or points were further explored during subsequent group discussions (i.e. topic guides were revised accordingly).

Data were analysed using the Theoretical Domains Framework (TDF) (23), to facilitate an exploration of behavioural determinants likely to predict and impact upon behaviour and behaviour change. Three researchers independently read, re-read and analysed transcripts of stroke survivor and healthcare professional focus groups. The first researcher has a background in stroke physiotherapy and rehabilitation research (SAM), the second is a chartered health psychologist with expertise in health behaviour change and qualitative research methods (LA), and the third was a master's degree student. The skill mix of the researchers ensured appropriate questions were asked and responses were further probed to generate a comprehensive understanding of what was required from an intervention. Analyses of the data involved assigning text segments to one or more domains of the TDF and generating themes within each domain. Given the explicit nature of the TDF, all focus group transcripts with healthcare professionals and stroke survivors were coded and analysed by hand and no qualitative software was required. Common themes across the stroke survivors and healthcare professionals were subsequently established. Regular meetings were held with all three researchers to discuss their independent coding and analyses and to discuss any discrepancies until a consensus on the final domains and domain-specific themes was reached.

### **Findings of focus groups discussions**

Eighteen stroke survivors and twenty-four healthcare professionals (HCPs) (physiotherapists n=14, technical instructors n=8, physiotherapy assistants n=2) participated across seven focus groups. All 14 of the theoretical domains of the TDF were identified from the data generated from stroke survivor focus

groups. The TDF domains and themes are presented in Table 1. The most commonly populated domains were 'environmental context and resources', 'beliefs about consequences' and 'beliefs about capabilities' (Stroke survivor TDF domains themes and related change objectives are presented in Table 2, Step 2).

Data generated from HCP focus groups populated seven theoretical domains: 'knowledge', 'skills', 'social/professional role and identity', 'belief about consequences', 'beliefs about capabilities', 'reinforcement' and 'environmental context and resources'. The most populated domains were 'environmental context and resources' and 'skills' (HCP TDF domains themes and related change objectives are presented in Table 3, Step 2).

Although the aim of the focus group discussions with stroke survivors was to explore the determinants of behavioural change in relation to long-term physical activity *and* reduction in sedentary behaviour post-stroke, participants focused their discussions on physical activity. This highlighted a potential lack of understanding and awareness about sedentary behaviour and the importance of this in the context of stroke and stroke rehabilitation.

Lack of sustainable physical activity options were identified as a key barrier by stroke survivors to engagement in long-term physical activity post stroke. A lack of timely information and long-term support was also reported. Enablers to increasing physical activity and reducing sedentary behaviour were identifying meaningful, accessible, sustainable activities with social support and developing skills for self-monitoring physical activity and well-being. HCPs also identified environmental context and access to resources as barriers to promoting physical activity and reducing sedentary behaviour of stroke survivors, as well as a lack of skills to effectively support behaviour change.

### **Exploration of intervention opportunities within existing pathways**

To identify current stroke rehabilitation services and explore potential for delivering the intervention within existing pathways, a questionnaire was sent to local community stroke teams in the North East of England. Questions explored current and future staffing, current service provision, practices around promoting and supporting physical activity and sedentary behaviour post-stroke and potential for participation in a future study. Community stroke services at seven NHS trusts in the North East of England were considered for inclusion in the exercise. Four of these trusts were already involved in another rehabilitation study led by the research team, therefore it was agreed that they would not be approached so not to over burden the teams.

### **Key findings of exploration of existing pathways**

Service and capacity mapping and interest and ability to take part in a future feasibility study of the intervention were determined (Appendix A). All three trusts did not report any specific interventions or resources already in place to target free-living physical activity and sedentary behaviour and reported having an interest, capacity, and manager agreement to take part in a future feasibility study.

### **Key findings of needs assessment**

The needs assessment highlighted that physical activity and sedentary behaviour are not adequately addressed post-stroke and HCPs do not feel equipped to target these behaviours effectively. The systematic review of randomised controlled trials targeting long-term physical activity and sedentary behaviour after stroke identified promising behaviour change techniques and intervention components to incorporate into a new intervention. The qualitative focus group discussions explored physical activity and sedentary behaviour of stroke survivors, and the promotion and long-term support of post-stroke physical activity behaviour by HCPs. Data were analysed using the TDF which enabled further identification of potential BCTs and selection of theory alongside the findings of the systematic review. The needs assessment indicated that to increase physical activity and reduce sedentary behaviour after stroke, the intervention should be person-centred and adaptable to individual needs and preferences. A supported self-management approach was identified as a possible approach to target these requirements. Mapping of existing stroke rehabilitation pathways revealed there was potential to incorporate a physical activity and sedentary behaviour intervention and training for HCP into current practice.

## **Step 2: Identification of behavioural outcomes, and specification of performance and change objectives**

The needs assessment conducted in Step 1 identified the behaviours to be targeted by our intervention. Target behaviours were identified as physical activity and sedentary behaviour of stroke survivors and HCPs knowledge about physical activity and the promotion of physical activity in the context of stroke, and skills to support behaviour change to optimise consultation behaviour. The two behavioural outcomes of the PARAS intervention and related performance objectives are reported in Table 1.

### **Table 1. Behavioural outcomes and related performance objectives of PARAS**

**Stroke survivor behavioural outcomes:** *To develop knowledge to raise awareness of the importance of physical activity in the context of stroke, and skills to increase and sustain activity levels and reduce sedentary behaviour in order to perform activities of daily living.*

### **Performance objectives**

- Understands benefits of physical activity and reducing sedentary behaviour after stroke
- Requests support to increase physical activity and reduce sedentary behaviour at the most appropriate time
- Selects and safely performs meaningful and sustainable physical activity and/or reduces sedentary behaviour
- Identifies and utilises social support to maintain physical activity behaviour and reduce sedentary time
- Applies behavioural goal setting, action planning, and coping planning to selected physical activities and/or reducing sedentary behaviour
- Selects methods of self-monitoring physical activity and sedentary behaviour
- Self-monitors physical activity and sedentary behaviour, behavioural goal attainment and associated confidence and well-being
- Plans methods for maintaining physical activity or reducing sedentary behaviour

**HCP behavioural outcomes:** *To improve/increase knowledge about the benefits of physical activity in the context of stroke and to develop skills to promote and sustain activity levels and reduce sedentary behaviour to enable stroke survivors to perform activities of daily living.*

- Accepts supporting physical activity and reducing sedentary behaviour after stroke is beneficial for stroke rehabilitation and part of the HCP role
- Supports stroke survivors to successfully engage in the PARAS intervention
- Appropriately uses PARAS intervention resources to support stroke survivor engagement in the PARAS intervention
- Appropriately uses behaviour change counselling techniques to support stroke survivor's identify reasons for physical activity behaviour change and maintenance

Change objectives (i.e. aspects of behaviour individuals are required to learn, do or change) that need to be accomplished by stroke survivors and HCPs in order to achieve the behavioural outcomes and performance objectives were developed related to the TDF domains and sub-themes identified in Step 1. These are described in Tables 2 and 3.

**Table 2. Theoretical domains and associated themes identified from focus group data generated by stroke survivors and related change objectives**

TDF Domain	Themes identified	Stroke survivor change objectives
<b>Knowledge</b>	<p>Timing of information provision is important but highly individual</p> <p>Amount and intensity of physical activity has to increase to derive benefit</p> <p>Lack of knowledge about physical activity opportunities and support available prevents engagement</p>	<p>To have the knowledge and confidence to request information at the right time</p> <p>To develop skills and mastery of tools and resources to safely self-manage physical activity and sedentary behaviour</p>
<b>Skills</b>	<p>Planning and self-monitoring can facilitate engagement in physical activity and help reduce sedentary time</p>	<p>To have capacity and capability to master self-monitoring of physical activity</p>
<b>Social/Professional role</b>	<p>Past physical activity levels and engagement facilitates participation in physical activity and physical activity choices</p> <p>Being physically active with people of a similar age and varying abilities provides confidence</p>	<p>To identify meaningful physical activities</p> <p>To identify and engage social support</p>
<b>Beliefs about capabilities</b>	<p>Confidence about ability is a barrier to increasing physical activity</p> <p>Old age, comorbidities and fatigue limit ability to be active</p>	<p>To develop knowledge and capability to confidently undertake physical activity. This involves articulating reasons for change.</p> <p>To be able to describe personal barriers to physical activity and reducing sedentary behaviour and identify potential solutions.</p>

<b>Optimism</b>	A positive attitude facilitates participation in physical activity and reduces sedentary behaviour when prompted	To be able to set behavioural goals and actions and monitor well-being when goals are achieved
<b>Beliefs about consequences</b>	<p>Too much physical activity too soon could lead to further health problems including stroke recurrence</p> <p>Physical activity as a mechanism to return to pre-stroke self</p> <p>Fear of falls is a barrier</p> <p>Physical activity gets you out of the house</p> <p>Physical activity fills time post stroke</p>	<p>To be able to identify a physical activity that feels safe but is effective for achieving outcome goals</p> <p>To be able to identify meaningful, safe physical activity outcomes and select appropriate activities likely to lead to these outcomes</p>
<b>Reinforcement</b>	Sense of achievement can facilitate longer-term physical activity	<p>To identify and use appropriate tools to measure physical activity against behavioural and outcome goals</p> <p>To monitor wellbeing in response to goal attainment</p>
<b>Intentions</b>	Recognition of the importance of physical activity but HCP information provision not sufficient to enable physical activity	To access appropriate physical activity information and advice and select meaningful activities that are more likely to lead to behavioural change
<b>Goals</b>	Planning physical activity in advance increases the likelihood it will be undertaken	To set appropriate and realistic behavioural and outcome goals
<b>Memory, attention and decision processes</b>	Having to think about everything before doing it post-stroke makes engagement in physical activity more difficult	To use appropriate tools to set realistic goals and action plan to aid memory
<b>Environmental context and resources</b>	Stroke specific groups provide emotional and physical support that can facilitate physical activity.	To identify and engage social support to enable PA

	<p>Modifying home environment can facilitate physical activity and reduce sedentary time</p> <p>Restricted car use can impact on physical activity levels</p> <p>Mixed ability and co-morbidity groups can facilitate physical activity</p> <p>Knowledge and skills of professionals can affect uptake of physical activity</p> <p>Lack of longer-term physiotherapy input can affect long-term physical activity</p> <p>Lack of information provision, resources and available options is a barrier to physical activity</p> <p>Dependence on others to be able to leave home is a barrier to increasing physical activity</p>	<p>To understand and access resources available within the home and locally to increase physical activity and reduce sedentary time</p>
<b>Social influences</b>	<p>Peer support groups provide a means of support and can help to facilitate physical activity</p>	<p>To identify and engage with social support</p>
<b>Emotion</b>	<p>Group based activities that are enjoyable and provide a means of support can facilitate physical activity</p> <p>Anxiety and depression is a barrier to engaging on activities</p>	<p>To select safe physical activities that lead to meaningful outcomes and a sense of well-being</p>
<b>Behavioural</b>	<p>Planning and self-monitoring can</p>	<p>To use planning and self-monitoring</p>

<b>regulation</b>	facilitate engagement in physical activity and help reduce sedentary time	tools meaningfully and review physical activity and sedentary behaviour to support maintenance
-------------------	---	--

**Table 3. Theoretical domains and associated themes identified from focus group data generated by healthcare professionals and change objectives**

Theoretical Domains	Themes	HCP change objectives
<b>Knowledge</b>	Training in the benefits and use of physical activity in the context of stroke would be beneficial	<p>To understand the benefits of physical activity and reducing sedentary behaviour post-stroke</p> <p>To deliver person centred, personalised support to stroke survivors</p>
<b>Skills</b>	<p>Being able to promote physical activity tailored to individual needs is essential for promoting participation</p> <p>Skills to help patients overcome barriers to physical activity will facilitate longer-term engagement</p>	<p>Able to identify physical activity resources available to stroke survivors that meet their individual needs</p> <p>To support stroke survivors to undertake barrier identification and coping planning</p>
<b>Social/Professional role</b>	Promoting physical activity is part of the healthcare professional's role	Engage in training to use a range of behavioural tools to target physical activity
<b>Beliefs about capabilities</b>	Engaging patients in physical activity and reducing sedentary time is difficult when pre stroke activity levels were low	To apply appropriate behaviour change counselling techniques to engage stroke survivor in behaviour change and maintenance
<b>Beliefs about consequences</b>	<p>Being overweight can be a barrier to physical activity and reduction in sedentary time for stroke survivors</p> <p>Motivational strategies will only work on a proportion of patients</p> <p>Withdrawal of physiotherapy support makes promotion and support of long-term physical activity problematic</p>	<p>Able to identify the different barriers to behaviour change and support the formulation of appropriate coping plans</p> <p>Able to succeed with resistant or ambivalent stroke survivors</p> <p>To understand how to support stroke survivor's long-term physical activity within the context of individual service delivery, identifying meaningful, sustainable activities and social support</p>
<b>Reinforcement</b>	Seeing patients succeed is an incentive to promoting physical activity	Able to support stroke survivors to identify and achieve meaningful, sustainable physical activities and social support

<b>Environmental context and resources</b>	Increased availability of physical activity options for patients post stroke would be beneficial	To develop knowledge of physical activity resources available to stroke survivors
	Community physical activity groups are usually targeted at higher functioning stroke survivors	To be able to adapt physical activity support to individual needs of stroke survivors and enable identification of meaningful sustainable activities and goals
	Promoting long-term engagement in physical activity can be difficult without an individual in the team to take on this role	
	Tools to tailor physical activity to individual needs would be beneficial	To be able to access and effectively apply tools to support engagement in physical activity and reduction in sedentary behaviour e.g. self-monitoring tools
	Self-monitoring tools and technologies could be useful to initiate and maintain physical activity.	
	Funding and time are barriers to physiotherapists participating in training to effectively target and support stroke survivors to be physically active	To be able to access training on how to support physical activity and reduce sedentary behaviour post-stroke within restrictions of current job role

### Step 3: Selection of theory-based intervention content

Selection of the theories/models to underpin the behaviour change intervention were informed by the findings of steps 1 and 2.

#### Theoretical underpinning of stroke survivor component of intervention

Two theories were selected to underpin the stroke survivor component of the multifaceted intervention, they were the Health Belief Model (24) and Self-Regulation Theory. (25) The Health Belief Model assumes an individual's belief in the personal threat of an illness together with their belief that the effectiveness of a health behaviour or action will determine whether they change their behaviour (or not).

Step 1 informed the selection of this model to target individual perceptions of stroke and stroke recurrence including the use and perceived benefits and disadvantages of physical activity and inactivity. It was felt that this model would be appropriate particularly around challenging beliefs about the consequences of physical activity/inactivity and as such formulate reasons/intentions for engaging in physical activity.

Self-Regulation Theory assumes that behaviour is goal-directed or purposive. Findings from our systematic review and focus group discussions supported the need for specific strategies to target volition as well as motivation in recognition that maintenance of physical activity for stroke survivors can be particularly challenging given the level of cognitive and physical effort required. Furthermore, inclusion of several specific BCTs that target self-regulation e.g. goal setting-behaviour; problem-solving; action planning; feedback on behaviour were identified from the systematic review as promising.

Behaviour change techniques (BCTs) are the irreducible active ingredients of interventions targeting behaviour change, and are useful to inform, describe, deliver and evaluate behaviour change interventions. (26) TDF domains were identified from the data generated from stroke survivor focus group discussions and BCTs were selected with reference to those domains, supported by evidence from the systematic review (i.e. BCTs identified by the review as promising). When discrepancies occurred between the findings of the qualitative study and the systematic review, members of the research team discussed these findings and reached a consensus in terms of inclusion/exclusion of specific BCTs. The outcome of the decision-making process is summarised in Table 4 which also describes how BCTs were operationalised to target increases in levels of physical activity and a reduction in sedentary behaviour.

**Table 4. Theoretical intervention mapping targeting physical activity and sedentary behaviour of stroke survivors**

TDF Domain	Behaviour change technique (used/not used, promising/non-promising from systematic review findings)	Selection rationale	Theoretical constructs targeted and potential intervention components
Knowledge	<p>5.1: Information about health consequences (used/promising)</p> <p><b>Definition:</b> Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour</p>	<ul style="list-style-type: none"> <li>· Assessed as promising systematic review</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Appropriate theory: Health Belief Model (HBM)</p> <p>Constructs: All constructs of HBM</p> <p>Suggested/example intervention component(s):</p>
	<p>5.2: Salience of consequences (not used)</p> <p><b>Definition:</b> Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)</p>	<ul style="list-style-type: none"> <li>· Not supported by systematic review findings, but overruled based on small sample sizes</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<ul style="list-style-type: none"> <li>· Booklet for patients and/or DVD containing information and patient narratives</li> <li>· Access to repository of information via HCPs to obtain details of local activities, support and resources</li> </ul>
	<p>3.1: Social support (unspecified)(used/promising)</p> <p><b>Definition:</b> Advise on, arrange or provide social support (e.g. from friends, relatives, colleagues, buddies' or staff) or non-contingent praise or</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	

	<p>reward for performance of the behaviour. It includes</p> <p>encouragement and counselling, but only</p> <p>when it is directed at the behaviour</p>		
	<p>9.1 Credible source (used promising)</p> <p><b>Definition:</b> Present verbal or visual communication</p> <p>from a <b>credible source</b> in favour of or</p> <p>against the behaviour</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	
<b>Skills</b>	<p>4.1: Instruction on how to perform the behaviour <b>(used/non-promising)</b></p> <p><b>Definition:</b> Advise or agree on how to perform the behaviour (includes <b>'Skills training'</b>)</p>	<ul style="list-style-type: none"> <li>· Not supported by systematic review findings, overruled based on small sample sizes and the need for instruction on how to perform specific activities safely</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: Self-Regulation Theory (SRT)</p> <p>Constructs: Action planning, problem solving</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Workbook (template to be completed/populated in discussion with a HCP) and/or DVD</li> </ul>
	<p>6.1: Demonstration of the behaviour <b>(used/non-promising)</b></p> <p><b>Definition:</b> Provide an observable sample of the performance of the behaviour, directly in person or indirectly</p>	<ul style="list-style-type: none"> <li>· Not supported by systematic review findings, overruled based on the need to demonstrate behaviour for safety</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	
<b>Social/Professional</b>	3.1: Social support	<ul style="list-style-type: none"> <li>· Supported</li> </ul>	Relevant theory: SRT

<p>role</p>	<p>(unspecified) <b>(used promising)</b></p> <p><b>Definition:</b> Advise on, arrange or provide social support (<i>e.g. from friends, relatives, colleagues, 'buddies' or staff</i>) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the <b>behaviour</b></p>	<p>by systematic review findings</p> <ul style="list-style-type: none"> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Constructs: Feedback; problem solving</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Access to repository of information via HCPs to obtain details of local support and resources. Constructs are targeted by social support (<i>e.g., positive reinforcement and sharing of information to overcome barriers</i>).</li> </ul>
<p><b>Beliefs about capabilities</b></p>	<p>1.1: Goal setting (behaviour) <b>(used/promising)</b></p> <p><b>Definition:</b> Set or agree on a goal defined in terms of the behaviour to be achieved</p> <hr/> <p>1.2: Problem solving <b>(used/promising)</b></p> <p><b>Definition:</b> Analyse, or prompt the person to analyse, factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators (includes '<b>Relapse Prevention</b>' and <b>Coping Planning</b>)</p> <hr/> <p>4.2: Information about antecedents <b>(not used)</b></p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul> <hr/> <ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: HBM &amp; SRT</p> <p>Constructs: Individual perceptions; likelihood of action; goal setting; problem solving</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Information booklet and/or DVD concentrating on antecedents and pros and cons for changing behaviour. Booklet template to be completed in discussion with a HCP targeting goal setting and problem solving.</li> </ul>

	<p><b>Definition:</b> Provide information about antecedents</p> <p><i>(e.g. social and environmental situations and events, emotions, cognitions)</i> that</p> <p>reliably predict performance of the</p> <p>behaviour e.g. Advise to keep a record of</p> <p>snacking and of situations or</p> <p>events occurring prior to snacking</p>	<p>review, overruled based on strength of qualitative findings</p> <ul style="list-style-type: none"> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	
<b>Optimism</b>	<p>5.4: Monitoring of emotional consequences <b>(not used)</b></p> <p><b>Definition:</b> Prompt assessment of <b>feelings</b> after attempts at performing the behaviour</p>	<ul style="list-style-type: none"> <li>· Not used in systematic review, overruled based on strength of qualitative findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: HBM &amp; SRT</p> <p>Constructs: Modifying factors; self-monitoring</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Booklet to be completed/populated in discussion with a HCP, reviewed and feedback provided to provide positive reinforcement</li> </ul>
<b>Beliefs about consequences</b>	<p>5.1: Information about health consequences <b>(used/promising)</b></p> <p><b>Definition:</b> Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: HBM</p> <p>Constructs: Individual factors; modifying factors</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Information booklet and/or DVD with patient and HCP narratives</li> </ul>
	<p>5.3: Information about social and environmental</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> </ul>	

	<p>consequences <b>(used/promising)</b></p> <p><b>Definition:</b> Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behaviour</p>	<ul style="list-style-type: none"> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	
<b>Reinforcement</b>	<p>10.4: Social reward <b>(not used)</b></p> <p><b>Definition:</b> Arrange verbal or non-verbal reward if and only if there <i>has been</i> effort and/or progress in performing the behaviour (includes 'Positive reinforcement')</p>	<ul style="list-style-type: none"> <li>· Not used in systematic review, overruled based on strength of qualitative findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Feedback</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Feedback from a HCP or social group relating to attainment of goals</li> </ul>
<b>Intentions</b>	<p>5.1: Information about health consequences <b>(used/promising)</b></p> <p><b>Definition:</b> Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour</p> <p>5.3: Information about social and environmental consequences <b>(used/promising)</b></p> <p><b>Definition:</b> Provide information (e.g. written, verbal,</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: HBM</p> <p>Constructs: Individual factors; modifying factors</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Information booklet and/or DVD with patient and HCP narratives</li> </ul>

	visual) about social and environmental		
	consequences of performing the behaviour		
<b>Goals</b>	<p>1.1: Goal setting (behaviour) <b>(used/promising)</b></p> <p><b>Definition:</b> Set or agree on a goal defined in terms of the behaviour to be achieved</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Goal setting</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Goal setting component within the booklet. Template to be completed in discussion with a HCP</li> </ul>
<b>Memory, attention and decision processes</b>	<p>8.3: Habit formation <b>(not used)</b></p> <p><b>Definition:</b> Prompt rehearsal and repetition of the behaviour in the same context repeatedly so that the context elicits the behaviour</p>	<ul style="list-style-type: none"> <li>· Not used in systematic review, overruled based on strength of qualitative findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Goal setting; action planning</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Goal setting and action planning components within the booklet. Template to be completed in discussion with a HCP</li> </ul>
<b>Environmental context and resources</b>	<p>3.1: Social support (Unspecified) <b>(used/promising)</b></p> <p><b>Definition:</b> Advise on, arrange or provide social support (<i>e.g. from friends, relatives, colleagues, 'buddies' or staff</i>) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Action planning; feedback</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Access to repository of information about physical activity options and support via a HCP</li> </ul>

	<p>when it is directed at the <b>behaviour</b></p> <hr/> <p>12.1: Restructuring the physical environment (<b>not used</b>)</p> <p><b>Definition:</b> Change, or advise to change the <b>physical</b> environment in order to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards and punishments)</p>	<ul style="list-style-type: none"> <li>· Not used in systematic review, overruled based on strength of qualitative findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus that it is not appropriate for everyone</li> </ul>	<ul style="list-style-type: none"> <li>· A booklet showing examples of the physical environment that can be populated (tailored to the individual)</li> </ul>
<b>Social influences</b>	<p>3.1: Social support (Unspecified) (<b>used/promising</b>)</p> <p><b>Definition:</b> Advise on, arrange or provide social support (<i>e.g. from friends, relatives, colleagues, 'buddies' or staff</i>) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the <b>behaviour</b></p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Feedback; action planning; problem solving</p> <p>Suggested/example intervention component(s):</p> <ul style="list-style-type: none"> <li>· Access to repository of physical activity options and support via a HCP</li> <li>· Use of booklet to plan support around physical activity</li> </ul>
<b>Emotion</b>	<p>3.1: Social support (unspecified) (<b>used/promising</b>)</p> <p><b>Definition:</b> Advise on, arrange or provide social</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Feedback; self-monitoring</p> <p>Suggested/example intervention</p>

	<p>support (<i>e.g. from friends, relatives, colleagues, buddies' or staff</i>) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the <b>behaviour</b></p>	<ul style="list-style-type: none"> <li>· Expert consensus</li> </ul>	<p>component(s):</p> <ul style="list-style-type: none"> <li>· Access to repository of physical activity options (<i>e.g., local groups</i>) via a HCP to provide ongoing support</li> <li>· Use of booklet to monitor effect of PA on emotions and mood followed by feedback from a HCP</li> </ul>
	<p>5.4 Monitoring of emotional consequences (<b>not used</b>)</p>	<ul style="list-style-type: none"> <li>· Not used in systematic review, overruled based on strength of qualitative findings</li> <li>· Theme from qualitative research</li> <li>· Expert consensus</li> </ul>	
<p><b>Behavioural regulation</b></p>	<p>1.1: Goal setting behaviour (<b>used/promising</b>)</p> <p><b>Definition:</b> Def: Set or agree on a goal defined in terms of the behaviour to be achieved</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<p>Relevant theory: SRT</p> <p>Constructs: Goal setting; action planning; feedback; self-monitoring</p> <p>Suggested/example intervention component(s):</p>
	<p>1.4: Action planning (<b>used/promising</b>)</p> <p><b>Definition:</b> Prompt detailed planning of performance of the behaviour (must include at least one of context, frequency, duration and intensity).</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>	<ul style="list-style-type: none"> <li>· Booklet template to be completed with a HCP. Provision for self-monitoring and feedback (<i>e.g., use of pedometers</i>).</li> </ul>
	<p>2.2: Feedback on behaviour (<b>used/promising</b>)</p>	<ul style="list-style-type: none"> <li>· Supported by systematic review findings</li> </ul>	

<p><b>Definition:</b> Monitor and provide informative or evaluative feedback on performance of the behaviour (e.g. form, frequency, duration, intensity)</p>	<ul style="list-style-type: none"> <li>· Supported by qualitative findings</li> <li>· Expert consensus</li> </ul>
<p>2.3: Self-monitoring of behaviour (<b>used/non-promising</b>)</p>	<ul style="list-style-type: none"> <li>· Supported by qualitative findings</li> <li>· Expert consensus overruled systematic review. Feedback on behaviour required undertaking of self-monitoring.</li> </ul>
<p><b>Definition:</b> Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy</p>	

### Theoretical underpinning of the healthcare professional component of the intervention

Social Cognitive Theory (27) was selected to underpin the development and evaluation of the healthcare professional component of the multifaceted intervention to target consultation behaviour. This theory was considered appropriate with reference to the findings from the focus group discussions with HCPs during Step 1. For example, HCPs highlighted the need for specific knowledge and skills development training that would enable them to attain specific practice-related goals. These included promoting and supporting an increase in physical activity to enable improvements in specific functional outcomes of patients. Social Cognitive Theory provides specific examples of evidence based strategies for translating motivation/intentions into action/behaviour in healthcare professionals through the use of modelling to increase skills and self-efficacy. (28) Focus group data supported the need for modelling to facilitate skill acquisition and target beliefs about capabilities.

The selection of BCTs incorporated in to the HCP component of the intervention was also informed by findings from the qualitative focus group discussions conducted as part of step 1. The decision making process is summarised in Table 5 which also describes how BCTs were operationalised to support stroke survivors to engage in the PARAS intervention to engage in activities, improve their levels of physical activity and reduce sedentary behaviour.

**Table 5. Theoretical intervention mapping targeting healthcare professional consultation behaviour**



TDF Domain	BCTs identified by healthcare professionals in PARAS qualitative work	Theoretical constructs targeted and potential intervention components
<b>Knowledge</b>	5.1: Information about health consequences  9.1: Credible source	Relevant theory: Social Cognitive Theory  Constructs: Forethought capability, Vicarious learning capability  Suggested/example intervention component(s):  <ul style="list-style-type: none"> <li>· A face-to-face training programme presenting research evidence supporting increased physical activity and reduced sedentary behaviour in the context of stroke</li> <li>· Case studies of patients who have successfully increased their physical activity levels and/or reduced sedentary time and if possible</li> <li>· Case studies from physiotherapists who have successfully supported stroke survivors to be more physically active</li> </ul>
<b>Skills</b>	1.2: Problem solving  1.4: Action planning  3.1: Social support (practical)  3.3: Social support (emotional) – includes motivational interviewing  4.1: Instruction on how to perform the behaviour (Includes skills training)  5.1: Information about health consequences  6.1: Demonstration of the behaviour	Relevant theory: Social Cognitive Theory  Constructs: Forethought capability, Self-regulation capability, vicarious learning capability, Self-efficacy  Suggested/example intervention component(s):  <ul style="list-style-type: none"> <li>· A manual to accompany the face-to-face training programme which HCPs complete throughout as the training progresses</li> <li>· Role play and demonstrations of intervention materials being used</li> <li>· Encourage a buddy system among HCPs</li> </ul>
<b>Social/Professional role</b>	5.2: Salience of consequences	Relevant theory: Social Cognitive Theory

Constructs: Outcome expectancies); Forethought, Self-regulation

Suggested/example intervention component(s):

- Verbal delivery explaining the benefits of physical activity promotion and providing ongoing support.
- Patient narratives

**Beliefs about capabilities**

1.2: Problem solving  
1.4: Action planning

Relevant theory: Social Cognitive Theory

Constructs: Self-regulation

Suggested/example intervention component(s):

Problem solving and action planning in the context of practice (i.e. teaching how to complete action planning with patients).

**Beliefs about consequences**

1.2: Problem solving  
1.4: Action planning  
4.1: Instruction on how to perform the behaviour  
6.1: Demonstration of the behaviour

Relevant theory: Social Cognitive Theory

Constructs: Forethought, Self-regulation, Vicarious learning

Suggested/example intervention component(s):

- Completion of tasks within the training manual
- Teaching problem solving and action planning in the context of physiotherapy practice
- Instruction in the manual on how to action plan and problem solve
- A demonstration of action planning and problem solving

**Reinforcement**

2.5: Monitoring of outcomes of behaviour without feedback

Relevant theory: Social Cognitive Theory

Constructs: Self-regulation

**Environmental context and**

1.2: Problem solving

Relevant theory: Social Cognitive Theory

<b>resources</b>	4.1: Instruction on how to perform the behaviour (includes skills training)	Constructs: Forethought, Self-regulation, Vicarious learning, Self-efficacy
	5.2: Salience of consequences	Suggested/example intervention component(s):
	6.1: Demonstration of the behaviour	· Provision of face-to-face training programme with accompanying manual
	9.1: Credible source	· Repository of information providing details of local physical activity groups, support and resources

#### **Step 4: Development of the PARAS intervention**

Following the intervention mapping exercise in Step 3, a prototype intervention was developed and presented to stroke survivors and HCPs to further engage them in an iterative co-design process.

#### ***Stroke survivor co-design workshops***

We conducted three co-design workshops with stroke survivors (n=21). The aim of these workshops was to elicit views on intervention content, form and mode of delivery of the intervention. Prototypes of the intervention tools (workbook, physical activity diary, information on apps accessible on mobile phone) and a range of pedometers were circulated during workshops to facilitate discussion and generate feedback. During the first two workshops (n=13 stroke survivors) a feedback form was used to collate opinions/information (Appendix B). To support the involvement of stroke survivors with aphasia (impairment of language), the third workshop was delivered with the North East Aphasia Research User Group (<https://www.neta.org.uk/>) (n=8 stroke survivors). This workshop was delivered in an aphasia friendly format (i.e. using strategies to enable understanding of language) and verbal rather than written feedback was collated. To enable stroke survivors with aphasia and cognitive difficulties to take part in future testing of the intervention, aphasia friendly consent forms and information sheets (Appendix C and D) were developed specifically for the study and taken to the aphasia research group for feedback prior to use. All three workshops were audio-recorded and transcribed verbatim to capture feedback generated and facilitate the intervention development processes.

#### **Key findings of stroke survivor co-design workshops**

A detailed overview of workshop findings with stroke survivors is provided in Appendix E. In summary, participants reported a preference for the intervention to be supported by HCPs and delivered either at home or in a community outpatient setting. A preference was reported for at least two sessions, with the first session delivered face-to-face and subsequent sessions delivered either face-to-face or by telephone. The majority (>75%) of stroke survivors either strongly agreed or agreed that the content of the

intervention workbook was well organised, easy to follow and appropriate. The physical activity diaries were reported to be well designed and considered easy to use by most participants. However, mixed views were received on whether other stroke survivors would use the diaries and the commercially available apps discussed, although it was agreed that this required further testing in a feasibility study. Eight commercially available pedometers that have been used successfully in other physical activity studies (29-31) were presented to stroke survivors during the workshop. The CSX 301S 3D simple pedometer was considered the most appropriate from those shown and was the only pedometer to be voted by all participants as easy to use and something they would be likely to use.

### ***Healthcare professional feedback***

An online questionnaire was completed by four North East community stroke teams (n=11 HCPs) to elicit feedback on the prototype intervention. These teams had previously expressed an interest in reviewing the intervention and taking part in a future feasibility study. The Template for Intervention Description and Replication (TIDieR) checklist (10) was used to present the components of the prototype intervention to the stroke teams.

**Findings:** Feedback in relation to the intervention design and content was largely positive (Appendix F). Team 2, 3 and 4 strongly agreed or agreed with the suitability of the intervention, tools and mode of delivery. Team 2 were uncertain about whether they could deliver the intervention within their team because they reported discharging patients to other rehabilitation services (i.e. follow-up reviews might not be possible). Team 4 raised concerns about their confidence in being audio-recorded delivering the intervention for fidelity assessment and feedback in the context of a feasibility study.

Team 1 were less certain about the content of the intervention in terms of delivery expressing a need for training. There were also some issues highlighted by Team 1 in terms of whether their patients would be suitable for the intervention because it was felt that patients may have been discharged from their service if they were sufficiently mobile to take part in the intervention. A further meeting was held with Team 1 to discuss concerns and provide more detail that could enable a more informed decision regarding potential participation in a feasibility study of the intervention (e.g. to further emphasise that the intervention was not aimed at 'high functioning' patients). Following this meeting, Team 1 agreed they could potentially deliver the intervention.

### **Step 5: Formulation of an implementation plan**

An important consideration during the development of the PARAS intervention was implementation of the intervention and that it targeted all three pillars of high quality care: patient experience; safety and effectiveness. (32) To increase the likelihood of implementation, the APEASE criterion: affordability; practicability; effectiveness and cost-effectiveness; acceptability; side effects/safety and equity (33) were

considered and applied in the final intervention design. The final intervention components and APEASE criteria are provided in Table 6.

### **Step 6: Development of an evaluation plan**

In order to further develop and optimise the PARAS intervention within community stroke settings, the most appropriate next step was to undertake a feasibility study to inform the iterative development of the intervention (in accordance with the MRC Framework). A protocol was developed for a feasibility study and outlined objectives relating to the stroke survivor component of the intervention, including feasibility and acceptability of intervention components, mode of delivery and fidelity of delivery, receipt and enactment of the intervention. (34) The protocol also outlined outcomes relating to the healthcare professional training component of the intervention to assess their attitudes and skills pre-and post-training. The feasibility study is currently recruiting and is registered on the ISRCTN website (Trial identifier: ISRCTN35516780, date of registration: 24/10/2018 URL <http://www.isrctn.com/ISRCTN35516780>).

**Table 6** PARAS intervention components described with the Template for intervention Description and replication (TIDieR) and APEASE criteria considered in development phase

TIDieR component	Description	APEASE criteria considered
<p><b>Brief name:</b> Provide the name or a phrase that describes the intervention</p>	<p>Physical Activity Routines After Stroke (PARAS)</p>	
<p><b>Why:</b> Describe any rationale, theory, or goal of the elements essential to the intervention</p>	<p>See needs assessment step 1-5</p>	
<p><b>What:</b> <i>materials:</i> Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g. online appendix, URL).</p>	<p><i>Components provided to/used by stroke survivors</i></p> <ul style="list-style-type: none"> <li>· Consent form and participant information sheet</li> <li>· Intervention toolkit including: stroke survivor workbook; repository of local/national information on PA choices; self-monitoring tools (activity diary, pedometer (3DFitBud-Counter-Walking-Pedometer, 3D active, UK) and instructions, app advice); laminated goal summary sheet and fridge magnet pen; laminated benefits, outcomes and activities cards to aid discussion between stroke survivor and HCP and support people with speech and language problems</li> </ul> <p><i>Components provided to/used by healthcare professionals</i></p> <ul style="list-style-type: none"> <li>· Consent form and participant information sheet</li> <li>· HCP training brochure</li> <li>· Dictaphone</li> </ul>	<p><i>Affordability:</i> Portable document format (PDF) files of all the intervention tools were created, printed out and stored in a workbook file meaning extra patient specific sheets could be added to individual's files (e.g. physical activity diary). This process allowed iterative changes to be made without large costs of reprinting manuals. Rather than creating a website with large costs linked to maintenance and development, it was decided to trial a paper-based version of the intervention initially which could be developed online at a later date.</p> <p>The pedometer selected had a relatively low price point (£16.99) to enable increased used with NHS settings.</p> <p><i>Practicability:</i> HCPs were provided with a PARAS kitbag holding all the intervention tools so they could deliver the intervention then and there rather than having to for example find out information about available resources and get back to participants at a later date.</p> <p><i>Acceptability:</i> all components tested at co-design workshops and developed iteratively in response to feedback</p> <p><i>Equity:</i> The stroke survivor intervention tools were designed to be inclusive so individuals with speech and language or cognitive difficulties would not be excluded as is the case in the majority of stroke research studies.</p>

<p><b>What:</b> <i>procedures:</i> Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.</p>	<p><i>Stroke survivor procedures</i></p> <p>Supported self-management programme involving goal setting, action planning, barrier identification, coping planning and feedback around PA and sedentary behaviour.</p> <p><i>HCP procedures</i></p> <p>Training programme aimed at developing physical/sedentary behaviour counselling skills of HCPs. Initial training before delivery of intervention then feedback provided on delivery.</p>	<p><i>Acceptability, affordability and practicability:</i> Supported self-management was identified as the most appropriate mode of delivery for the stroke survivor component following our needs assessment and co-design workshops. This type of intervention appears more sustainable than for example face-to-face structured group exercise which presents with a number of environmental and resource related barriers.</p> <p><i>Acceptability and effectiveness:</i> Although HCPs working in community stroke care will have some experience of goal setting etc. qualitative workshops identified there were training needs in this area and it was acceptable to target these needs.</p>
<p><b>Who:</b> For each category of intervention provider (e.g. psychologist, nursing assistant), describe their expertise, background and any specific training given.</p>	<p><i>Provider of stroke survivor component</i></p> <p>A healthcare professional (HCP) who is a credible source (e.g. well informed on stroke rehabilitation) and plays a key role in the stroke survivors community rehabilitation e.g. physiotherapist, occupational therapist, nurse.</p> <p><i>Provider of HCP component</i></p> <p>Health psychologist with experience in delivering behaviour change interventions in long-term conditions, research physiotherapist with 20 years clinical experience and 10 years research experience in developing and delivery physical activity and rehabilitation stroke interventions</p>	<p><i>Affordability, practicability and acceptability:</i> PARAS focus groups identified delivery of the stroke survivor component should be by a healthcare professional with experience working in stroke. Using healthcare professionals embedded within community stroke teams meant these individuals already had specialist core stroke skills meaning training was not required in this area alongside training in PARAS delivery. As the intervention was designed to be delivered within usual care this meant there were not additional salary costs. Initially consideration was made to include technical instructors and rehab assistants however on discussion with these individuals it was felt they would prefer to support the delivery rather than lead on the delivery and that they were not happy to be audio-recorded as part of the fidelity assessment.</p> <p><i>Acceptability and effectiveness:</i> As the providers of the HCP training had developed the intervention and were experienced in this field from both a therapy and a psychology perspective they were thought to be the most credible source to deliver the training.</p> <p><i>Practicability:</i> At this feasibility stage it was decided that two members of the research team would deliver the HCP training face-to-face. This allowed the research team to highlight any iterative changes required to the training programme before scaling.</p>

<p><b>How:</b> Describe the modes of delivery (e.g. face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group</p>	<p><i>Stroke survivor component</i></p> <p>First session face-to-face, follow-up sessions either face-to-face or remotely by phone dependent on patient choice.</p> <p><i>HCP training component</i></p> <p>Face-to-face for initial training, then email and phone contact to provide feedback</p>	<p><i>Acceptability:</i> The modes of delivery were assessed as acceptable from our needs assessment, co-design workshops and questionnaires.</p> <p><i>Affordability and practicality:</i> Our qualitative work indicated that this mode of delivery of the stroke survivor intervention was practical. As the community HCP involved in delivering the stroke survivor component were already working with the stroke survivors participating in the study it was practical for them to initially see the participants face-to-face. To lower travel costs the option of providing the review sessions by phone was provided</p> <p><i>Acceptability, affordability and practicality:</i> The HCPs were very clear that they wanted training face-to-face as they felt E-Learning was not effective. The HCP component was delivered in a group format to each of three community teams involved. This reduced costs of training individuals. Delivering three spate sessions rather than delivering the training to everyone at once meant that the training could be fitted around the needs of each service.</p>
<p><b>Where:</b> Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.</p>	<p><i>Stroke survivor component</i></p> <p>UK NHS community stroke services. Delivered in patient's homes or outpatient settings</p> <p><i>HCP training component</i></p> <p>Initial face-to-face training delivered at participating community stroke teams' education centres.</p>	<p><i>Acceptability:</i> Our needs assessment, co-design workshops and resource capacity mapping exercise within services identified the acceptability of the intervention location.</p> <p><i>Practicality:</i> It was hypothesised that delivering the stroke survivor intervention within patients homes would allow the HCP to provide better support to the participants as they would have an increased understanding of the participants environmental circumstances. This was felt to outweigh costs associated with community visits.</p> <p><i>Affordability:</i> Although travelling to the community sites to deliver the HCP training had cost implications, it was believed more HCP would attend if the trainers travelled to the participants. In the future, it is thought that this training could be delivered online but at this stage to enable as much knowledge on delivery face-to-face training was deemed most appropriate.</p>
<p><b>When and how much:</b> Describe the number of times the</p>	<p><i>Stroke survivor component</i></p> <p>At least two sessions. The first session/s targets goal</p>	<p><i>Acceptability:</i> Our needs assessment and co-design workshops identified what was acceptable in terms of timing and dose of delivery of the components of the intervention.</p>

intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose.

setting using the workbook and other tools, there will then be a review session timed to coincide with review date for PA/sedentary behaviour goals. There is no upper limit to sessions the number is defined by patients' support needs/availability of resources.

The programme to be initiated once 'functional rehab' goals have been achieved and the stroke survivor is moving towards supported self-management. The time from stroke will vary dependent on needs of participant/health care professional's opinion on the best timing/availability of resources.

#### *HCP training component*

Three-hour face-to-face training session. Email and phone delivery support by study team. Email feedback on the delivery of the intervention after completion with two stroke survivors.

*Side effects/safety:* Our needs assessment and co-design workshops provided evidence that the intervention training and delivery methods would be safe with minimal side effects. As the stroke survivors were already being seen by a community stroke team with specialist skills it was felt that this team would be able to effectively identify any risks associated with taking part in the intervention and potential changes in physical/sedentary behaviour.

*Effectiveness:* It was hypothesised that all the components of the stroke survivor intervention could be delivered effectively within the two or more sessions.

It was also hypothesised that all elements of the stroke survivor intervention delivery could be taught effectively within three hours with email and phone contact for support during delivery

*Affordability:* The supported self-management approach for the stroke survivor component provided a more affordable but at the same time potentially effective method of delivery than for example a face-to-face exercise intervention.

**Tailoring:** If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how

#### *Stroke survivor component*

Support graded to individuals' ability, preference, and values and progressed as able

#### *HCP training component*

*Acceptability:* The needs assessment, co-design workshops and questionnaires were used to assess the acceptability of tailoring.

*Affordability:* To enable effectiveness our needs assessment identified that a person centred individual tailored approach was required for the stroke survivors. This approach is potentially more expensive than a group based approach, however

The HCP training was tailored according to personal needs during the face-to-face training, email and telephone support. All participating HCPs received feedback on delivery that was tailored to their individual learning needs.

the increased potential for effectiveness should outweigh these costs.

*Equity:* the stroke survivor component was designed to allow a person-centred tailored approach that would not exclude any stroke survivor who has the potential to move more or sit less.

**How well:**

Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them.

**Treatment fidelity strategies for design of study**

HCP training. Plan for implementation setbacks e.g. map out stroke team resources prior and during study and plan in case anyone is leaving, rotating etc.

**Treatment fidelity strategies for monitoring and improving provider training**

Face to face training and standardised training manual provided to HCP. Testing of HCP acquisition skills during training and delivery. Minimise drift in HCP skills during programme delivery e.g. monitor how work books are completed and delivery of sessions through audio recording and checklist completion. Programme leads available to provide training on aspects of delivery on request. Tailor training to needs of HCPs delivering programme

**Treatment fidelity strategies for monitoring and improving delivery of programme**

Assessment of delivery of programme through audio recording and analysis of sessions and completion of workbook to enable provision of feedback and

*Practicability and effectiveness:* Informed by previous delivery of physical activity interventions in diabetes and cardiovascular disease.

Fidelity assessment based upon Bellg, A. J., Borrelli, B., Resnick, B., Hecht, J., Minicucci, D. S., Ory, M., & Czajkowski, S. (2004). Enhancing treatment fidelity in health behavior change studies: best practices and recommendations from the NIH Behavior Change Consortium. *Health Psychology, 23*(5), 443.

*Acceptability:* The main issue brought up by the HCPs during the development phase was the need to audio-record the intervention delivery. When it was discussed that this approach was to determine whether our training programme was appropriate the HCPs stated they thought this was acceptable. Whether this was actually the case will be further tested in a feasibility study.

training on delivery of programme to HCPs

**Treatment fidelity strategies for monitoring and improving receipt of programme**

Assess participants understanding of programme, use of cognitive skills and ability to perform behavioural skills through completion of workbook and analysis of audio-recorded sessions

**Treatment fidelity strategies for monitoring and improving enactment of programme skills**

Review workbook completion and achievement of goals.

## Discussion

Low levels of physical activity and high levels of sedentary behaviour are common following stroke (35) and are associated with cardiovascular health, mental health and quality of life. (36) An intervention development process, informed by the MRC guidelines for the development and evaluation of complex interventions, (19) using Intervention Mapping as a framework (20) was undertaken to address this problem as part of the routine care pathway (37). An initial needs assessment identified a lack of effective theory-and-evidence informed interventions targeting long-term free-living physical and sedentary behaviour in stroke survivors. (9) Interventions that showed promise were limited by inadequate study design and a lack of comprehensive description to facilitate replicability. Furthermore, a lack of fidelity assessment limits understanding of the components of interventions delivered that are associated with positive outcomes.

We conducted a series of qualitative focus groups to identify determinants of behavioural change, and to explore the barriers and enablers to engagement in long-term physical activity and reduction in sedentary behaviour post-stroke. This enabled identification of behavioural domains and associated sub-themes within those domains that could be targets for a new intervention. The needs assessment highlighted the need for a timely, sustainable, person-centred intervention to support physical activity and sedentary

behaviour after stroke. This led to the decision to use supported self-management and the subsequent mapping of the components of the intervention during co-design workshops to allow iterative development of the final intervention. Consideration of the APEASE criteria was undertaken to facilitate the development of an implementation plan. A feasibility study protocol was developed to evaluate the intervention, and this study is currently underway.

Historically, structured exercise has been the most common mode of targeting low levels of physical activity after stroke. (7) Although structured exercise can lead to short-term changes in function, how this mode of delivery impacts on long-term health and well-being has not been established. Perhaps more importantly, our qualitative research mirrored previous findings indicating that many barriers exist to this approach in terms of implementation e.g. resources, training, access, costs making it unsustainable for many stroke survivors. (13) Furthermore, structured exercise does not account for individual physical activity needs and preferences. Our qualitative work indicated that stroke survivors wish to partake in activities that provide meaning to their lives and allow them to recapture activities they engaged in prior to experiencing a stroke. This may be through structured exercise, but more commonly reported was engagement in day-to-day activities such as washing the car, shopping or playing with grandchildren. It was therefore important that the intervention was person centred rather than 'one size fits all' as with previous structured exercise research trials.

Developing an intervention that targets and addresses the needs of the end user is paramount and was the reason for early engagement with stroke survivors, informal carers and HCPs. Co-design and co-production is vital to ensure the voices of patients and healthcare professionals are heard and valued. There is now an expectation within self-management in stroke and at a governmental level that person-held experience is incorporated into healthcare intervention design. (38) The early use of co-design can potentially enable future implementation, with those taking part in the process becoming champions for the intervention. (39)

Engaging with patients with aphasia during co-design is complex and as a result is often not undertaken. Aphasia is a common communication problem affecting approximately one third of stroke survivors. (40) In previous self-management interventions in stroke, up to 46% of studies have excluded individuals with aphasia limiting extrapolation of findings to large numbers of stroke survivors. (41) One of the strengths of our intervention development process was early engagement with a group of stroke survivors with aphasia, and their views were incorporated in to the intervention content and design. This ensured that the intervention developed was suitable for the large proportion of stroke survivors with speech and language problems.

Continuous engagement with stroke survivors, carers and healthcare professionals during the developmental process was undertaken to increase the likelihood of developing an intervention that could be successfully implemented into practice. Alongside user views, we also applied the APEASE criteria to consider the social context of intervention delivery to further facilitate implementation. (33) Our systematic review highlighted that the majority of RCTs and pilot studies in this field have been led by

research teams, not clinicians, and attempts have not been made to embed testing within existing clinical pathways and settings. (9, 37, 42-47) The PARAS intervention was developed with implementation into the clinical care pathway in mind, with minimal adaptation as implementation of research findings into rehabilitation settings has been previously shown to be slow, with evidence often not influencing practice. (48)

Our needs assessment highlighted that the intervention should be multi-faceted, targeting both the behaviour of the stroke survivors and the behaviour of the healthcare professionals promoting physical activity and providing support. This is a novel approach in this field, where most of the research has focused exclusively on stroke survivors. Our qualitative work indicated that the stroke survivors have a preference to be supported by a healthcare professional, therefore it was important to consider behavioural change counselling strategies for use by healthcare professionals to enable this support. It could be argued that healthcare professionals already have skills to support these long-term behaviour changes given the importance of lifestyle in the context of stroke, however observational data on habitual physical activity and sedentary behaviour post-stroke (1) indicates the contrary and the findings of our qualitative study highlighted the need for healthcare professional training in this area. Previous research further suggests that perceptions on physical activity post-stroke vary between stroke survivors, informal carers and healthcare professionals, (8) therefore training on how to deliver person-centred support to enable meaningful engagement in physical activity, which is more likely to result in long-term change, may be required.

The TDF was selected as a framework for analysis of our qualitative data to identify behavioural determinant of behavioural change, and selection of behaviour change techniques in order to facilitate intervention mapping. The main advantages of the TDF are that it provides a robust theoretical basis for implementation studies and can be used to identify barriers and enablers of behaviour and aid behaviour change intervention development. (49) The TDF has been used extensively to understand behaviour in clinical populations including stroke. (50) Occasionally issues are identified at the boundaries between the domains of the TDF but having three independent researchers reviewing the data facilitated consensus on occasions where data fell into more than one domains.

It is anticipated that the application of complex intervention development processes will increase the likelihood of future effectiveness and implementation of the intervention in healthcare settings. However, several limitations associated with our developmental process should be acknowledged. Stroke survivors that took part in the initial qualitative focus group discussions were required to travel, meaning only those who had access to transport or were mobile could attend. In addition, invitations to participants in these groups were advertised mainly at local stroke groups or patient carer panels which may have limited representation of a general stroke population. Although we advertised for informal carers to attend the focus groups, only three took part and information contributed was minimal and did not enable formal analyses. Therefore, this limited our understanding from a carer perspective. These limitations are being addressed, and as such the feasibility study will explore intervention views from a broader representation

of stroke survivors. The participants will be recruited from community stroke services and will not need to travel to take part in the research (it will be delivered in the home).

The healthcare professionals recruited may not have been representative, which limits generalisability. Purposive sampling was not undertaken and community stroke teams self-selected to attend focus groups. The majority were physiotherapists and assistants, rather than from the broad range of disciplines who may also have been suitable to deliver the intervention e.g. nurses, occupational therapists, speech and language therapists, exercise of referral/fitness instructors. Whether other healthcare professionals of different disciplines would be willing to deliver the intervention will be explored during the feasibility study.

## **Conclusions**

Effectively targeting complex behaviours such as physical activity and sedentary behaviour post-stroke requires systematic and iterative development of evidence and theory informed interventions. Alongside effectiveness, the likelihood of adoption, implementation and sustainability of an intervention should also be considered during intervention development. Here we have presented the development of an intervention targeting long-term habitual physical activity and sedentary behaviour post-stroke. Throughout the developmental process there was active engagement of stroke survivors, their carers and healthcare professionals to increase likelihood of the acceptability and effectiveness of the intervention and long-term implementation. The PARAS intervention is currently being testing in three North East community stroke services and the results of this feasibility study will further inform the development of the mode, form and content. Following the MRC guidelines for the development and evaluation of complex interventions, the most promising intervention will then be further evaluated assessing efficacy and cost-effectiveness and process.

## **Abbreviations**

BCT: Behaviour Change Technique

MRC: Medical Research Council

NHS: National Health Service

PARAS: Physical Activity Routines After Stroke

RCT: Randomised Controlled Trial

TDF: Theoretical Domains Framework

## **Declarations**

**Ethics approval and consent to participate**

Ethical approval for the development workshops with stroke survivors and healthcare professionals was gained on the 24/10/2016 from the Faculty of Medical Science ethics committee at Newcastle University, Newcastle upon Tyne, UK (reference number 01211/2016). Fully informed written consent was gained from all participants who took part in the study.

### **Consent for publication**

Not applicable

### **Availability of data and materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

### **Competing interests**

The authors declare that they have no competing interests

### **Funding**

This report is independent research supported by Health Education England and the National Institute for Health Research (HEE/ NIHR ICA Programme Clinical Lectureship, Dr Sarah Anne Moore, ICA-CL-2015-01-012). The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the National Institute for Health Research or the Department of Health. The funding source and sponsor had no role in the design of this study execution, analyses, interpretation of the data, or decision to submit results.

### **Author's contributions**

Mentoring during the intervention and study development process: LA

Study design: SAM, LA, DF, CP

Systematic review: SAM, LA, DF, CP

Qualitative focus group discussions: Designed by SAM, LA, DF. Conducted by LA, SAM. Data analysed by LA, SAM. Data interpretation SAM, DF, LA.

Intervention mapping: SAM, LA, DF

Delivery of co-design workshops: SAM

Evaluation study design: SAM, DF, LA, CP

SAM and LA drafted the manuscript

All authors contributed to revising the drafts and read and approved the final manuscript

## Acknowledgements

We would like to thank the following for their contribution:

1. Stroke survivors, their carers/relatives and health care professionals who took part in the study
2. North East Aphasia Research Group (ARUG).
3. The NIHR North East Stroke Specialty Group Patient and Carer Panel for feedback on study development
4. Staff at Newcastle University and Northumbria Healthcare NHS Foundation Trust who have contributed to the project: Patricia McCue, Norman Marillier, Liz Costigan.

## References

1. Fini NA, Holland AE, Keating J, Simek J, Bernhardt J. How Physically Active Are People Following Stroke? Systematic Review and Quantitative Synthesis. *Phys Ther.* 2017;97(7):707-17.
2. Morton S, Fitzsimons C, Hall J, Clarke D, Forster A, English C, et al. Sedentary behavior after stroke: A new target for therapeutic intervention. *Int J Stroke.* 2019;14(1):9-11.
3. Shaughnessy M, Michael KM, Sorkin JD, Macko RF. Steps after stroke: capturing ambulatory recovery. *Stroke.* 2005;36(6):1305-7.
4. Bailey DP, Hewson DJ, Champion RB, Sayegh SM. Sitting Time and Risk of Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis. *Am J Prev Med.* 2019;57(3):408-16.
5. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet.* 2012;380(9838):219-29.
6. Moore SA, Hallsworth K, Jakovljevic DG, Blamire AM, He J, Ford GA, et al. Effects of Community Exercise Therapy on Metabolic, Brain, Physical, and Cognitive Function Following Stroke: A Randomized Controlled Pilot Trial. *Neurorehabil Neural Repair.* 2015;29(7):623-35.
7. Saunders DH, Sanderson M, Hayes S, Johnson L, Kramer S, Carter DD, et al. Physical fitness training for stroke patients. *Cochrane Database Syst Rev.* 2020;3:Cd003316.
8. Morris JH, Oliver T, Kroll T, Joice S, Williams B. From physical and functional to continuity with pre-stroke self and participation in valued activities: a qualitative exploration of stroke survivors', carers' and physiotherapists' perceptions of physical activity after stroke. *Disabil Rehabil.* 2015;37(1):64-77.
9. Moore S, Hrisos N, Flynn D, Price C, Errington L. A systematic review assessing the effectiveness of interventions and component behaviour change strategies targeting long-term physical activity and/or sedentary behaviour in stroke survivors. 2017(CRD42017059865).
10. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ.*

2014;348:g1687.

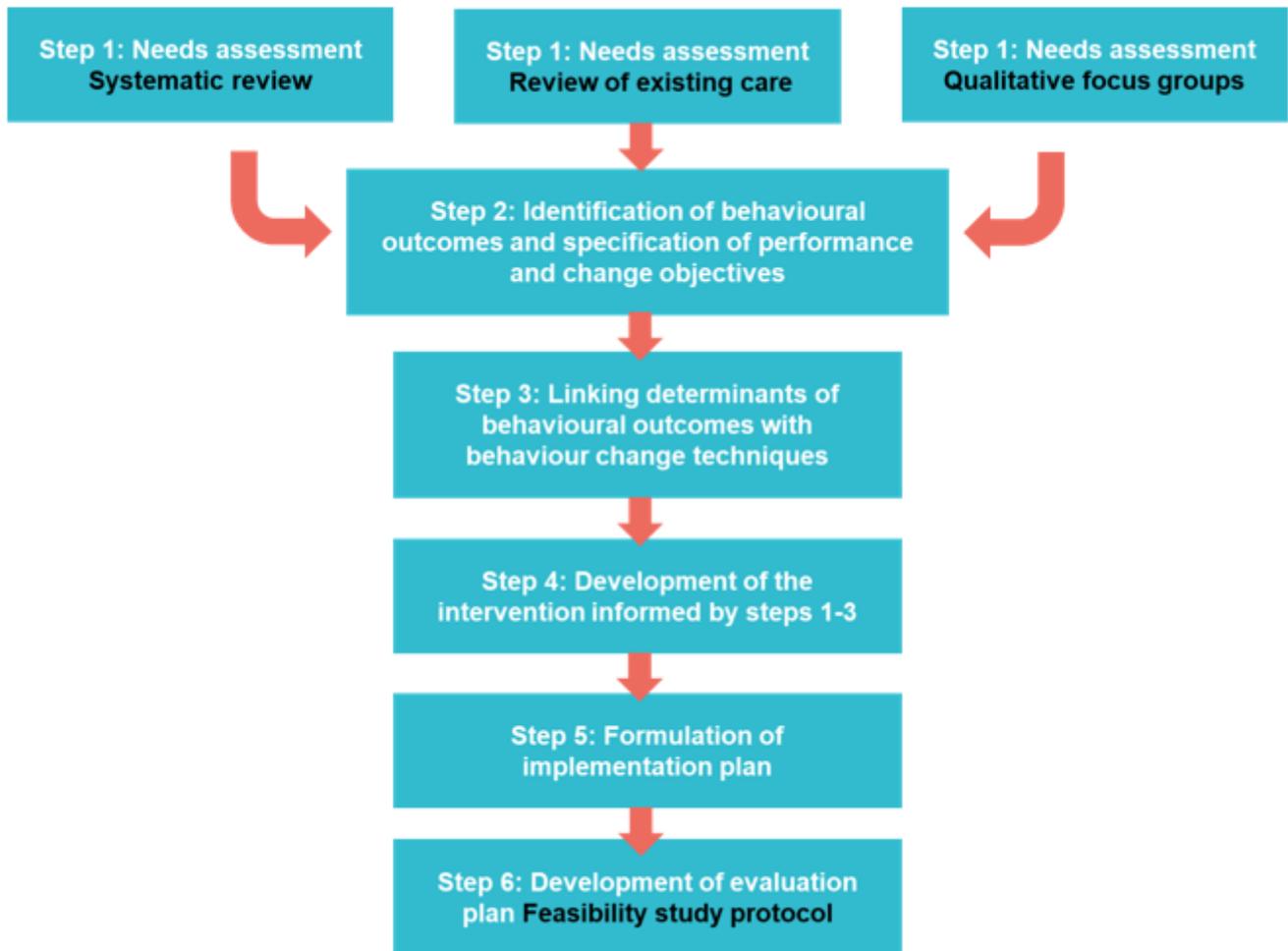
11. Bellg AJ, Borrelli B, Resnick B, Hecht J, Minicucci DS, Ory M, et al. Enhancing treatment fidelity in health behavior change studies: best practices and recommendations from the NIH Behavior Change Consortium. *Health Psychol.* 2004;23(5):443-51.
12. Gurlan M, Bernard P, Bortolon C, Romain AJ, Lareyre O, Carayol M, et al. Efficacy of theory-based interventions to promote physical activity. A meta-analysis of randomised controlled trials. *Health Psychol Rev.* 2016;10(1):50-66.
13. Nicholson S, Sniehotta FF, van Wijck F, Greig CA, Johnston M, McMurdo ME, et al. A systematic review of perceived barriers and motivators to physical activity after stroke. *Int J Stroke.* 2013;8(5):357-64.
14. Nicholson SL, Donaghy M, Johnston M, Sniehotta FF, van Wijck F, Johnston D, et al. A qualitative theory guided analysis of stroke survivors' perceived barriers and facilitators to physical activity. *Disabil Rehabil.* 2014;36(22):1857-68.
15. Kok G. A practical guide to effective behavior change: How to apply theory- and evidence-based behavior change methods in an intervention. *The European Health Psychologist.* 2014;16:156-70.
16. Fernandez ME, Ruiters RAC, Markham CM, Kok G. Intervention Mapping: Theory- and Evidence-Based Health Promotion Program Planning: Perspective and Examples. *Front Public Health.* 2019;7:209.
17. Hurley DA, Murphy LC, Hayes D, Hall AM, Toomey E, McDonough SM, et al. Using intervention mapping to develop a theory-driven, group-based complex intervention to support self-management of osteoarthritis and low back pain (SOLAS). *Implement Sci.* 2016;11:56.
18. Brug J, Oenema A, Ferreira I. Theory, evidence and Intervention Mapping to improve behavior nutrition and physical activity interventions. *Int J Behav Nutr Phys Act.* 2005;2(1):2.
19. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *Int J Nurs Stud.* 2013;50(5):587-92.
20. Bartholomew LK, Parcel GS, Kok G, Gottlieb NH, Fernández ME. *Planning Health Promotion Programs: An Intervention Mapping Approach.* 3 ed. San Francisco, CA: Jossey-Bass; 2011.
21. Gardner B, Smith L, Lorencatto F, Hamer M, Biddle SJ. How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychol Rev.* 2016;10(1):89-112.
22. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine.* 2013;46:81-95.
23. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science.* 2012;7(1).
24. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the Health Belief Model. *Health Educ Q.* 1988;15(2):175-83.

25. Leventhal H, Brissette I, Leventhal EA. The common-sense model of self-regulation of health and illness. In: Cameron LD, Leventhal H, editors. *The Self-Regulation of Health and Illness Behaviour*. London: Routledge; 1997. p. 42-65.
26. Michie S, Wood CE, Johnston M, Abraham C, Francis JJ, Hardeman W. Behaviour change techniques: the development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomised controlled trials and analysis of qualitative data). *Health Technol Assess*. 2015;19(99):1-188.
27. Bandura A. *Social foundations of thought and action: A social cognitive theory*: Prentice-Hall, Inc; 1986.
28. Godin G, Belanger-Gravel A, Eccles M, Grimshaw J. Healthcare professionals' intentions and behaviours: a systematic review of studies based on social cognitive theories. *Implement Sci*. 2008;3:36.
29. Harris T, Kerry SM, Limb ES, Victor CR, Iliffe S, Ussher M, et al. Effect of a Primary Care Walking Intervention with and without Nurse Support on Physical Activity Levels in 45- to 75-Year-Olds: The Pedometer And Consultation Evaluation (PACE-UP) Cluster Randomised Clinical Trial. *PLoS Med*. 2017;14(1):e1002210.
30. Sullivan JE, Espe LE, Kelly AM, Veilbig LE, Kwasny MJ. Feasibility and outcomes of a community-based, pedometer-monitored walking program in chronic stroke: a pilot study. *Top Stroke Rehabil*. 2014;21(2):101-10.
31. Carroll SL, Greig CA, Lewis SJ, McMurdo ME, Sniehotta FF, Johnston M, et al. The use of pedometers in stroke survivors: are they feasible and how well do they detect steps? *Arch Phys Med Rehabil*. 2012;93(3):466-70.
32. Darzi A. *The Lord Darzi Review of Health and Care: Interim Report*. Institute for Public Policy Research (IPPR); 2018.
33. Michie S, Atkins L, West R. *The Behaviour Change Wheel: A Guide to Designing Interventions*. 1 ed: Silverback Publishing; 2014.
34. Moore SA, Avery L, Price CIM, Flynn D. A feasibility, acceptability and fidelity study of a multifaceted behaviour change intervention targeting free-living physical activity and sedentary behaviour in community dwelling adult stroke survivors. *Pilot and Feasibility Studies*. 2020;6:1-13.
35. Moore SA, Hallsworth K, Plotz T, Ford GA, Rochester L, Trenell MI. Physical activity, sedentary behaviour and metabolic control following stroke: a cross-sectional and longitudinal study. *PLoS One*. 2013;8(1):e55263.
36. Rand D, Eng JJ, Tang PF, Hung C, Jeng JS. Daily physical activity and its contribution to the health-related quality of life of ambulatory individuals with chronic stroke. *Health Qual Life Outcomes*. 2010;8:80.
37. Moore S, Hrisos N, L A, Flynn D, Price C, L E. A systematic review assessing the effectiveness of interventions and component behaviour change strategies targeting long-term physical activity and/or sedentary behaviour in stroke survivors. PROSPERO International prospective register of

systematic reviews2017 [CRD42017059865]. Available from:  
[https://www.crd.york.ac.uk/PROSPERO/display\\_record.php?RecordID=59865](https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=59865).

38. Kulnik ST, Pöstges H, Townsend R, Micklethwaite P, Jones F. A gift from experience: co-production and co-design in stroke and self-management. *Design for Health*. 2019;3(1):98-118.
39. Clarke D, Jones F, Harris R, Robert G. What outcomes are associated with developing and implementing co-produced interventions in acute healthcare settings? A rapid evidence synthesis. *BMJ Open*. 2017;7(7):e014650.
40. Engelter ST, Gostynski M, Papa S, Frei M, Born C, Ajdacic-Gross V, et al. Epidemiology of aphasia attributable to first ischemic stroke: incidence, severity, fluency, etiology, and thrombolysis. *Stroke*. 2006;37:1379-84.
41. Brady MC, Frederick A, Williams B. People with aphasia: capacity to consent, research participation and intervention inequalities. *Int J Stroke*. 2013;8:193-6.
42. Jones TM, Dear BF, Hush JM, Titov N, Dean CM. myMoves Program: Feasibility and Acceptability Study of a Remotely Delivered Self-Management Program for Increasing Physical Activity Among Adults With Acquired Brain Injury Living in the Community. *Physical Therapy*. 2016;96(12):1982-93.
43. Preston E, Dean CM, Ada L, Stanton R, Brauer S, Kuys S, et al. Promoting physical activity after stroke via self-management: a feasibility study. *Topics in Stroke Rehabilitation*. 2017;24(5):353-60.
44. English C, Healy GM, Olds TS, Parfitt G, Borkoles E, Coates A, et al. Reducing Sitting Time After Stroke: A Phase II Safety and Feasibility Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*. 2015;97(2):273-80.
45. Jones TM, Dear BF, Hush JM, Titov N, Dean CM. myMoves Program: Feasibility and Acceptability Study of a Remotely Delivered Self-Management Program for Increasing Physical Activity Among Adults With Acquired Brain Injury Living in the Community. *Phys Ther*. 2016;96(12):1982-93.
46. Preston E, Dean CM, Ada L, Stanton R, Brauer S, Kuys S, et al. Promoting physical activity after stroke via self-management: a feasibility study. *Top Stroke Rehabil*. 2017;24(5):353-60.
47. English C, Healy GN, Olds T, Parfitt G, Borkoles E, Coates A, et al. Reducing Sitting Time After Stroke: A Phase II Safety and Feasibility Randomized Controlled Trial. *Arch Phys Med Rehabil*. 2016;97(2):273-80.
48. Morris JH, Bernhardsson S, Bird ML, Connell L, Lynch E, Jarvis K, et al. Implementation in rehabilitation: a roadmap for practitioners and researchers. *Disabil Rehabil*. 2019:1-10.
49. Atkins L, Francis J, Islam R, O'Connor D, Patey A, Ivers N, et al. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implement Sci*. 2017;12:77.
50. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci*. 2012;7.

## Figures



**Figure 1**

PARAS developmental process with reference to intervention mapping

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [FVPARASTIDieRChecklistWord.docx](#)