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RESEARCH ARTICLE

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Understanding development of contractures in people with stroke: formulation of a logic-model to inform care and prevention

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ABSTRACT

Purpose: Contracture is stiffness and reduction in how much a joint and muscle can move and may impact on self-care and functional ability. We outline the development of the first comprehensive Logic-Model of the problem for contracture development, to inform prevention and treatment.

Method: The initial Logic-Model was developed based on the literature by the research team. The draft Logic-Model of the problem was presented to people with stroke and carers from our Public, Patient Involvement (PPI) group and clinicians. This process resulted in a comprehensive model to describe factors associated with contracture development.

Results: Following construction of the initial logic-model, items were identified by the PPI group and clinicians as elements that might particularly influence contracture development, and categorised as follows: **Personal Determinants: Person with stroke:** perceived advantage and disadvantage (of knowledge of health condition), apathy, low self-efficacy, limited skills and knowledge **Family carers and supporters:** negative attitude and self-efficacy, lack of skills and knowledge,; **Professionals and paid carers:** low awareness of services and knowledge. For **Environmental Factors:** lack of support for management was identified as a priority.

Conclusion: The resulting Logic-Model of the problem will enable development of evidence-based pathways to prevent and treat contracture.

IMPLICATIONS FOR REHABILITATION

- A number of factors are associated with contracture development in people with stroke, these include, the presence of pain, physical immobility (particularly being immobile in bed), cognitive impairment and comorbidities of Parkinson's disease or dementia.
- Understanding the interplay of elements influencing contracture development and the impairment, activity, participation and environmental factors involved will better enable people with stroke, carers and professionals in prevention and treatment.
- Lack of knowledge and self-efficacy (confidence in the ability to impact outcome) are factors that are likely to be contributing to contracture development for people with stroke, carers and professionals.
- Improving knowledge and self-efficacy for contracture prevention and management may be factors that can improve management and outcome.

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Stroke; logic-model; contracture; prevention; treatment

Introduction

Contracture is stiffness and reduction in how much a joint and muscle moves, and can develop in some people after stroke [1]; the reported incidence ranges from 43% to 100% [2–4] Given there are approximately 126,000 people in England admitted each year to hospital with stroke [5,6] and approximately 1.3 million people living with the effects of stroke in the United Kingdom (UK), the management of contracture presents a sizeable and costly problem. It is estimated that rehabilitation of people with contractures compared to those without costs an additional £25,000 [7].

In stroke, contracture occurs more commonly at some joints, such as the ankle and wrist [6,8–11]. This can have specific functional implications at the ankle, such as making it harder to get the heel to the floor for transferring or walking [12]. At the wrist, fixed flexion i.e., where the joint is stuck in a bent position, can make dressing much more difficult even if motor control or active movement are retained or recover [13,14]. However, in severe stroke, contracture can also have wider impacts including the shoulder, elbow, hip and knee, causing significant difficulty with postural management, positioning and personal care [12]. Stroke therefore has clear challenges in the range of contracture severity and a relatively diverse presentation. Additionally, those with severe stroke are often not as easily supported in the stroke pathway and are therefore at more risk in addition to the greater risk associated with severity [7]. More targeted resources for those with severe stroke are therefore needed to address their additional needs [7].

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Contracture formation is complex and multi-factorial, with a number of structures implicated in development, including the joint capsule, ligaments, muscles and tendons of associated joints [15]. Contractures are associated with poor outcomes such as pain and pressure ulcers and pose a challenge for positioning, providing personal care for people with stroke and limit rehabilitation progression [16,17]. However, there has been little empirical research on why contractures develop in people with stroke, which is surprising given the relatively high incidence, prevalence, costs and negative impact for the individual. There is a need to understand the mechanisms underlying contracture development to inform better prevention and treatment in the stroke care pathway and consider how these factors may be modified to prevent or limit formation [7]. While National guidance recommends prevention measures and where people are at risk of losing joint range, that specific treatment modalities such as casts and splints should be considered as an option for management, there are mixed results due to inconsistency in delivery and much remains unknown [18].

As such, an in-depth evidence-based approach (including the theory development encapsulated in this study) is needed to address the current limitations with an aim to improve prevention and management in due course [19]. This paper details the development of a Logic-Model of the problem (i.e., factors leading to contracture development) using PRECEDE methodology (18), with the aim of better informing contracture prevention and management. A Logic-Model is a visual diagram(s) that maps out how a complex intervention or pathway-problem is proposed to work or develop (1); it is used to uncover the *logic* underpinning pathways from cause to effect [20].

Producing a Logic-Model of the problem will comprehensively identify areas from inception that maybe more amenable to change by clinical teams. The target users and settings for this model are broad and include healthcare professionals (including medical, allied health professional, nursing and care staff) in hospitals, bedded rehabilitation services and community care/rehabilitation (including care and nursing homes). There is also potential to inform decisions by people following a stroke and their families and friends which might be critical for contracture prevention. On completion of the development of the Logic-Model of the problem (contracture development), the next stage will be to transform the model into a Logic-Model of Change to inform intervention design [21].

Objectives

1. Identify elements across the World Health Organisation, International Classification of Functioning Disability and Health [22] domains that may contribute to contracture development at a joint or joints following a stroke.
2. Prioritise these elements, in conjunction with people with stroke, carers and clinicians, to identify elements that might be possible to change to improve outcome.

Methods

Process of initial development of the Logic-Model of the problem (contracture)

Utilising a Logic-Model development methodology, an initial model of the problem was developed by identifying issues people with stroke are facing that may contribute to contracture development. The PRECEDE method [21] was applied, which allows mapping of the causal elements that are thought to contribute to contracture development (e.g. reduced mobility).

Procedure

Initial elements of the Logic-Model of the problem of contracture were developed based on expert knowledge supported by synthesising the published literature [7,17,18,23–31]. Specific reference was made to a recent systematic review, as the most up to date summary of the current evidence [31].

The PRECEDE method [21] was applied in 1) identifying the focus of the work with the research team. Following initial discussion within the team and consultation with PPI experts and expert clinicians, a need for the development of a Logic-Model of the problem was identified. 2) The research team then identified literature for inclusion in the model based on the systematic review evidence.

The PRECEDE model was used as a framework for creating the Logic-Model (theory) of the problem. The standard headings for the PRECEDE model were used. In a modified approach to PRECEDE, we then incorporated headings from the WHO International Classification of Functioning Disability and Health [22], adding Impairment, Activity Limitation and Participation. We have also considered separate elements in the PRECEDE diagram (Figure 1) which emphasise the behaviour (under Personal Determinates) of professionals and carers (paid and family) that may influence the development or treatment of contracture. The graphic Logic-Model of the problem (Figure 1) was produced using these headings.

The initial design of the logic model was further built upon in a co-design process with people with stroke and their carers from our Public, Patient Involvement group (PPI) and clinician experts. The PPI group members consisted of two people with stroke and two carers of people with stroke. The clinician consultation group was made up of 7 clinicians with experience in stroke (3 Occupational Therapists and 4 Physiotherapists). Co-design consultation was held separately with each group, and members were asked to review the initial draft logic-model of the problem and answer the following questions:

- Have we missed anything in the logic-model that might explain or contribute to development of contracture?
- From the factors presented in the logic-model of the problem, which are the top three factors (items) from 1. Personal Determinants and 2. Environmental factors; that you would prioritise as areas for potential intervention to prevent or limit contracture?

By using this approach, specific individual factors as well as environment issues associated with developing contracture were considered, explored and mapped into the Logic-Model of the problem.

Results

Initial development of the Logic-Model of the problem (contracture)

The recent systematic review [31] identified factors related to contracture development which were broadly classified into three domains: 1) sociodemographic factors, 2) physical factors, and 3) proxies for bed confinement. Sociodemographic factors were found not to be associated with joint contractures. Whereas

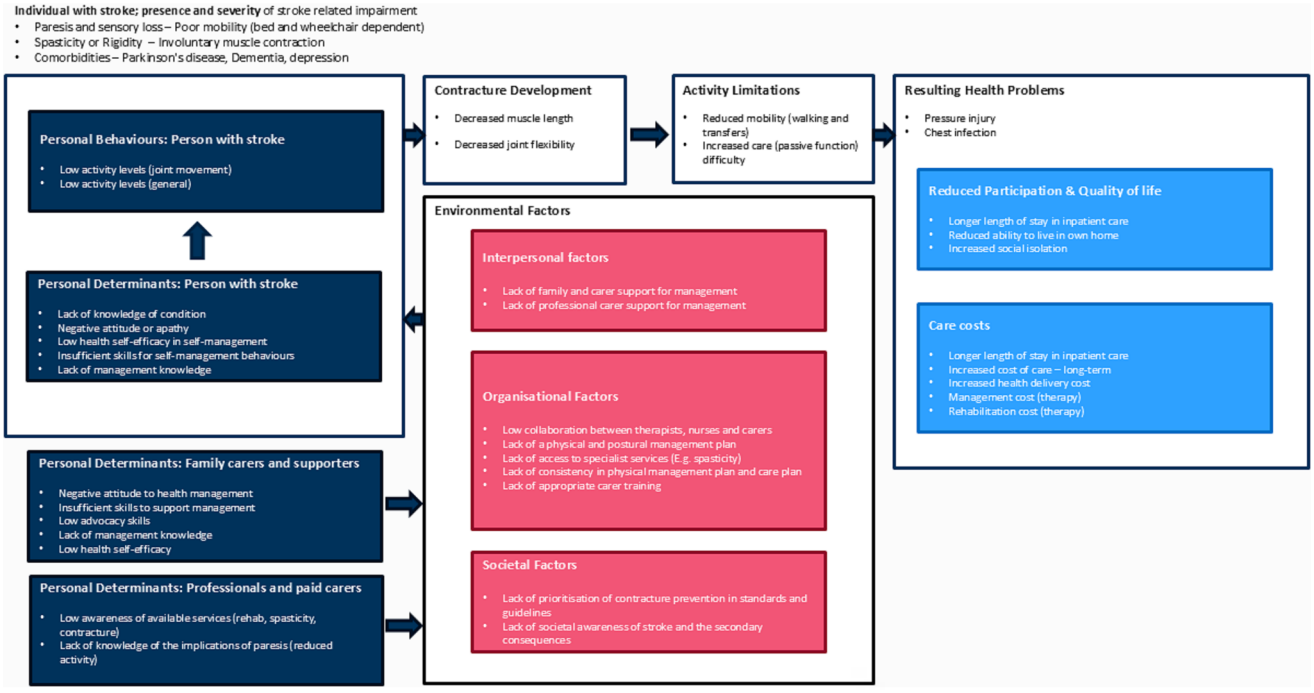

Figure 1. Summary logic model of the problem – contracture development.
Summary of the main elements within the Logic-Model of the problem and the priortised elements identified by people with stroke, carers and clinicians, with arrows indicating the relationship between the key elements.

functional ability, pain, muscle weakness, physical mobility, and bed confinement provided the most consistent evidence of association with joint contractures. However, the relationship between spasticity and joint contractures remained unclear. Other factors such as an individual's cognition and behaviour might be important, but there was insufficient evidence to make any conclusions [31].

The PRECEDE headings identified were

Health Condition, Personal Determinants: Family carers and supporters, Personal Determinants: Professional and paid carers, Personal Behaviours, Environmental Factors, Consequential Health Problems. In a modified approach to PRECEDE, we then incorporated headings from the WHO International Classification of Functioning Disability and Health [22], adding Impairment, Activity Limitation and Participation (environmental and personal factors are already incorporated within the PRECEDE model). In addition, we also added costs into the model and separated out contracture development separately from consequential health problems. The literature was then used to initially populate these headings with items that are thought to impact contracture development following stroke.

Risk factors identified from the systematic review and related published literature were included in the initial Logic-model using the framework of the PRECEDE model and are summarised in Figure 1, with the subsequent priority areas that might influence contracture development identified by users (people with stroke, carers and clinicians).

Refinement of the logic-model

The project PPI group and clinical experts reviewed the initial logic-model and also suggested additional items. The *logic-model* following responses and changes is displayed in Figure 2 (with areas of prioritisation for possible intervention still included as also shown in Figure 1). Additional items added to the *working logic-model* through consultation were (indicated with '**' in Figure 2):

Personal determinants: Person with stroke

- Sensory impairment – *Clinician suggestion*. The implication in this recommendation is that monitoring the position of a limb or pressure on a limb, would be more difficult for a person with sensory impairment.
- Perceived advantage and disadvantage (knowledge of health condition) – *Clinician suggestion.* The implication in this recommendation is that understanding the long-term positive and negative implications of treatment/management significantly influence the willingness to undertake management that is an additional task within care provision.

Personal determinants: Family carers and supporters

- motivation, depression – *PPI suggestion*. The implication in this recommendation is that depression in particular may have a significant impact on motivation to carry out self-management tasks to prevent physical deterioration.

Personal determinants: Professionals and paid carers

- Low moral – *Clinician suggestion*. The implication in this recommendation is similar to the point made by PPI representative in that low-moral may have a significant impact on motivation to carry out self-management tasks to prevent physical deterioration, but in this instance also applies to carers (both professional and family carers).

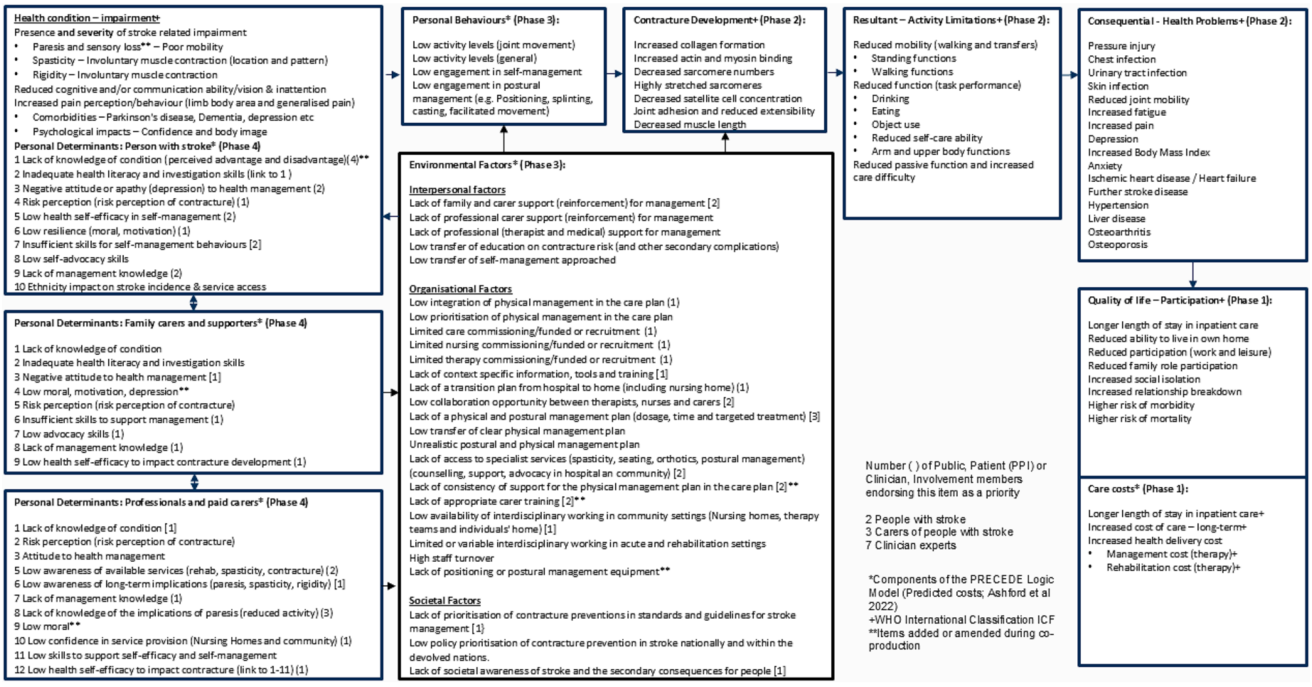

Figure 2. Full logic model of the problem – contracture development.
Figure 2 provides detail of all the elements within the Logic-Model of the problem and also the level of endorsement by people with stroke, carers and clinicians. Additionally, it indicates items added by the PPI and clinician experts.

Environmental factors

- Lack of context specific tools and training – *Clinician suggestion*. The implication in this recommendation is that particularly for professional carers (but also for family carers and people at risk of contracture) there is a lack of tools (equipment, but also systems) and training to fully implement physical management practice.

All elements of the Logic-Model included initially and then added or modified are shown in Figure 2. The prioritised items by PPI and clinician participants are shown in Figure 1 and are also shown in Figure 2, alongside items not specifically prioritised and the items added.

Discussion

In an innovative modified approach to PRECEDE, we have incorporated headings from the WHO International Classification of Functioning Disability and Health [22], with inclusion of Impairment, Activity Limitation and Participation as components within the model (environmental and personal factors are already incorporated within the PRECEDE model). This provides an advantage in this context and in rehabilitation environments, to better identify areas for potential behaviour change. We have also been innovative in including separate elements in the PRECEDE diagram (Figure 1) which emphasise the behaviour of professionals and carers (paid and family) that may need change to influence the development or treatment of contracture.

This paper outlines the first complete Logic-Model of the problem for contracture development (Figure 1), which has been produced following incorporation of the published evidence with a co-design consultation with the PPI group and clinicians. New items were identified and added as a result: **Personal Determinants: Person with stroke:** sensory impairment, perceived advantage and disadvantage (of knowledge of health condition); **Personal Determinants: Family carers and supporters:** motivation, depression; **Personal Determinants: Professionals and paid carers:** Low moral; **Environmental Factors:** Lack of context specific tools and training. Items identified confirmed or added a further dimension to an item already included.

We have identified a range of elements that may contribute to contracture development at a joint or joints following a stroke. We have then been able to prioritise these elements, in conjunction with people with stroke, carers and clinicians, to identify elements that might be possible to change to improve outcome for people at risk of contracture development.

While there has been some interest in the development of contracture, limited empirical work has been published [7,30]. Our group has undertaken a study in 155 participants with post-stroke arm impairment, with 110 reviewed at 1 year. Hypertonicity (stiffness in muscles) developed in 77%, with severe hypertonicity present in 25%. Pain was reported by 65%, and 94% developed shoulder contracture [29]. These specific elements have also been incorporated into this review and subsequently into the Logic-Model of the problem.

Contractures are thought to primarily occur due to immobility, often in the presence of a neurological condition, like stroke, which is reinforced in our Logic-Model. They are thought to result from development of fibrous tissue within muscle and in some instances, joint ankyloses [16]. In a review of contracture studies, Wagner et al. (2010) looked at data from the US Online Survey, Certification and Reporting (OSCAR) which is collected during routine inspections of long term care facilities and reported that 29% of residents had evidence of contracture in 2005 [32], indicating that both severity, but also care related factors may be relevant, which have been incorporated in the Logic-Model. Wagner and colleagues [33] found several variables associated with contractures, these included being non-white, using 'Medicaid' (the United States of America health funding system), a longer

length of stay, poorer function and mobility, lower levels of activity and pain. Individuals with contracture were also more cognitively impaired, more likely to be receiving physical restraint and have had a stroke or urinary incontinence. However, only being non-white and having pain were statistically significant. Other factors did not reach statistical significance in this study but may be more significant in a specific stroke population, particularly in those with moderate to severe stroke. These elements identified, particularly, immobility and comorbidity, may be important and reinforce the need to include these elements in the model.

Selikson et al. (1988) [34] identified high frequency of contracture in those with stroke, dementia or Parkinson's disease [34], which again emphasised the potential contribution of comorbidity. In a review by Offenbacher, the two main reported risk factors for contractures in older people were immobility (likely to relate to some extent to the severity of impairment) and the presence of a neurological condition, namely stroke [35]. Many variables have been discussed as possible contributors to contracture development, but pain appears to play a more consistent role in many studies and reviews. In order to maximise management and prevention, it is crucial, and in line with the development of complex intervention [19], that we first understand *how* and *why* contractures develop, which the logic-model of the problem helps to do, thereby addressing a gap in the theory development of this phenomenon.

Contracture management and prevention

There has been significant focus on stretch intervention in the literature and this maybe one element to consider in a future Logic-Model for change. Stretch based intervention, such as manual passive stretching, splinting/orthotics or progressive/serial casing, have been proposed as possible interventions to prevent or treat contracture. However, a Cochrane review in 2010 (updated 2017) found moderate to high quality evidence that stretching techniques had no immediate, short- or long-term effects on joint range of movement (ROM), pain, spasticity, function or quality of life in those with and without neurological conditions [17]. Another Cochrane review on manual passive movement also concluded there were no clear benefits [36]. Nevertheless, it can be argued that a primary reason for lack of effect in these studies may be linked to how interventions were implemented due to a high level of variability in treatment provision and the duration of stretch i.e., implementation failure [37]. All treatment must address *how* intervention is applied (consistency and the *mechanism* of action) and the *dose* (amount) provided [7]. In the brain injury literature, highlighted in the Cochrane review, there is a finding indicating that serial-casting intervention can produce change, but that follow-on maintenance treatment is likely to be needed afterward to maintain the change achieved [17]. It is unlikely that stretch-based intervention alone to prevent or reverse contracture would be effective. A multi-modal approach is likely to be needed to prevent or manage contracture, and this is reflected in the logic model of contracture presented in this paper (see Figures 1 and 2). The summary in Figure 2 provides key elements that might need to be considered.

As in many areas of health, proactively preventing problems is key; a preventative approach to contracture is likely to be more effective than restoration once present. Mosley and colleagues [23,24,26] identified if range of movement loss is identified early post-stroke it may be possible to reverse initial changes through prolonged stretch using a serial casting intervention, which would then need to be maintained once regained. It however remains difficult to determine the optimal preventative approach due to limited knowledge and understanding [7] of the full range of factors involved. This also holds true for management once contracture has developed.

Limitations

The Logic-Model of the problem development is based on elements identified and assembled in a systematic manner from the literature into the Model. To reduce the risk of bias in this initial stage of Logic-Model development, pre-defined structures were used and adapted to order the elements included (e.g. the PRECEDE model and the ICF).

The consultation with clinicians, patients and carers involved relatively small numbers of participants and therefore there is a risk of bias. However, this is weighed against the items taken from the literature, which were confirmed in all cases where consultees selected items. No entirely new items were identified at this stage, indicating a degree of saturation had already been reached with the items identified.

In summary, a number of factors are associated with contracture development in people with stroke, these include, the presence of pain, physical immobility (particularly being immobile in bed), cognitive impairment and comorbidities of Parkinson's disease or dementia. Identification of additional factors associated with contracture development, and a more nuanced understanding of those we already know, are important to advance our knowledge of how to prevent contractures or limit the impact of contracture development in people with stroke. The resulting Logic-Model of the problem from this study plays an important role in the development of evidence-based interventions and care pathways that will optimise treatment outcomes for people with stroke.

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Disclosure statement

SA has a specific interest in outcomes evaluation and has published on the use of Goal Attainment Scaling, as well as a number of standardised measures. All of these tools are freely available, and he has no personal financial interest in these measures or tools.

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