



Faculty of Health and Social Sciences

**Development, Validation and Evaluation of the
Feasibility of the Observational Risk Assessment of
Contractures (Longitudinal Evaluation) Tool**

THE ORACLE STUDY

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and Dorset Healthcare University Foundation Trust

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Philosophy

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Abstract

Hina Tariq: Development, validation and evaluation of the feasibility of observational risk assessment for contractures: The ORACLE study

Background

Joint contractures are a prevalent and debilitating complication of prolonged immobility in individuals living in care homes. Despite high prevalence rates, there is no standard, evidence-based risk assessment tool to evaluate the risk of contractures and prompt early intervention. This project aimed to develop and validate ORACLE (Observational Risk Assessment of Contractures: Longitudinal Evaluation), a novel assessment tool tailored to help care staff in early identification of risk of contractures and timely initiation of preventive measures.

Methods

A multi-phase, sequential, mixed-methods design was adopted. The project was structured into two main phases: 1) Content validation and 2) External validation. In the first phase, three consecutive studies were conducted: a systematic review, a Delphi survey and a quality improvement (QI) study to develop an educational video. The second phase consisted of two streams of work: a) psychometric testing and b) qualitative interviews with care staff.

Results

Study 1: The systematic review included 47 studies and identified three categories of associated factors: sociodemographic factors, physical factors, and proxies for bed confinement. The findings informed the design of the Delphi study.

Study 2: The experts demonstrated a high level (70-100%) of consensus regarding the clinical factors (10 out of 15 items), preventive care approaches (9 out of 10 items), and contextual factors (12 out of 13 items). The findings informed the development of ORACLE.

Study 3: Baseline data revealed that most care staff lacked contracture knowledge. Post-intervention, the level of knowledge and understanding increased, demonstrating that introducing the educational video is a feasible and positively received method of enhancing care staff's awareness of contractures.

Study 4: ORACLE demonstrated high inter-rater and intra-rater reliability and good convergent validity with Barthel Index.

Study 5: Three overarching themes were identified: 1) usability of ORACLE, 2) acceptability of ORACLE and 3) contextual factors that can potentially influence the practical implementation of ORACLE in a care home setting.

Conclusions

This project offers new knowledge in contracture prevention by providing a novel evidence-based risk assessment tool for contractures. ORACLE is a reliable and practical tool for assessing contracture risk in care home residents, with the potential to improve preventive care in this setting. However, qualitative insights emphasise the importance of organisational support, continued staff training and ongoing support to ensure consistent application, implementation and sustainability of ORACLE.

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Dedication

To my dearest brother, Tamoor Tariq, your loss on July 24th, 2023, forever changed our lives. You will always hold a special place in my heart. Your encouragement for my PhD journey, your unconditional love and support, will never be forgotten.

I miss you every day. Till we meet again in Jannah!

TAMoor TARIQ

(1983-2023)

Author's Declaration

This thesis follows the format of an integrated thesis, in line with the BU's Research Degree Code of Practice. It integrates five papers, including three published manuscripts: one submitted for publication, and one currently in preparation.

As the lead author, I was responsible for the study design, data collection, analysis and drafting of the manuscript, contributing significantly to the substantive content of each paper.

Paper	Title	Chapter	Page numbers	Publication status
1	Factors associated with joint contractures in adults: a systematic review with narrative synthesis	3	44-62	Published
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3	The Development and Evaluation of a Quality Improvement Educational Video on Joint Contractures for Care Home Staff	5	84-90	Published
4	Psychometric properties of the Observational Risk Assessment of Contractures (Longitudinal Evaluation) tool: The ORACLE study	6	93-112	In preparation
5	Insights from the care home staff on the use of Observational Risk Assessment of Contractures: Longitudinal Evaluation (ORACLE): a qualitative study	7	115-133	Submitted

In this thesis, certain aspects of the research have been previously disseminated at academic conferences and published in a peer-reviewed journal.

Research publications:

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Tariq, H., Collins, K., Dunn, J., Tait, D. and Porter, S., 2024. The Delphi of ORACLE: An Expert Consensus Survey for the Development of the Observational Risk Assessment of Contractures (Longitudinal Evaluation). *Clinical Rehabilitation*, 38(5), 664-677.

Tariq, H., Dunn, J., Forrester, S., Collins, K. and Porter, S., 2024. Development and evaluation of a quality improvement educational video on joint contractures for care home staff. *BMJ open quality*, 13(4).

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Tariq, H., 2023. Development of a Risk Assessment Tool for Contractures: the ORACLE study: In: **Upper Limb Stroke Rehabilitation Summer School** 13-15 September 2023 Leuven, Belgium.

Tariq, H and Dunn, J., 2022. Joint Contractures in Care Homes: A journey of quality from quandary. In: **Quality conference** 22 March 2023 Bournemouth, UK

Tariq, H., 2022. Development and validation of a contracture risk assessment tool: the ORACLE study. In: **12th World Congress for Neurorehabilitation** 14-17 December 2022 Vienna, Austria.

Tariq, H., 2022. Development of a Risk Assessment Tool for Contractures: the ORACLE study: In: **the 8th PhD Virtual Connect -By Sigma European Membership Involvement Committee** 30 November 2022 Virtual

Tariq, H., 2022. Development of a Risk Assessment Tool for Contractures: the ORACLE study: In: **ACPPLD-ALE (Association of Chartered Physiotherapists for People with Learning Disabilities)** 26 September 2022 Virtual

Tariq, H., Collins, K. and Dunn, J., 2021. Developing a contracture risk assessment tool and a regional contracture strategy. In: **Rehab 2021-Living and ageing with long term conditions** 9-10 November 2021 Virtual.

Educational material:

Contracture awareness video for care home staff
Developed in collaboration with Dorset Healthcare as part of the Clinical academic doctorate based on the evidence collected as a PhD researcher:

Dorset Healthcare University NHS Foundation Trust, 2023. Joint Contracture Awareness Video [video]. YouTube. Available from:
<https://www.youtube.com/watch?v=aITUZ63khr0>

Chapter 1: Introduction

1.1 Chapter overview

This chapter provides a background to the research problem, setting the context and significance of the research area. It begins with an overview of contractures, including their types, aetiology and pathophysiology and epidemiology across various conditions, and the impact of contractures on the affected individuals. Following this, the contractures are discussed within the context of care homes, establishing the study's rationale in detail, followed by an outline of the specific aims and objectives. The chapter then concludes by summarising the structure of the entire thesis.

1.2 Background

1.2.1 What are contractures?

There is no universally accepted definition for joint contractures. However, contractures are commonly defined as a reduction in the active or passive range of motion (ROM) resulting from structural changes within the intra-articular (bone, cartilage, capsule) or extra-articular (muscles, tendons, skin) tissues surrounding the joint(s) (Figure 1) (Jamshed and Schneider 2010; Halar & Bell, 2012).

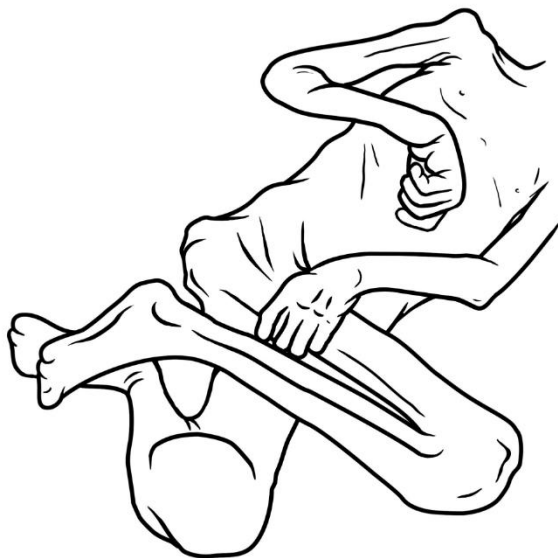


Figure 1 Contractures (personal collection 2023)

1.2.2 Types of Contractures

Contractures can be categorised or described based on (i) the type of tissue involved, (ii) severity, (iii) direction of restricted ROM and (iv) underlying pathology (Figure 2).

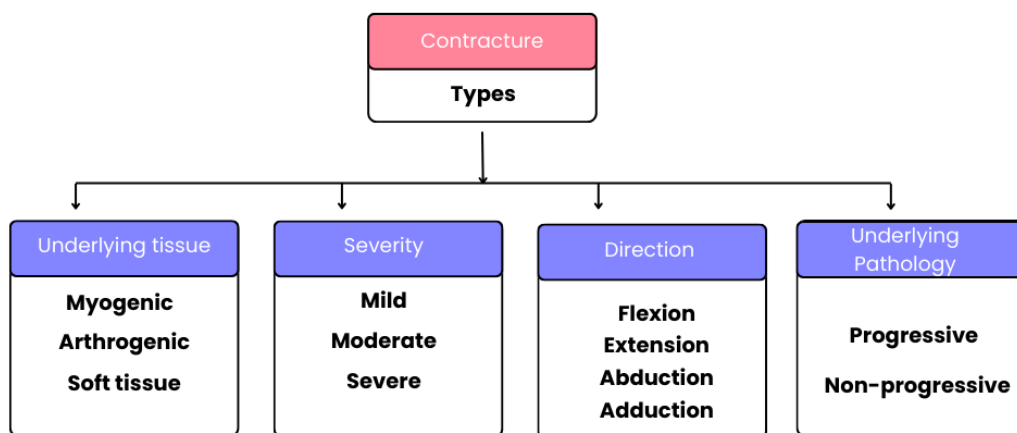


Figure 2 Types of contractures

(i) *Type of tissue involved*

The type of connective tissue involved in joint movement restriction can define the type of contracture developed; however, multiple tissues can have underlying involvement, and it is often difficult to identify a single point of joint restriction (Campbell et al. 2014). There are three types of joint contractures based on the underlying tissue (s) involved:

a. *Myogenic contractures*

Myogenic contractures are defined as a reduction in the muscle length resulting in limited active and passive ROM (Trudel and Uhthoff 2000; Halar and Bell 2012). These are most commonly associated with upper motor neuron lesions such as brain and spinal cord injury (SCI), multiple sclerosis and cerebral palsy

(CP) (Trudel and Uhthoff 2000). They are also frequently seen in muscle degeneration disorders like muscular dystrophy or following a prolonged period of immobility, such as extended bed confinement in the intensive care unit (ICU).

b. *Arthrogenic contractures*

Arthrogenic contractures typically result from damage or stiffening of the connective tissues surrounding a joint, like bone, cartilage and the joint capsule and are often coupled with pain (Trudel and Uhthoff 2000). These contractures are commonly seen in orthopaedic conditions, e.g. osteoarthritis, rheumatoid arthritis, systemic sclerosis and osteochondritis (Trudel and Uhthoff 2000). Post-traumatic joint contractures can also be categorised under this category, which develop as a result of injury, e.g. fractures or joint dislocations (Hildebrand et al. 2021).

c. *Soft-tissue contractures*

Soft-tissue contractures, also known as scar contractures, involve the cutaneous, subcutaneous, and/or loose connective tissue surrounding the joint (Halar and Bell 2012). They are a common consequence of burns and open wounds (Tan et al. 2019; Klingshirn et al. 2020).

(ii) Severity

Researchers commonly categorise contractures based on the degree of loss of ROM at a specific joint: (a) no contracture, (b) mild, (c) moderate and (d) severe (Diong et al. 2012; Kwah et al., 2012; Hoang et al., 2014; Hardwick et al. 2018).

- a. *No contracture*: no loss of ROM
- b. *Mild contracture*: loss of up to 1/3rd of total ROM
- c. *Moderate contracture*: loss between 1/3rd to 2/3rd ROM
- d. *Severe contracture*: loss greater than 2/3rd ROM

Some researchers also categorised contractures by the severity of functional impairment at the joint: (a) *severe*, (b) *moderate or clinically relevant*, or (c) *clinically non-relevant* (Pohl and Mehrholz 2005).

(iii) Direction and joint involved

Contractures are frequently named based on the direction opposite to the restricted ROM and the specific joint affected (Campbell et al. 2014). For example, an *elbow flexion contracture* denotes a limitation in elbow extension (Suksathien and

Suksathien 2010), and a *hip abduction contracture* refers to a restriction in the adduction of the hip joint (Al Bayati and Kraidy 2016).

(iv) Underlying Pathology

Contractures can be categorised as *progressive* or *non-progressive* based on the underlying pathology. *Progressive contractures* are acquired and typically develop as a secondary complication of chronic conditions, e.g., stroke, SCI, arthritic diseases, or surgical procedures like total knee and hip arthroplasty (Bartoszek et al. 2016). These contractures are associated with external clinical factors, including physical mobility, muscle weakness, spasticity, impaired cognition, and pain (Skalsky and McDonald 2012). In contrast, *non-progressive contractures* are usually congenital, affecting multiple joints and limbs and are primarily associated with genetic conditions, e.g., arthrogryposis multiplex congenita (Darin et al. 2002). Literature suggests that progressive contractures that develop as a secondary consequence are usually preventable and need timely recognition and intervention. The scope of the current study is focused on progressive arthrogenic or myogenic contractures. Scar contractures and contractures that are a part of the primary diagnostic criteria in conditions like Dupuytren's disease, adhesive capsulitis, or ischemic contractures fall outside the scope of this research.

1.2.3 Aetiology and Pathophysiology

Extended immobility has been identified as the single most frequent cause of progressive joint contractures (Selikson et al. 1988; Skalsky and McDonald 2012). When a joint is immobilised in a shortened or fixed position for an extended period, e.g., a knee joint positioned in flexion, it leads to a reduced number of sarcomeres, causing adaptive shortening of the muscles and connective tissues (Skalsky and McDonald 2012; Matozinho et al. 2021). The connective tissues, in turn, lose their elasticity and undergo fibrosis, ultimately leading to an inability to move joints normally and the development of contractures (Skalsky and McDonald 2012; Matozinho et al. 2021).

Immobility can contribute to the development of contractures through external aetiological factors such as spasticity, muscle weakness and pain. The literature explains several possible pathophysiological mechanisms responsible for adaptive shortening of the structures depending on the underlying aetiological factor. The increased resistance to stretch is caused by the mechanical properties of the tissues,

which can be influenced by both neural and non-neural factors (Salierno et al. 2014).

Neural factors originate centrally and cause muscle hyperactivity of the muscles (Salierno et al. 2014). For example, in spasticity, the disinhibition of the mono-synaptic stretch reflex causes the affected muscles to become hyperactive and contract in response to stretch, which reduces the individual's ability to control the affected muscle and limb (Mukherjee and Chakravarty, 2010; Salierno et al. 2014). Consequently, the joint remains in a fixed position, leading to connective tissue changes as with immobilisation (Ada et al. 2006).

Muscle weakness can develop as a consequence of neurological conditions or sarcopenia resulting from a sedentary lifestyle or poor nutrition. When one muscle group becomes weak and is unable to match the force of the opposite or antagonist muscle group, this results in restricted joint movement and fixed positions, leading to connective tissue shortening and contractures (Skalsky and McDonald 2012). For example, a muscle imbalance between functioning shoulder internal rotators and weak or paralysed external rotators may lead to static posturing and internal rotator contracture (Goh and Cornwall 2020). In addition, muscle weakness can hinder the joint's ability to be moved through the full range and hold its position against gravity, again contributing to contractures (Ada et al. 2006).

Non-neural factors encompass alteration in the mechanical properties of the tissues secondary to orthopaedic injuries, heterotrophic ossification, splinting, paralysis, pain or any condition that restricts joint movement (Salierno et al. 2014). In the case of pain, e.g., after fractures, surgeries, or chronic musculoskeletal conditions, the body's natural response is to immobilise or "splint" the joint in a fixed and comfortable position for extended periods. Over time, this can lead to structural changes in articular or non-articular tissues, leading to contractures (Campbell et al. 2014).

1.2.4 Epidemiology of Contractures

1. Neurological Conditions

Stroke and Acquired Brain injury: The development of contractures is a commonly reported secondary impairment after stroke and acquired brain injury.

Kwah et al. (2012) conducted a study on a 200-consecutive sample of adult stroke patients admitted to a Sydney Hospital in Australia and reported that 52% of the patients developed at least one contracture within a period of six months. The incidence of contractures was seen to be higher in patients with moderate to severe stroke. It varied from 12-28% across different joints, and shoulder and hip were the most frequently affected joints (Kwah et al. 2012).

Another recent longitudinal study by Matozinho et al. (2019) on individuals with hemiparesis due to stroke admitted to a public hospital in Brazil (69 patients) reported that the incidence of contracture in upper extremities was 28% in one or more joints 3 months post-stroke. This incidence varied across joints of the upper limb: 13% for the shoulder, 6% for the wrist and 16% for the wrist joint. There was also a higher incidence of contractures in patients with moderate stroke when compared to mild-stroke patients (Matozinho et al. 2019). Sackley et al. (2008) also conducted a longitudinal study on 122 stroke survivors identified through Nottingham Stroke Register (UK) during the first year after severe stroke. The reported incidence was 43% in the first three months of stroke, which increased to 56% in six months and 67% within one-year post stroke (Sackley et al. 2008). Regarding acquired brain injury, Singer et al. (2004) in their longitudinal study (n=105) reported an overall incidence of ankle contractures to be 16.2% over one year in patients with moderate to severe brain injury (Singer et al. 2004). Based on the data from the study by Pohl and Mehrholz (2005), which determined the prevalence of shoulder contractures in 50 patients with severe brain damage of various etiologies, 56% of the patients suffered from a contracture in at least one joint (Pohl and Mehrholz 2005).

Spinal Cord Injury: Diong et al. (2012) conducted a prospective cohort study on 92 consecutive acute SCI patients presented to two Sydney spinal cord injury units. The baseline and follow-up assessment of the patients was taken within 35 days of their injury and one year later, respectively. The results demonstrated an overall incidence of contractures to be 66% in at least one joint. It also found that the incidence of contractures was higher in tetraplegic patients (83%) compared to that of the paraplegic patients (47%) (Diong et al. 2012). A longitudinal study by Eriks-Hoogland (2009) involving spinal cord injury patients admitted to specialised rehabilitation centres reported the incidence of contractures, defined as limited

shoulder range of motion during and one year after the rehabilitation. Seventy percent of the patients with tetraplegia experienced a limited range of motion, whereas 29% of the patients with paraplegia had a limited range of motion during or in the first year after inpatient rehabilitation (Eriks-Hoogland et al. 2009). Another longitudinal study by Vogel et al. (2002) investigated the prevalence of musculoskeletal and neurological complications in 216 adults with pediatric-onset SCI at follow-up through telephonic interviews. The results showed that 23% of the participants experienced hip contractures, 16% had ankle contractures, and 7% had elbow contractures (Vogel et al. 2002).

Other neurological conditions: The data on the prevalence and incidence of joint contractures in other neurological conditions is under-reported. A cross-sectional study by Hoang et al. (2014) investigated the prevalence of joint contractures in 330 people with multiple sclerosis living in Australia. Fifty-six percent (56%) of the participants reported having at least one joint contracture of the upper or lower extremity (Hoang et al. 2014). Souren et al. (1995) determined the prevalence of contractures in a consecutive sample of 161 patients with Alzheimer's disease. It was reported that 24% of the patients had at least one contracture of the large joint of at least one extremity and three-quarters of the non-ambulatory patients developed joint contractures defined as a loss of 50% of the ROM. Of those, 97% of the patients had more than one limb involved, while all four extremities were involved in 69% of the patients (Souren et al. 1995). Rabiner et al. (1996) conducted a study to describe the prevalence and location of contractures within nursing home residents. Of the total residents who had at least one contracture reported, 46.7% suffered a stroke, 38.1% had dementia, 14.29% had Parkinson's disease, and 11.9% had a diagnosis of Alzheimer's disease (Rabiner et al. 1996).

2. Musculoskeletal Conditions

Marchand et al. (2017) performed a retrospective chart review of 390 patients with intra-articular elbow fracture treated with surgical fixation and reported that a total of 27% patients (n=105) developed arthrofibrosis (defined as an elbow flexion contracture greater than 45°) (Marchand et al. 2017). A study conducted by Myden and Hildebrand (2011) followed the patients after traumatic elbow injuries for one year to describe the incidence of secondary intervention due to joint contractures. It

was reported that after one-year post-injury, 12% of the patients still experienced a functional joint limitation and 12% presented with a contracture that required surgical intervention (Myden and Hildebrand 2011). A small cross-sectional study by Campbell et al. (2015) examined 23 individuals with a diagnosis of osteoarthritis (OA) in a primary care setting. The study reported that 13 patients (62%) had a knee flexion intra-articular contracture. Additionally, patients with contractures had a longer duration of OA than those without contracture (Campbell et al. 2015). Ritter et al. (2007), in their large retrospective cohort study, reported that 93%(n=5228) of patients with knee contractures who presented for the total knee arthroplasty (TKA) had a diagnosis of osteoarthritis, 5% (n=280) had rheumatoid arthritis and 1.1% (n=63) had osteonecrosis (Ritter et al. 2007). Though systemic sclerosis (SSc), also known as scleroderma, is a multi-system disease involving the vascular system, immune system, skin and internal organs, the involvement of the musculoskeletal system is one of the significant causes of disability and low quality of life (Lóránd et al. 2014). The prevalence of joint involvement in SSc patients, including contractures, has been reported to occur from 46% to 97% (Avouac et al. 2006).

1.2.5 Impact of Joint Contractures

Joint contractures are complex healthcare phenomena that have a significant and far-reaching impact on the affected individual. Once developed, contractures may lead to a vicious cycle of impairments, each impacting the next, leading to a further progression of existing contractures (Figure 3).

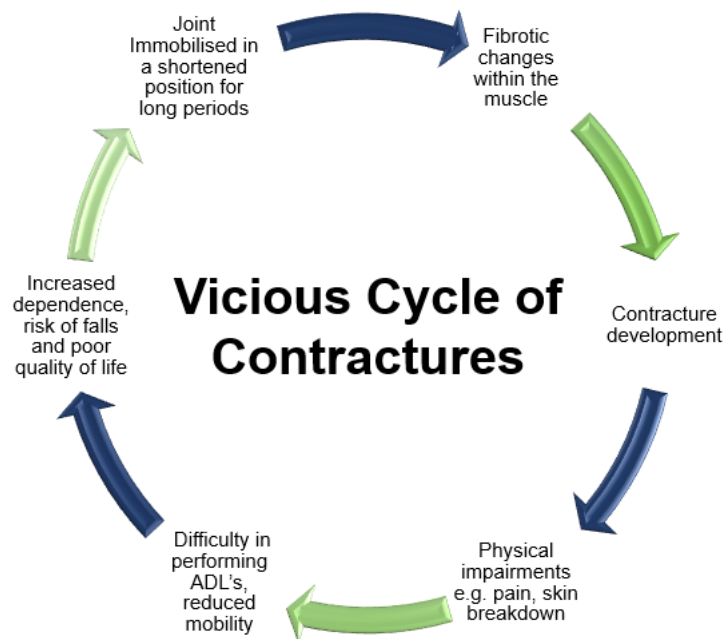


Figure 3 Vicious cycle of contractures (personal collection 2019)

When a joint is positioned in a shortened position for prolonged periods, it leads to fibrotic changes, causing the development of a contracture (Skalsky and McDonald 2012). Initially, these contractures may be clinically non-relevant or mild; however, they increase the risk of physical impairments (Born et al. 2017). As a result, there is difficulty in performing self-care activities, e.g. eating, dressing, and bathing, along with restrictions in physical mobility and reduced social engagement (Müller et al. 2013). This, in turn, contributes to further deconditioning, increased dependence, increased risk of falls, poorer quality of life and progression of existing contractures to more severe or clinically relevant (Heise et al. 2016).

1.3 Contractures in Care homes

UK Care Standards Act (2000) define care homes as establishments that provide accommodation along with nursing and personal care (UK Care Standards Act 2000). Under this act, there are two main types of care homes: residential homes and nursing homes. Residential care homes offer 24-hour supervision and support, typically from trained care assistants, to help residents with personal care and daily tasks. These homes may cater to specific populations, such as frail older adults, individuals with dementia, or those with learning disabilities. Nursing homes, on the other hand, provide the same care as residential homes but are also equipped to

provide 24-hour medical care from registered nurses, in addition to support with daily living. They often provide care to residents who need more complex care, such as help with medication management, skin care, continence, nutrition, or dementia care.

In the literature, the terms most commonly used interchangeably with care homes include long-term care facilities, geriatric care settings, and assisted living facilities.

1.3.1 Prevalence of contractures in care homes

The data on the prevalence of contractures in long-term facilities is underreported and varies widely; this wide variation in prevalence reflects the heterogeneity in the population demographics and inconsistency in the definition and assessment methods of contractures.

Only one study by Yip et al (1996) reported on the prevalence of contractures in the UK, demonstrating a rate of 55% in individuals who received NHS continuing geriatric care (Yip et al. 1996). A multicenter cross-sectional study in France was conducted by Dehail et al. (2014) on residents of 39 geriatric care settings. Of the total study population (n=3145), 22% (n=692) residents were reported to have at least one joint contracture (Dehail et al. 2014). Wagner et al. (2008) conducted a secondary analysis to examine the prevalence of contractures among 273 frail nursing home residents in the metropolitan Philadelphia area, United States. They reported a prevalence of 61.2% in at least one joint contracture, while 45.4% of the residents reportedly had two or more contractures. The prevalence was higher in the upper extremities (52.4%) as compared to the lower extremities (48.4%), and shoulder and knee joints were the most commonly affected joints (44% each) (Wagner et al. 2008). In a descriptive study of 59 older adults living in long-term care settings in the United States, Resnick (2000) found that 32% of the residents had one or more upper limb contracture while 26% of the residents had at least one lower limb contracture (Resnick 2000). In another longitudinal study of 112 nursing home residents in the United States, Mollinger and Steffen (1993) reported that 75% had some degree of unilateral knee flexion contracture (Mollinger and Steffen 1993). Rabiner et al. (1996), in their study involving nursing home residents, reported a contracture prevalence of 27% in at least one joint (Rabiner et al. 1996). Selikson et al. (1988) conducted a retrospective cohort study of 80 nursing home residents in the United States, categorising 42.5% as non-ambulatory and 15% as ambulatory. The

study found that 70.5% of non-ambulatory residents developed a contracture, whereas no contractures were observed in the ambulatory group. (Selikson et al. 1988).

1.3.2 Impact of contractures on care home residents

The aetiology and consequences of contractures are both multifaceted, and therefore, an interdisciplinary approach is needed for the prevention and management of residents living in complex environments like care homes. Batorszek et al. (2015) utilised a biopsychosocial model of the International Classification of Functioning, Disability and Health (ICF) to fully understand and describe the impact of contractures on individuals living in care home settings (Bartoszek et al. 2015b). ICF, developed by the World Health Organisation (WHO), is a dynamic model that integrates biological, psychological and social factors into a framework to describe health-related states and how these factors interact to affect the individual's overall functioning and quality of life (WHO 2002; Stucki et al., 2002). ICF helps to understand the impact of contractures on the affected individual with a holistic view beyond just the physical impairments (Kostanjsek et al. 2011; Bartoszek et al. 2015b). The ICF has two parts: Part one consists of *Functioning and Disability* and includes the domains of (i) *Body functions and structures*, (ii) *Activities* and (iii) *Participation*. Part two denotes *Contextual Factors* that include (i) *Environmental Factors* and (ii) *Personal Factors*

Body Functions and Structures: Contractures significantly reduce the joint ROM through mechanical restriction, making joint movement difficult or impossible. In addition, because contractures keep the joints in a fixed position, they often lead to muscle disuse and atrophy, which in turn leads to muscle weakness (Wang et al. 2019). Joint contractures, once developed, can further increase the risk of other physical impairments, namely abnormal positioning, pain, discomfort, pressure ulcers, skin breakdown and increased risk of falls (Wagner et al. 2008; Born et al. 2017). A qualitative study conducted by Fischer et al. (2014) found that individuals with contractures living in geriatric care settings reported problems related to '*mobility of a single joint*' and '*sensation of pain*' as the most common concerns under this category (Fischer et al. 2014).

Activities and Participation: The activities domain refers to the execution of tasks or activities by an individual, and participation restrictions refer to the individual's restrictions in life situations and societal roles (Kostanjsek et al. 2011). Contractures significantly affect functional mobility and the ability of the affected individual to perform the Activities of Daily Living (ADLs). Contractures affecting the weight-bearing joints like the knee or hip can severely limit walking, standing, and sitting, making it difficult for the affected individuals to move around independently (Offenbacher et al. 2014; Born et al. 2017; Klingshirn et al. 2020). People with upper extremity joint contractures might have difficulty carrying out tasks like dressing, eating, and bathing. Hand or finger contractures can also affect fine motor skills and the ability to perform activities that require dexterity, such as grooming, writing, or gripping utensils (Campbell et al. 2014). On the other hand, lower extremity joint contractures might limit one's ability to transfer and walk independently, entailing a higher risk of falls (Offenbacher et al. 2014; Born et al. 2017; Klingshirn et al. 2020). The physical limitations caused by contractures also affect the individual's overall ability to engage in social or recreational activities (Chen et al. 2022). In the study by Fischer et al. (2014), the most commonly reported concerns belonged to this category (Fischer et al. 2014).

Environmental factors: Environmental factors refer to the external or contextual factors consisting of physical, social and attitudinal environments that either act as a facilitator or barrier to the overall functioning of the affected individual (Kostanjsek et al. 2011). Environmental factors play an important role in the mobility and independence of individuals with contractures, particularly those residing in long-term care facilities. Examples of these include access to external healthcare services (e.g., physiotherapy, occupational therapy) and appropriate assistive devices (e.g., wheelchairs, frames, etc.). In addition, social support systems, including family, caregivers, and peers, are vital in mitigating the emotional and practical challenges caused by contractures (Bartoszek et al. 2015b). Individuals with contractures have reported '*Products and technology for personal indoor and outdoor mobility and transportation*', '*support from immediate family or health professionals*' and '*health services, systems and policies*' as relevant environmental factors in their care (Fischer et al. 2014).

Personal factors: Personal factors refer to the internal characteristics of the individual that influence how the affected individual experiences health conditions (Kostanjsek et al. 2011). As contractures significantly affect a person's functional independence and increase dependency on caregivers for their daily tasks, affected individuals may exhibit emotional and psychological distress (Bartoszek et al. 2015b).

1.3.3 Risk of contractures in care homes

Care home residents are particularly vulnerable to the development of joint contractures due to several contributory factors. First, many residents experience mobility limitations due to age-related changes, neurological impairments, or musculoskeletal disorders. Prolonged immobility, e.g. due to bed confinement, may lead to joint stiffness and muscle shortening, significantly increasing the risk of contractures. It has been reported that care home residents spend most of their time remaining sedentary (Forster et al., 2017). Reduced mobility or lack of physical activity adversely affects the residents' physical and psychological well-being, including reduced motivation to engage in physical and social activities, pain, increased risk of pressure sores, contractures, and physical dependency (Graham et al., 2018, Forster et al., 2017).

Moreover, cognitive impairments such as dementia or Alzheimer's disease can also make it difficult for the residents to engage in physical or social activities and participate in rehabilitation programs. The inability to follow instructions or remember to move regularly leads to extended periods of immobility, thereby adding to the risk of contractures. Stroke, Dementia and Parkinson's are particularly notable as they are commonly associated with contracture development. Research indicates that 12-18% of care home residents have a history of stroke, 70% have dementia or severe cognitive impairment, and 8% have Parkinson's disease (PD), which is significantly higher than the 0.3% prevalence of PD in the general population. A high prevalence of these conditions explains the significance of the vulnerability of residents being at risk of developing contractures.

A further challenge is the lack of medical or clinical training among care home staff. The care home workforce in the UK primarily consists of care assistants, who make up 76%, while the registered nursing staff account for only 12% (Griffiths et al. 2019). Although the registered nursing staff provide personalised care to the

residents, the care assistants work more closely with them, spending most of the time delivering care and support. While they are trained to assist the residents with their daily activities, they often lack the specialised knowledge to identify early signs of contractures or to assess the risk effectively. The lack of nursing staff and specialised healthcare practitioners, such as physiotherapists or occupational therapists at the care home facilities, exacerbates this issue, as timely interventions, such as physical therapy or mobility exercises, may not be consistently provided. This lack of timely and specialised care and risk assessment places residents at a higher risk of developing contractures.

Structured risk assessments are important in referring patients to the appropriate healthcare practitioner and enacting early treatment strategies to reduce the risk of the condition progressing in the care homes. However, there is a clear lack of a standardised, evidence-based measure that can actively identify the risk of contractures and trigger appropriate and timely referrals to healthcare professionals (Bartoszek et al. 2015a).

A cross-organisational and multidisciplinary working group led by Dorset Healthcare aimed to address this significant gap and developed a prototype of a contracture risk assessment tool (Appendix I) grounded in their clinical expertise. To establish the academic validation of the tool before widespread use and implementation, Dorset Health Care collaborated with Bournemouth University and sponsored this match-funded PhD Studentship.

1.4 Rationale for this study

1.4.1 Health and Health Systems Impact

Contractures are a debilitating consequence of prolonged immobility, potentially leading to physical impairments, limited functional mobility, decreased independence with everyday activities, and reduced social participation.

The development of progressive joint contractures often follows an insidious pattern, and their initial progression is neither painful nor disabling. Joints only become painful when they are stretched beyond the point of soft-tissue restriction. For this reason, contractures are often unrecognised by the individual and their carers until they start interfering with their daily functional activities (Campbell et al., 2020). Therefore, structured and regular risk assessments are mandatory to identify the risk of contractures on time. Valid and reliable measurements are also vital to offer

appropriate guidance for risk protection and management and to have confidence in the tool being used (Bruton et al., 2000). Unfortunately, despite high prevalence rates, no standardised tool is available to screen or assess the risk of contracture development and progression in adults.

A valid and reliable tool may have the potential to be utilised by a range of healthcare professionals to identify the magnitude of risk, calibrate that risk, help them prescribe a set of actions in response to the level of risk, and track subsequent changes in the risk. In addition, timely and appropriate referrals may aid in the prompt escalation of early interventions by the specialists aiming to reduce the risk of contracture development or progression of existing contractures. This would potentially impact an individual's ability to maintain independence with activities of daily living and mobility, contributing to improved quality of life.

Moreover, this project also aims to explore the contextual factors that influence the implementation of healthcare interventions designed to prevent and manage contractures in care homes, for example, resource limitations, adequate staffing levels and staff training.

1.4.2 Educational impact

There is a clear lack of adequate educational resources and guidelines for risk assessment, prevention, and management of contractures in the literature, which is a major hindrance in providing optimal care for contractures. The development of evidence-based educational resources, particularly for care home staff, through this project could help increase the awareness and understanding of contractures, their risks, and preventative measures, ultimately improving the quality of care. In addition, one of the long-term goals of this project is to provide a validated tool to standardise screening and risk assessment practice across care homes and other settings (e.g., hospitals). This standardisation may serve as a foundation for the policymakers to develop guidelines for this purpose in the future.

1.4.3 Societal and economic impact

As indicated earlier, contractures, once developed, lead to a chain of irreversible impairments resulting in a vicious cycle that further worsens the condition. This leads to an increased burden of care, difficulty in moving and handling tasks for the carers, and increased financial costs as the needs of the affected individual increase. Using a

standard risk assessment tool may prevent contractures, potentially reducing the burden on the carers and the financial costs for the care homes and the NHS.

1.5 Research aims and objectives

1.5.1 Overarching Aim

To further develop, validate and evaluate the feasibility of Observational Risk Assessment of Contractures-Longitudinal Evaluation (ORACLE) in care homes.

1.5.2 Research Objectives

The following research objectives were developed to fulfil this overarching aim:

1. To collate and synthesise the available evidence on factors associated with joint contractures in adults through a systematic literature review.
2. To further develop, refine and assess the content validity of ORACLE through expertise and knowledge held by field experts through a modified e-Delphi survey.
3. To develop training material for care staff members on contractures for improved understanding of contractures and effective use of ORACLE.
4. To determine a cut-off score for ORACLE and evaluate the following psychometric properties of ORACLE:
 - a. Convergent validity
 - b. Intra-rater reliability
 - c. Inter-rater reliability
 - d. Floor and ceiling effects
5. To explore the usability and acceptability of ORACLE among the care home staff through interviews with care home staff.
6. To identify contextual factors that may support or inhibit the practical implementation of ORACLE in care homes through interviews with care home staff.
7. To refine the ORACLE tool and develop implementation guidance for care homes based on the research findings to improve its efficiency and usability.

1.6 Outline of the thesis

This thesis is organised into eight chapters:

Chapter 1: Introduction

This chapter provides an overview of the research problem, the rationale for the study, the research objectives, and the structure of the thesis.

Chapter 2: Methodology and Methods

This chapter explains the methodology, underpinning philosophy and rationale behind the approach. It also details the multi-phase research design, and an overview of the methods employed across five studies.

Chapter 3: Systematic review (Study 1)

This chapter introduces an integrated published research paper that presents the outcomes of a systematic literature review that collated the evidence on factors associated with contractures. The findings of this review provided evidence on the foundational factors of ORACLE.

Chapter 4: Delphi survey (Study 2)

This chapter presents the second consecutive study of this project presented in the form of an integrated published research paper. The findings of the two rounds of the Delphi survey are presented, highlighting the key components that reached consensus for inclusion in the ORACLE. The chapter also discusses the contextual factors relevant to care home settings and their potential influence on the practical application of ORACLE.

Chapter 5: Educational video (Study 3)

This chapter details the third consecutive study presented as an integrated published research paper. The Quality improvement (QI) project aimed to develop and evaluate an evidence-based educational video for care home staff to improve their awareness and understanding of contractures. The findings highlight the increase in staff knowledge and understanding of contractures and the practical implications of implementing educational interventions in care homes. The chapter also discusses the feedback received from staff and how it informed revisions to the video.

Chapter 6: Psychometric testing (Study 4)

This chapter presents the fourth consecutive study in the form of a prepared manuscript: the psychometric testing of ORACLE. It describes the testing of ORACLE's reliability, including intra-rater and inter-rater reliability, and its convergent validity with the Barthel Index

Chapter 7: Qualitative Study (Study 5)

This chapter presents the fifth consecutive study in the form of a manuscript (submitted for publication). It explores the usability and acceptability of ORACLE among care home staff. The findings from this study provide a deeper understanding of the staff's perceptions, the contextual barriers in care homes, and the importance of ongoing training to ensure ORACLE's effective use.

Chapter 8: Discussion and Conclusion

The final chapter integrates the findings from all five studies, discussing their collective contributions to the project. It reflects on the contribution to new knowledge and highlights the project's strengths and limitations. The chapter provides recommendations for care homes, policymakers, and future research. The conclusion summarises the key messages, emphasising ORACLE's potential to improve contracture prevention and enhance resident care in long-term care settings.

Chapter 2: Methodology

2.1 Chapter Overview:

Chapter 2 presents an account of the methodological choices used to fulfil the aims and objectives of this multi-phase study. The chapter first explains the overarching methodology, the underpinning philosophy and the rationale behind the chosen methodology. It then summarises the methods undertaken in each phase of the study. Details of specific methods used within each phase can be found in the methods section of the respective chapter (Chapter 3, 4,5,6 and 7).

2.2 Methodology

The researcher's methodological stance is a critical factor in the research process. It plays a key role in setting the foundation for the research design, data collection methods, and interpretation of findings. Research methodology refers to the general framework or approach adopted based on the nature of the research question. It provides a rationale for the research, enhancing the validity and reliability of the study and its outcomes. A mixed methods approach was adopted to achieve the objectives of this research.

2.2.1 Mixed Methods Research

Mixed methods research (MMR), also known as 'muti-method' or 'multiple methods research', can be described as a methodological approach that integrates both quantitative and qualitative data within a single research study (O'Cathain et al. 2007). The rationale behind choosing this methodology is discussed later in this chapter.

Prior to the formal development of MMR, researchers often adhered to a single research paradigm and mixing the two main methodological approaches (quantitative and qualitative) was seen as incompatible due to philosophical discrepancies (ontology and epistemology) (Mertens 2018). While the roots of combining different forms of data can be traced back to the mid- 20th century, it wasn't until the late 1980s and early 1990s when MMR emerged as a recognised and distinct methodological approach (Mertens 2018). John W. Creswell and Jennifer Greene were among the key figures who introduced and contributed to establishing MMR as a formal research approach (Greene et al. 1989; Creswell and Garrett 2008). Over the

years, MMR has gained significant popularity as a research approach in various disciplines like education, health and social science (Creswell 2015).

MMR is characterised by its methodological pluralism, which refers to the idea that no single method, theory, or approach is sufficient to capture the complexity of a given phenomenon.

Complex healthcare phenomena need to be researched by drawing on the strengths of both qualitative and quantitative approaches while mitigating their weaknesses, allowing for a comprehensive understanding and interpretation of reality (Strudsholm et al. 2016).

Philosophical Underpinnings

The researcher's philosophical stance plays an important role in setting a foundation for the research design, methods, analysis, and interpretation (Collis and Hussey 2009). According to Creswell (2015), MMR is underpinned by philosophical assumptions that inform the methods such as data collection and analysis (Creswell 2015). The connection between the underlying philosophy and MMR guides the researcher regarding decisions related to what questions could be asked, how to interpret the data, and how to assess the validity of findings (Hall 2013).

This MMR is informed by a critical realist ontology which stems from the philosophical paradigm of critical realism (CR). CR is a theory-driven approach which purports to provide an in-depth and comprehensive understanding of the outcomes in relation to their causal mechanisms and theories of how they produce an effect, for whom, and in what circumstances (Blackwood et al. 2010; Alderson 2021). It offers a unique advantage for researchers who seek to understand complex social and health phenomena by combining empirical data with theoretical explanations (Alderson 2021). Applying CR in healthcare enables a deeper understanding of complex health phenomena (Koopmans and Schiller 2022) like contracture risk assessment by viewing them as processes that are influenced by various factors, including the agents and structures present in the individual and their inner or outer contexts. In the context of this research, a realist-informed mixed methods approach allowed the researcher to delve into the contextual mechanisms that may influence the implementation of ORACLE in a complex environment of care homes. The Consolidated Framework for Implementation Research (CFIR) serves as an analytical lens that aligns well with realist principles by systematically

examining the multi-level contextual factors (Damschroder et al. 2022). In Chapter 8, the researcher uses CFIR as an analytical framework to structure and interpret the findings of this research from an implementation science perspective.

Rationale for choosing MMR

There are three primary research approaches: quantitative, qualitative, and mixed methods. Quantitative research focuses on objective measurement, analysing relationships between variables, and quantifying problems (Creswell and Creswell 2017). This approach is widely recognised in the scientific community for its use of empirical observations and scientific methods to answer research questions (Creswell and Creswell 2017). Based on an "empirical realist" ontology, it assumes a single, objective reality that can be observed and measured (Creswell and Creswell 2017). While this approach has been instrumental in identifying causal relationships and testing hypotheses in healthcare research (Filipe 2010), it is not without limitations. Quantitative methods may fall short of capturing the nuanced and contextual complexities of healthcare phenomena (Doyle et al. 2009; Ryan 2018). In addition, the quantitative data may fail to observe the subjective experiences of individuals and groups, which are important in identifying the patterns of health behaviours, understanding the interaction with the healthcare system, exploring healthcare needs, and designing appropriate interventions (Filipe 2010). In contrast, qualitative research seeks to understand human behaviour and experiences by focusing on subjective meanings and social constructs (Creswell and Creswell 2017; Filipe 2010; Ryan 2018). Rooted in a "relativist" ontology, it posits that reality is socially constructed and that no single reality exists (Ryan 2018). This approach values the researcher's interpretation of the data, acknowledging that the research process is inherently subjective (Wynn Jr and Williams 2008). Qualitative methods provide in-depth insights into individuals' lived experiences and the social contexts surrounding healthcare, which are critical for improving interventions and outcomes (Koopmans and Schiller 2022). However, these methods are limited by their potential lack of generalisability and the risk of researcher bias (Ryan 2018).

Mixed Methods Research (MMR) bridges the gap between these two approaches, utilising their strengths while mitigating their respective weaknesses (Creswell and Garrett 2008). MMR is particularly well-suited for studying complex health conditions and interventions influenced by multifaceted factors, including social,

cultural, and environmental (Tariq and Woodman 2013). The rationale for choosing MMR has been discussed extensively in the literature. The purpose classification of MMR was first introduced by Greene et al. (1989), who identified five primary purposes for conducting MMR: (1) complementarity, (2) development, (3) initiation, (4) expansion and (5) triangulation, (Greene et al. 1989). Bryman (2006) further built upon this and provided a more specific list of rationales (Bryman 2006). Doyle et al. (2016) consolidated the seven most commonly identified rationales: (1) exploration, (2) completeness, (3) offsetting weaknesses, (4) illustration, (5) addressing different research questions, (6) expansion and (7) triangulation (Doyle et al. 2016) which align with this project (Table 1).

Exploration:	An initial phase is required to develop an instrument or intervention, identify variables to study or develop a hypothesis that requires testing.
Completeness:	Provides a more comprehensive account of phenomena under study.
Offset weaknesses:	- Ensures that weaknesses of each method are minimised (Creswell, 2015a). - Caution is required when identifying this as a primary rationale, as each method should be sufficiently rigorous in its own right (O’Cathain, 2010).
Illustration:	- Qualitative data are used to illuminate quantitative findings. - Putting ‘meat on the bones’ of dry quantitative data (Bryman, (2006).
Different research questions:	Both quantitative and qualitative questions may be posed at the beginning of the study in addition to mixed methods questions (Creswell, 2015b).
Expansion:	- The first phase has findings that require explanation qualitatively. - Unexpected findings that need to be explained.
Triangulation (convergence):	- Using quantitative and qualitative methods so that findings may be mutually corroborated. - This may also be an unanticipated outcome of the study where a mixed methods study was undertaken for another reason, but convergence was evident.

Table 1 Rationales for choosing mixed methods research

Source: Adapted from Table I: Doyle et al (2016: 624)

Contractures are complex health issues with a multifaceted nature, influenced not only by disease and clinical factors but also by social and environmental contexts (Bartoszek et al. 2015).

The choice of MMR for this project was driven by the need to answer different research questions related to the development, validation and evaluation of the feasibility of ORACLE. The development process required integrating the available

evidence (through a systematic review) with the insights from the experts (through a Delphi survey). Thereafter, quantitative methods were used to establish the psychometric properties of ORACLE, while the qualitative data provided in-depth feedback on its usability and acceptability and insights on its practical implementation within care home settings.

MMR enabled a more holistic understanding of contractures and the contextual factors that could possibly facilitate or inhibit the applicability of ORACLE within care homes. By using MMR, the study aimed to produce a risk assessment tool that is rigorously validated and contextually relevant. Moreover, MMR is widely recognised to provide the most appropriate framework for tool development and validation as it involves rigorous qualitative and quantitative methods, ultimately optimising the tool fidelity and ensuring its sustainability in real-world settings (Onwuegbuzie et al. 2010).

2.3 Methods overview

The methods employed in five consecutive studies are detailed separately in Chapters 3, 4, 5, 6, and 7. However, a summary of the methods is outlined below.

2.3.1 Study Design

Research study design is a framework used for the collection, measurement and analysis of data in a research study (Ranganathan and Aggarwal 2018).

A multiphase research study design was adopted for this study. A multiphase design integrates concurrent and/or sequential quantitative and qualitative methods over a period of time (Cresswell & Plano, 2011). A sequential mixed-methods model of scale development and validation was used to achieve the objectives of the study (Figure 4). This is in line with the exploratory sequential design (ESD) proposed by Creswell and Clark (2017) for the development of an instrument. This design consists of 4 distinct phases: (i) a qualitative phase which explores the phenomenon and defines the construct of the tool, (ii) a tool development phase which includes item generation and modification (iii) a quantitative phase in which the developed tool is tested on a new sample of participants and finally (iv) the researcher interprets the connected results of both qualitative and quantitative phases for generalisability.

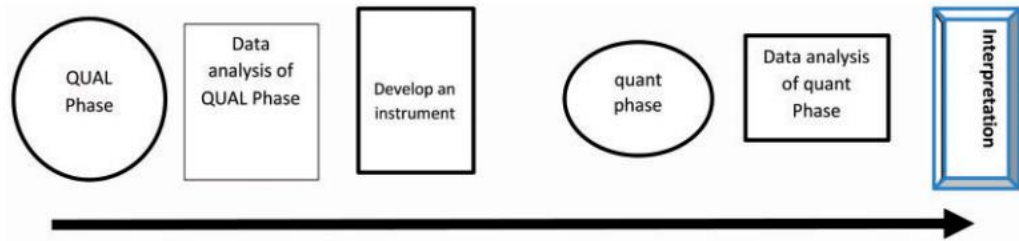


Figure 4 Exploratory sequential design

Source: Adapted from Figure 3.2(c): Creswell and Plano Clark (2011: 69)

In line with the above ESD design, the current study was structured into two main phases: content and external validation. Figure 5 below outlines the main phases and sub-stages of the research and how they are connected; these are briefly explained in the following section.

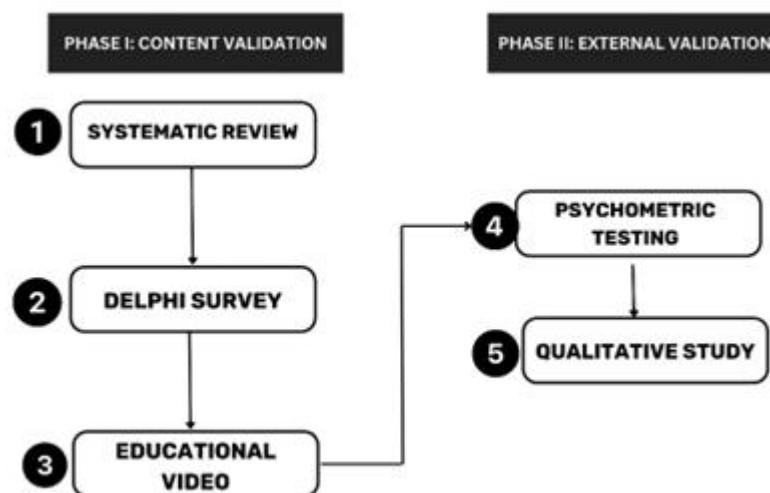


Figure 5 Multi phase Study Design

Phase I: Content Validation

Content validity refers to the extent to which a tool tends to include all the characteristics it purports to measure (Fetters and Tilson 2018). This phase focused on the content formulation and revision of the ORACLE based on evidence gathered through a review of the literature (systematic review) and expert opinion (Delphi survey). Thereafter, a contracture educational resource (educational video) was developed for care home staff.

Study 1: Systematic review

Research Objective 1: To evaluate the current evidence on factors that potentially contribute to the development and progression of contractures.

Study 2: Delphi survey

Research Objective 2: To further develop, refine and assess the content validity of ORACLE through expertise and knowledge held by field experts.

Study 3: Educational video

Objective 3: To develop training material for care staff members on contractures for improved understanding of contractures and effective use of ORACLE.

Phase II: External Validation

External validity refers to the extent to which the results are generalisable to a broader population (Walliman 2011). It consisted of two streams of work: Stream A aimed to establish the psychometric validation by completing the ORACLE assessments on adult care home residents. In stream B, the care staff was interviewed to explore the usability, acceptability and practical implementation of ORACLE in care homes.

Study 4: Psychometric testing of ORACLE

Objective 4: To investigate the following psychometric properties of ORACLE: convergent validity, intra-rater reliability, inter-rater reliability, floor and ceiling effects

Study 5: Usability, Acceptability and Practical Implementation of ORACLE

Objective 5: To explore the usability and acceptability of ORACLE among the care home staff through interviews with care home staff.

Objective 6: To identify contextual factors that may support or inhibit the practical implementation of ORACLE in care homes through interviews with care home staff.

Study 1: Systematic review

A systematic literature search was conducted across four databases (MEDLINE, CINAHL, AMED, EMBASE), spanning from 1999 to 2022. Inclusion criteria targeted studies focusing on adults (≥ 18 years) with progressive contractures secondary to conditions such as stroke, brain injury, and prolonged immobility. Studies focusing on non-progressive, congenital, or paediatric contractures were excluded. Two independent reviewers screened studies, performed data extraction,

and assessed methodological quality using Joanna Briggs Institute (JBI) quality appraisal tools. The extracted data were synthesised narratively.

Study 2: Delphi Survey

A modified two-round Delphi survey was conducted with a panel of 30 expert healthcare professionals in fields like physiotherapy, occupational therapy, nursing and rehabilitation medicine. In round one, experts rated a pre-designed list of clinical factors, preventive care approaches, and contextual factors on a Likert scale. Round two sought consensus in areas where there was initial disagreement and introduced additional items suggested by panellists. Items with $\geq 70\%$ consensus were included in the tool. New items achieving consensus in the second round were also incorporated.

Study 3: Educational video

This Quality Improvement project followed a pre-and post-test design using the Plan-Do-Study-Act (PDSA) cycle model, with two iterative cycles. Based on evidence gathered from studies 1 and 2, a contracture awareness video was created. The first PDSA cycle included showing the video to care staff at two care homes and collecting feedback via pre- and post-video surveys to gauge knowledge gain. Verbal and written feedback informed adjustments to the video before its re-filming in the second PDSA cycle.

Study 4: Psychometric Testing

The study evaluated the psychometric properties of ORACLE in care home residents using a cross-sectional observational design. The convergent validity was measured by correlating ORACLE's total scores with the Barthel Index (BI), a commonly used measure of physical function and independence. Intraclass Correlation Coefficients (ICCs) were calculated to determine inter-rater and intra-rater reliability, while convergent validity was assessed using Pearson's correlation coefficients between ORACLE scores and BI scores, with a strong negative correlation (-0.86 , $p < 0.001$) supporting ORACLE's validity.

Study 5: Qualitative study

Semi-structured interviews were conducted with a sample of care home staff to explore the usability, acceptability and practical implementation of ORACLE in care homes. The interview guide focused on usability, ease of use, perceived benefits, challenges, and contextual factors affecting ORACLE's implementation. Interview transcripts were thematically analysed to identify patterns and themes.

2.3.2 Study Samples

Eligibility criteria

The inclusion and exclusion criteria of all five studies are summarised in [Table 2](#).

Study	Inclusion Criteria	Exclusion Criteria
Systematic review	Adults ≥ 18 years with progressive contractures developed secondary to a primary condition.	Studies focusing on non-progressive, congenital, or paediatric contractures were excluded.
Delphi survey	At least five years of clinical experience in providing frequent (once every six months) care to adults with joint contractures OR Published at least one peer-reviewed research paper on joint contractures.	Healthcare professionals involved in the development of the prototype tool and study team members
Educational video	Care home staff	-
Psychometric testing	Adults aged 18 or above residing in residential and/ or nursing care homes located in Dorset.	Adults receiving end of life care.
Qualitative study Healthcare Assistants	Staff routinely engaged in the care of the residents (nurse associates, student nurses, and healthcare assistants).	Staff not involved in the application or interpretation of the risk tool.
	Senior Staff members Managers/registered nurses/senior staff members engaged in organising the application of ORACLE in the care home.	

Table 2 Eligibility criteria across studies

Sample size and Sampling technique

The sample sizes and the sampling techniques used across five studies is summarised in Table 3.

Study	Sampling technique	Sample size
Systematic review	-	47 studies
Delphi survey	Purposive	30
Educational video	Convenience	9
Psychometric testing	Convenience	224
Qualitative study	Purposive	10
	Healthcare assistants	6
	Registered nurses/care, home managers/Senior staff members,	4

Table 3 Sample size and sampling techniques across studies

Chapter 3: Systematic Literature review

3.1 Chapter overview:

This chapter presents an integrated published research paper constituting the first stage in the multiphase research design. The aim of this systematic review was to identify and collate evidence on factors associated with contractures.

The chapter begins with a succinct introduction and rationale for the systematic review, followed by a detailed description of the materials, methods, eligibility criteria, search procedure, study selection, quality appraisal, data extraction, and synthesis. The search results and PRISMA flow chart are presented to illustrate the study selection process, followed by the quality assessment results and characteristics of the included studies to demonstrate the credibility of the evidence. The main results categorise the identified factors into three main domains 1) sociodemographic factors, 2) physical factors and 3) proxies for bed confinement. These findings are summarised and discussed in relation to the existing literature while acknowledging and considering the study's strengths and limitations.

The chapter concludes by explicating the link between the systematic literature review and the Delphi study by highlighting how insights from the review influenced the development of the subsequent study.

3.2. Integrated paper

This section presents the integrated paper, titled, *Factors associated with joint contractures in adults: a systematic review with narrative synthesis* published in 'Disability and Rehabilitation' as part of the integrated thesis format submission.

See: Tariq, H., Collins, K., Tait, D., Dunn, J., Altaf, S. and Porter, S., 2023. Factors associated with joint contractures in adults: a systematic review with narrative synthesis. *Disability and rehabilitation*, 45(11), pp.1755-1772. DOI: [10.1080/09638288.2022.2071480](https://doi.org/10.1080/09638288.2022.2071480)

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Factors associated with joint contractures in adults: a systematic review with narrative synthesis

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ABSTRACT

Purpose: The primary objective of the review was to collate the available evidence on factors associated with joint contractures in adults.

Methods: A systematic literature search was conducted on MEDLINE, CINAHL, AMED, and EMBASE. Studies that involved participants aged ≥ 18 and assessed joint contracture as a primary or secondary outcome were included. Two independent reviewers screened studies against the eligibility criteria, performed data extraction, and assessed the quality of evidence. A narrative synthesis by domain and sub-domain was undertaken. The protocol was registered on PROSPERO: CRD42019145079.

Results: Forty-seven studies were included in the review. Identified factors were broadly classified into three major domains: sociodemographic factors, physical factors, and proxies for bed confinement. Sociodemographic factors were not associated with joint contractures. Functional ability, pain, muscle weakness, physical mobility, and bed confinement provided the most consistent evidence of association with joint contractures. The evidence regarding the relationship between spasticity and joint contractures remains unclear. Other factors might be important, but there was insufficient evidence to make inferences.

Conclusions: The review identified and collated evidence on factors associated with joint contractures, which can be utilised to develop effective prevention and management strategies.

ARTICLE HISTORY

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KEYWORDS

Contracture; range of motion; PROM; joint; adult; associated factor; risk factor

► IMPLICATIONS FOR REHABILITATION

- Clinical interventions based on the timely identification of risks related to joint contractures in vulnerable adults have the potential to prevent or ameliorate their development or progression.
- Quality and consistency of care for vulnerable adults would be enhanced by developing effective joint contracture prevention and rehabilitation strategies based on the evidence presented in this review.
- As many vulnerable adults are located in the community or non-acute care settings, strategies should target these loci of care.
- Structured risk assessments that can support non-physiotherapy staff working in these loci of care to identify risks related to joint contractures would provide an important resource for risk management.

Introduction

Joint contractures, commonly defined as a limitation in the passive joint range of motion (PROM), usually develop following structural alterations within the periarticular connective tissue(s) [1]. The connective tissue changes prevent movement of the involved joint(s) through its full available range of motion (ROM). Both intra-articular tissues involving bone, cartilage, and capsules, as well as extra-articular tissues, such as muscles, tendons, and skin, can restrict a joint from moving through its full available ROM [2]. The type of connective tissue involved in joint movement restriction usually defines the type of contracture developed; however, multiple tissues can have underlying involvement, and it is often difficult to identify a single origin of joint

restriction [2]. As a result, contractures can further increase the risk of physical impairments; consequently, there is difficulty in performing self-care, restrictions in physical mobility, and social activities [3]. This, in turn, leads to a vicious cycle of further immobility, exacerbation of existing or formation of new joint contractures, and decreased quality of life (QOL) [4].

There are three different types of joint contractures based on the underlying tissue involved: myogenic, arthrogenic, and soft tissue contractures. Myogenic contractures denote a reduction in muscle length leading to a limitation in both active and PROM [2], commonly seen in neurological conditions, e.g., brain and spinal cord injury (SCI), multiple sclerosis (MS), and cerebral palsy (CP) or after a prolonged period of immobility such as bed confinement in the intensive care unit (ICU). Arthrogenic contractures

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are usually coupled with pain and involve prominent changes in bone, cartilage, and the joint capsule [5]. This may result from damage and/or tightening of connective tissue, such as in osteoarthritis (OA), systemic sclerosis (SSc), osteochondritis, and intra-articular fractures [6]. Finally, soft tissue contractures, also known as scar contractures, involve cutaneous, subcutaneous, and loose connective tissue around the joint [2]. These are frequently seen in soft-tissue injuries like burns and open wounds. Regardless of tissue involvement, all types of contractures significantly impact functional ability and physical mobility [7].

Depending upon the underlying pathology, joint contractures can also be classified as progressive or non-progressive. Progressive contractures are acquired, associated with chronic conditions like an injury to the brain, or spinal cord, arthritic diseases, and surgical repair procedures such as total knee arthroplasty (TKA), and are usually associated with extrinsic factors. Examples of extrinsic factors encompass restricted joint ROM, reduced physical mobility, muscle weakness, spasticity, impaired cognition, and pain [8–10]. In contrast, non-progressive contractures are usually congenital, affect multiple joints and limbs and are associated with genetic causation, e.g., arthrogryposis multiplex congenita.

This review will focus on progressive myogenic and arthrogenic joint contractures and their associated factors.

Epidemiology of contractures

Data regarding the epidemiology of contractures are under-reported and record a wide range of prevalence and incidence. It is likely that this large variation is partially artifactual and attributable to the lack of a universally accepted definition of contractures, poorly understood aetiology, and/or lack of a standardised measure for the screening and assessment of contractures [8]. However, there is also evidence of an objective variance in prevalence related to different conditions [11].

The development of contractures is a commonly reported secondary impairment associated with chronic neurological and musculoskeletal conditions. The prevalence of contractures in brain injuries ranges from 16.2% up to 67% [12–16]; overall incidence of contractures in at least one joint in SCI was reported to be 66% [17]; 56% in MS [18], and 24% in Alzheimer's disease [19]. Ritter et al. [20], in their large retrospective cohort study, reported that 93% of patients with knee contractures who presented for the TKA had a diagnosis of OA, 5% had rheumatoid arthritis (RA), and 1.1% had osteonecrosis [20]. The prevalence of joint involvement in SSc, including the occurrence of contractures, also ranges widely between 46% and 97% [21].

Impact of joint contractures on function and quality of life

The presence of joint contractures is a self-limiting problem that leads to sequelae of further decline in mobility, function, and complications such as abnormal positioning, pain, pressure sores, skin breakdown, depressive symptoms, osteoporosis, and fractures, ultimately affecting the overall QOL [22,23]. In addition, upper limb joint contractures decrease the ability to perform self-care activities such as eating, dressing, and bathing, whereas lower limb joint contractures might limit one's ability to walk independently, entailing a higher risk of fall and bed confinement [7,22,24].

A study by Heise et al. [4] on 294 older individuals residing in geriatric settings demonstrated a significant association between functioning, disability, and QOL among individuals living with

joint contractures. Recent studies have identified several domains of limitations relevant to contractures using the biopsychosocial model provided by the International Classification of Functioning (ICF) [3,4,8]. The most frequently identified problems with joint contractures were associated with activity limitation, participation restriction [4], mobility, muscle power, and pain [25]. Fischer et al. [26] described the impact of joint contractures from the patients' perspective on multidimensional components of functioning and disability. These included pain, emotional distress, difficulty in performing activities of daily living (ADLs) like walking, climbing stairs, house chores, shopping, etc., and increased dependency on assistive devices and caregivers [26].

Rationale for the systematic review

Although the primary literature on joint contractures is growing, it still lacks an in-depth understanding of the role of proximate, ultimate, and associated factors [8]. Previous reviews have explored the risk factors associated with joint contractures; however, they were limited in the scope of the search restricted to one database [11] or restricted to exploring only the elderly population [24]. The lack of evidence limits the ability of caregivers and health care clinicians to identify the risk of joint contracture development in a timely fashion and thus early diagnosis and initiation of early intervention [24].

This systematic review aims to identify and collate the factors associated with progressive myogenic or arthrogenic contractures. It is hoped that its findings will aid the identification of individuals at risk of contracture development or progression. Earlier identification and management of contractures may impact an individual's ability to maintain independence with ADLs and functional mobility contributing to improved QOL.

Methods

This systematic review conforms to the updated guidance on Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Protocols (PRISMA-P) checklist [27]. The protocol of this review was registered on the International Prospective Register of Systematic Reviews (PROSPERO) database: CRD42019145079.

The following bibliographic electronic databases were searched: MEDLINE, CINAHL, EMBASE, and AMED from January 1999 to January 2022. Individual search strategies were developed for each database to account for differences in Thesaurus terminology and indexing. A complete search strategy for MEDLINE can be found in Supplementary information (A). Restrictions were applied for date of publication, age (adults), and humans where applicable. The reference lists of all relevant papers and documents were also screened for references not identified in the database search.

Study eligibility

The selection of studies was based on the Population, Exposure, and Outcome (PEO) framework [28].

Population

Studies involving human participants aged 18 years or above who developed progressive arthrogenic or myogenic contracture(s) as a secondary consequence of a primary condition (e.g., brain and SCI, OA, etc.), orthopaedic surgery, or a period of prolonged immobility were included. Studies involving children, non-

progressive contractures, and scar contractures were excluded as the underlying aetiology in these populations is mostly congenital and intrinsic, and do not fall into the scope of this review. Studies that included both children and adults as participants were only considered if the results for adults were presented separately. Moreover, studies on conditions in which contractures formed a part of the primary diagnostic criteria, especially in idiopathic conditions such as Dupuytren's disease and adhesive capsulitis, were also excluded.

Exposure of interest

The exposure of interest was factors associated with joint contractures, for example, physical mobility, pain, cognition, or functional ability. Intrinsic or disease-specific factors, genetic, congenital, pharmacological, and surgical factors were excluded.

Outcome

Studies which included joint contractures as a primary or secondary outcome were included. Joint contractures in this review are operationally defined as a limitation or reduction in the joint PROM.

Types of studies

The review included prospective and retrospective cohort studies, case-control studies, and cross-sectional analytical studies. Secondary analysis of interventional studies where baseline data were obtained were also included. Biological and qualitative studies were excluded, as were case series, individual case reports, theses, conference abstracts, letters, commentaries, or books without primary data or quantitative outcomes. Studies published in languages other than English were also excluded due to a lack of resources for the translation of data.

Study selection

Studies retrieved from the electronic search were collated and uploaded into Endnote reference manager v9 (Clarivate Analytics, Philadelphia, PA), and duplicates were removed. A database record was also maintained using Microsoft Excel (Redmond, WA), detailing each review stage. Two independent reviewers then screened the titles (HT and KC/JD), abstracts, and full texts (HT and SA) based on the inclusion criteria. Where necessary, any discrepancies or disagreements were resolved through discussion or using a third reviewer (SP/KC/JD). Reasons for exclusion at the full-text stage are documented in the PRISMA flowchart (Figure 1).

Assessment of methodological quality

The methodological quality of the eligible studies was assessed by two independent reviewers (HT and SA) using methodologically appropriate critical appraisal checklists from the Joanna Briggs Institute (JBI) [29]. These included checklists for cohort studies, case-control studies, analytical cross-sectional studies, randomised controlled trials, and quasi-experimental studies. The discrepancies and disagreements were resolved through discussion or using a third reviewer where necessary (KC/JD).

Data extraction and synthesis

Data from the included studies were extracted by two independent reviewers (HT and SA) in an excel sheet in accordance with the PRISMA guidelines [30]. The extracted information included but was not limited to the following: author names, publication date, country of origin, study characteristics (e.g., study design, setting), participant characteristics (e.g., sample size, age, gender), the definition of contractures, methods of assessment used for outcomes and exposures, and relevant study findings. If consensus was not reached, the discrepancies or disagreements were resolved through discussion or using a third reviewer (KC/JD). A meta-analysis of the data was not possible because of a lack of homogeneity between the studies regarding the study population, setting, and outcomes; therefore, a narrative synthesis was conducted.

Results

A step-by-step process of study screening and selection and the reasons for exclusion are given in the PRISMA flow diagram (Figure 1).

The electronic database searching retrieved 10 026 citations: An additional 16 citations were identified from other sources, such as hand-searching reference lists of included studies, relevant systematic reviews, and book chapters. After removing duplicates, title, and abstract screening, full texts of 183 studies were assessed for inclusion in detail, of which additional 136 studies were excluded, with reasons recorded. Forty-seven studies met the inclusion criteria and were included in the review [9,12,15–18,21,31–70].

Characteristics of included studies

A summary of the characteristics of the included studies is presented in Table 1. Of the 47 studies included, 20 studies used a cross-sectional design [18,31,33,36,37,39–41,44,47,48,51,53–55,59,62,64,66,68], 13 were prospective cohort studies [12,16,17,32,34,35,38,45,50,57,58,69,70], six were retrospective registry review-based cohort studies [42,43,49,52,56,61], and three were case-control studies [15,21,65]. The remaining five publications were a secondary analysis of previously conducted studies [9,46,60,63,67].

The included studies were conducted in various countries. Sixteen studies were conducted in North America [9,38–44,47,49,51,52,61,62,68,69], 12 in the UK and Europe [15,21,34–37,45,55,60,63,65,67], six in Australia [12,17,18,31,32,66], eight in Asia [33,48,50,53,54,56,58,64], one in Brazil [16], and the remaining four had participants from different parts of the world [46,57,59,70].

Participants

A total of 275,631 participants were included in 47 studies; the sample size ranged from 21 to 254 519, the participants' age ranged from 18 to 93, and had both male and female participants. It is important to note that three papers [42–44] included the same cohort of participants in their studies. Therefore, these papers were treated as one study to avoid spurious multiplication of the number of participants. The findings of the papers, however, are reported separately as each of them evaluated different factors.

The study patient population included a variety of specific diagnostic groups. Twenty-two studies included patients with neurological conditions, of which 12 were on brain injuries [12,15,16,31–34,46,50,60,63,65], six were on SCI [17,36,45,47,51,68],

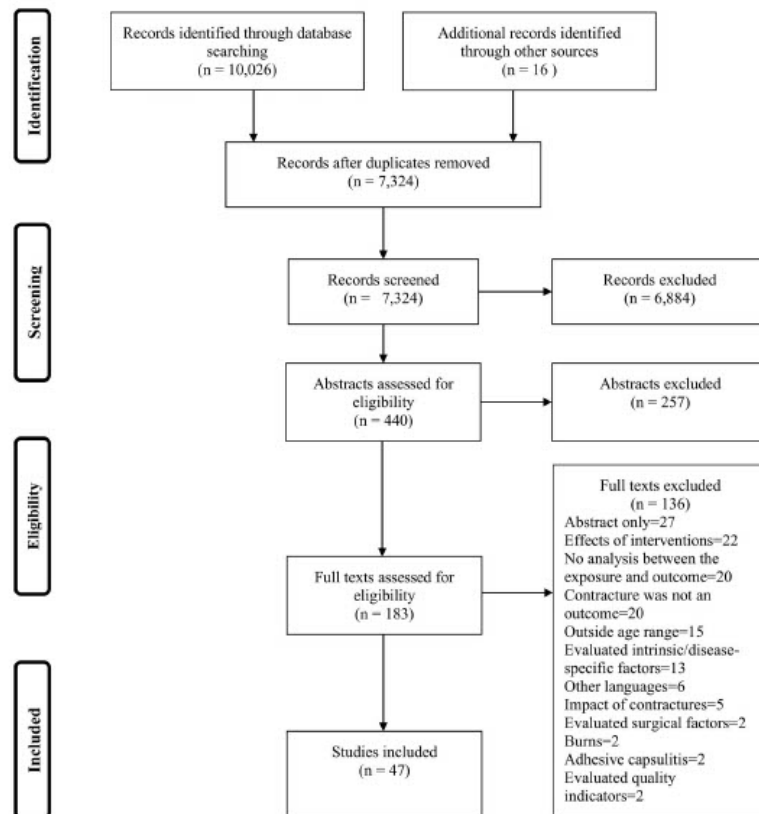


Figure 1. PRISMA flow diagram.

three were on CP [37,53,62], and one study was on MS [18]. Seventeen studies included participants with different musculoskeletal conditions out of which seven studies included patients with SSc [21,35,38,57,59,69,70], five studies evaluated patients who underwent orthopaedic surgery [49,52,54,56,61], four studies examined patients with OA [39,40,55,66], and one study included transtibial amputees [48]. The remaining eight studies targeted patients with mixed diagnoses [9,41–44,58,64,67].

Joints assessed

Twenty-one studies assessed single joints [15,31–34,36,39,40,45,48–50,52,54,56,60–63,65,66], 21 studies assessed multiple joints [9,12,16–18,21,35,37,38,42–44,46,47,51,55,57,58,68–70], and the remaining five studies did not specify the number of joints assessed [41,53,59,64,67]. The most commonly assessed single joint was knee (eight studies) [39,40,48,49,52,54,56,65], followed by the shoulder (four studies) [15,33,36,45], elbow (three studies) [31,32,61], wrist [60,63], ankle [34,50], and hip [62,66] (two studies each). Sixteen studies assessed joints of the upper extremity [15,16,21,31–33,

36,38,45,46,51,57,60,61,63,70], 14 studies assessed joints of the lower extremity [34,37,39,40,48–50,52,54–56,62,65,66], 12 studies assessed both joints of upper and lower extremities [9,12,17,18,35,42–44,47,58,68,69], and the remaining five did not specify the joints assessed [41,53,59,64,67].

Contracture definition

Out of the total 47 studies, 37 studies provided an operational definition of contracture [12,15–18,31–38,40–52,55–62,65,66]. Of these, 12 studies categorised them according to their severity [12,15,17,18,33,35,36,40,44,51,57,59]; eight studies used a different term for contractures: limitation in joint ROM [33,66], limited PROM [37,47], impaired ROM [45], and arthrofibrosis [49,52,61]. Ten studies did not specify any operational definition for contractures [9,21,53,54,63,64,67–70].

Contracture identification and documentation

The most common method to identify contractures was goniometry which measured the PROM (14 studies) [16,33,37,39,

Table 1. Characteristics of included studies.

Reference	Sample	Design	Joints assessed	Measurement/assessment of contracture	Operational definition for contracture	Included factors	Excluded factors	Overall quality
Ada and O'Dwyer [31]	<i>N</i> = 24 Age range = 36–87 years Diagnosis: stroke Setting: rehabilitation units Country: Australia	Cross-sectional	Elbow	Photographic measurement	Loss of elbow extension range	Associated reactions	–	37.5%
Ada et al. [32]	<i>N</i> = 27 Mean age = 63 years Diagnosis: stroke Setting: hospital Country: Australia	Prospective cohort	Elbow	Photographic measurement	Quantified as the Intad minus the affected angle in degrees	Loss of muscle strength; spasticity; upper limb activity	–	55.6%
Aras et al. [33]	<i>N</i> = 85 Mean age = 58.7 years Diagnosis: stroke Setting: hospital Country: Turkey	Cross-sectional	Shoulder	PROM by goniometer	Limitation in the PROM mild, moderate, severe: <50%, 50–67%, or >67% of the normal for flexion and <22.2%, <22.2–33.3%, or >33.3% of the normal for ext rotation	Pain	–	62.5%
Avouac et al. [21]	<i>N</i> = 162 (120 SSC; 42 controls) Age range = 20–90 years Diagnosis: SSC Setting: hospital Country: France	Case-control	Hand joints (wrist; MCP; PIP; DIP)	Radiographs	–	Functional disability	Type of SSC; pulmonary fibrosis; fibrosis severity; positive ATA	40%
Baagøe et al. [34]	<i>N</i> = 33 (19; 14 controls) Mean age = 48 years Diagnosis: ABI Setting: hospital Country: Denmark	Prospective cohort	Ankle	Custom-built handheld device which measured ROM with a gyroscope	Reduced ROM	Spasticity	–	72.7%
Balint et al. [35]	<i>N</i> = 131 Mean age = 56 years Diagnosis: SSC Country: Hungary	Prospective cohort	PIP, MCP, wrist, elbow, shoulder, hip, knee, ankle	Assessment of ROM (tool unspecified)	Contracture: limitation of ROM >25% of the normal ROM Severe contracture: limitation of >50% of the normal ROM	Gender; dominant vs. non-dominant side; skin hypo/hyperpigmentation; functional status; upper limb disability	SSC specific skin manifestations; SSC specific laboratory measures; disease duration; pulmonary/cardiac involvement; effect of drug therapies; steroid use	77.8%
Bossuyt et al. [36]	<i>N</i> = 1549 Mean age = 52.3 years Diagnosis: SCI Setting: community Country: Switzerland	Cross-sectional	Shoulder	3-point ordinal scale	Limited ROM of a joint (mild-infrequent, moderate-occasional, and significant-chronic problem)	Musculoskeletal shoulder pain	Lesion level (paraplegia vs. tetraplegia)	62.5%
Brantmark et al. [37]	<i>N</i> = 102 Median age = 20 years Diagnosis: CP Setting: community Country: Sweden	Cross-sectional	Hip, knee, ankle	PROM by goniometer	Limited PROM: hip abduction <40°, hip int. rot <40°, hip ext. rot <40°, hip extension ≤0°, popliteal angle <140°, knee extension <0°, foot df with flexed knee <20°, foot df with extended knee <10°	Mobility	–	75%

(continued)

Table 1. Continued.

Reference	Sample	Design	Joints assessed	Measurement/ assessment of contracture	Operational definition for contracture	Included factors	Excluded factors	Overall quality
Bunil et al. [38]	<i>N</i> = 219 Mean age = 48 Diagnosis: SSC Setting: community Country: USA	Prospective cohort	Hand	Manual measurement with a plastic tape measure in cm during extension (from thumb tip to 5th digit tip)	Limitation in ROM >25% of the normal range	Age; female gender; ethnicity; functional status	SSc specific skin manifestations; SSc specific laboratory measures; SSc disease type	33.3%
Campbell et al. [39]	<i>N</i> = 21 Mean age = 68.2 Diagnosis: OA Setting: primary care Country: Canada	Cross-sectional	Knee	ROM by goniometer	A lack of full 180° knee extension of >6° was considered a KFC	Age; female gender; weight; height; BMI	Duration of OA; radiological severity; valgus/varus deformity; surgical factors	66.7%
Campbell et al. [40]	<i>N</i> = 4796 Mean age = 61.5 Diagnosis: OA Setting: primary care Country: USA	Cross-sectional	Knee	PROM by goniometer	The inability to extend the knee to 0° was considered a KFC. Mild FC: loss of 1–5°; moderate FC: loss of 6–14°; severe FC: >15°	Age; male gender; height; weight; BMI; ethnicity; pain; functional mobility	Knee OA; WOMAC score	87.5%
Castle and Engberg [41]	<i>N</i> = 254 519 Mean age = 80.7 Diagnosis: mixed Setting: Nursing homes Country: USA	Cross-sectional	Unspecified	Dichotomised as: none, face/neck, shoulder/ elbow, hand/wrist, hip/knee, and foot/ankle.	Abnormal shortening and stiffening of muscle tissue that can decrease the joint ROM	Physical restraints	–	85.7%
Clavet et al. [42]	<i>N</i> = 155 Mean age = 59.6 Diagnosis: mixed Setting: ICU Country: Canada	Retrospective cohort	Shoulder, elbow, hip, knee, ankle	ROM documentation	Any contracture: recorded ROM that is short of full range. Functionally significant contracture: severe limitation in ROM causing functional limitation	Age; gender; duration of IMV; LOS in ICU; LOS in hospital	Presence of DM; admission diagnosis; receiving steroids or NM blockers; APACHE II severity score	55.6%
Clavet et al. [43]	<i>N</i> = 155 Age = 59.6 Diagnosis: mixed Setting: ICU Country: Canada	Retrospective cohort	Shoulder, elbow, hip, knee, ankle	ROM documentation	Lack of ROM	Ambulatory status; mobilisation in the ICU; LOS in ICU; hospital resource utilisation	–	77.8%
Clavet et al. [44]	<i>N</i> = 50 Mean age = 61.3 Diagnosis: mixed Setting: ICU Country: Canada	Cross-sectional	Shoulder, elbows, hip, knee, ankle	Joint Contracture Questionnaire (ordinal scale)	ROM short of full range, that can cause for each joint, a functional limitation	Age; mobility; self-care; activities; pain; anxiety; QOL	Mortality	57.1%
Diong et al. [17]	<i>N</i> = 92 Mean age = 43 Diagnosis: SCI Setting: hospital Country: Australia	Prospective cohort	Shoulder, elbow, forearm, wrist, hand, knee, ankle	(1) 4-point ordinal scale. (2) PROM measured at standardised torque.	An increase of at least one point on the 4- point scale between the baseline measure and the one-year follow-up. 0: no loss 1: loss of <1/3rd range 2: loss of 1/3rd to 2/3rd range 3: loss of >2/3rd range	Age; spasticity; pain; muscle strength	Limb fracture; neurological status	66.7%
Eriks-Hoogland et al. [45]	<i>N</i> = 199 Mean age = 41 Diagnosis: SCI Setting: rehabilitation centres Country: Netherlands	Prospective cohort	Shoulder	PROM by goniometer	Impaired PROM: a decrease of 10° or more was defined as impaired ROM. Normal shoulder ranges were defined	Age; gender; shoulder pain; spasticity	Lesion characteristics; time since injury; level of injury	77.8%

(continued)

Table 1. Continued.

Reference	Sample	Design	Joints assessed	Measurement/ assessment of contracture	Operational definition for contracture	Included factors	Excluded factors	Overall quality
Pheodoroff et al. [46]	N = 456 Mean age = 57 Diagnosis: stroke Countries: 22 countries in Europe, Pacific Asia, and South America	Secondary analysis	Shoulder, elbow, wrist, hand	Composite contracture score – severity of contractures rated on a scale of 1–12.	≥3 quarters limitation of movement in at least one segment	Age; pain	Primary goals in active and passive function; onset of stroke	54.5%
Frye et al. [47]	N = 29 Mean age = 42.3 Diagnosis: SCI Setting: hospital Country: USA	Cross-sectional	Shoulder, elbow, forearm, wrist, hip, knee, and ankle	PROM by goniometer	Knee hyperextension is listed as a + value, and limitations in extension are documented as a negative value (degrees lacked from full extension or 0°). For any motion where the participant was unable to reach the neutral or starting position, the value was listed as a negative	Functional independence; ADLs	–	62.5%
Ghazali et al. [48]	N = 50 Mean age = 55.4 Diagnosis: transtibial amputees Setting: community Country: Malaysia	Cross-sectional	Knee	Unspecified	Contracture: unable to fully extend the stump. Degree of contracture was measured as the remaining angle for the stump to achieve a full extension. Significant contracture: a contracture angle ≥10°	Age	Diabetes; length of stump	62.5%
Haller et al. [49]	N = 186 Mean age = 46.4 Diagnosis: post-operative tibial fracture Setting: trauma centre Country: USA	Retrospective cohort	Knee	PROM by goniometer	Arthrofibrosis: defined as a requirement for either MUA or an invasive surgical procedure to restore movement. Inadequate ROM (<90° flexion or >10° FC) at 6 months or inadequate ROM for ADLs as determined by the patient	Age; male gender	Diabetes; tobacco use; infection; high energy fracture; surgical factors; CPM	71.4%
Hamzah et al. [50]	N = 70 Mean age = 38 Diagnosis: ABI Setting: NICU Country: Malaysia	Prospective cohort	Ankle	PROM by goniometer	Ankle contracture present if 2 consecutive weekly measurements of maximum ankle dorsiflexion were <0° at knee extension	Age; gender; ethnicity; spasticity; dystonia; clonus; duration of IMV; LOS in hospital	Cause of brain injury; severity of brain injury; sepsis	77.8%
Hardwick et al. [51]	N = 38 Median age = 52 Diagnosis: SCI Setting: medical centre Country: USA	Cross-sectional	Shoulder, elbow, forearm, wrist, fingers, thumb	PROM by goniometer	1. No contracture: no loss in range of motion 2. Mild contracture: loss of up to 1/3rd range	Age; muscle strength; innervation status; functional independence	Injury level; time post-injury	75%

(continued)

Table 1. Continued.

Reference	Sample	Design	Joints assessed	Measurement/ assessment of contracture	Operational definition for contracture	Included factors	Excluded factors	Overall quality
Harmer et al. [52]	<i>N</i> = 2243 Mean age = 68 Diagnosis: TKA Setting: hospital Country: USA	Retrospective cohort	Knee	ROM documentation	3. Moderate contracture: loss of 1/3rd – 2/3rd range 4. Severe contracture: loss > 2/3rd range FC was defined as >10° short of full extension. Flexion deficit was defined as <90° of flexion	Pain	–	60%
Hoang et al. [18]	<i>N</i> = 156 Mean age = 54.8 Diagnosis: MS Setting: community Country: Australia	Cross-sectional	Shoulder, elbow, wrist, hip, knee, ankle	4-point ordinal scale	PROM 0 – full range 1 – (mild) loss of ≤1/3rd of range 2 – (moderate) loss of ≤2/3rd range 3 – (severe) loss of > 2/ 3rd of range	Muscle weakness; functional exercise capacity (5-minute walk test)	Type of MS; severity of MS	75%
İçağas, Öglü et al. [53]	<i>N</i> = 70 Mean age = 29.4 Diagnosis: CP Setting: primary care Country: Turkey	Cross-sectional	Unspecified	Unspecified	–	Age; mental state; education status; accommodation; employment status	Comorbidity	62.5%
Kinoshita et al. [54]	<i>N</i> = 141 Mean age = 75 Diagnosis: TKA Setting: hospital Country: Japan	Cross-sectional	Knee	PROM by goniometer	–	Gender	–	75%
Kocić et al. [55]	<i>N</i> = 200 Mean age = 69.4 Diagnosis: OA Setting: hospital Country: Serbia	Cross-sectional	Hip and knee	PROM by goniometer	While returning to the starting position of full knee extension, the limited ROM was measured as FC	Self-reported function	–	87.5%
Koh et al. [56]	<i>N</i> = 556 Mean age = 68 Diagnosis: TKA Setting: hospital Country: South Korea	Retrospective cohort	Knee	PROM by goniometer	FC ≥ 10° of ROM	Age; gender; height; weight; BMI; anterior knee pain; ability to rise from chair and climb stairs; QOL	WOMAC score; surgical factors; preoperative clinical status; AKS score	90.9%
Kwah et al. [12]	<i>N</i> = 200 Median age = 78 Diagnosis: stroke Setting: hospital Country: Australia	Prospective cohort	Shoulder, elbow, forearm, wrist, fingers, thumbs, hip, knee, ankle	Contracture scale (4- point ordinal scale)	0 – no loss in ROM 1 – loss of up to 1/3rd of ROM 2 – loss of 1/3rd to 2/ 3rd of ROM 3 – loss of > 2/3rd of ROM	Age; premorbid function; muscle strength; spasticity; motor function; pain	Severity of stroke	77.8%
Kwakkenbos et al. [57]	<i>N</i> = 1193 Mean age = 55.1 Diagnosis: SSC Setting: community Countries: Canada, USA, UK, France, Spain	Prospective cohort	Small joints of hands	Dichotomised as: no/ mild and moderate/severe	Presence of joint contracture s: no/mild (0–25%) and moderate/severe (> 25%) limitation in ROM	Hand function limitation	–	44.4%
Lam et al. [58]	<i>N</i> = 1914 Mean age = 83.4 Diagnosis: mixed Setting: residential long-term care Country: China	Prospective cohort	Shoulder, elbow, hip, knee	Dichotomised as present or absent	A functional limitation in the ROM in either arm or leg, which was not reversible on subsequent assessment	Age; gender; dependency in bed mobility; inability to walk; chronic pain, trunk, or limb restraint	Presence of neurologic diseases, ROM exercise; deterioration in care needs	55.6%

(continued)

Table 1. Continued.

Reference	Sample	Design	Joints assessed	Measurement/ assessment of contracture	Operational definition for contracture	Included factors	Excluded factors	Overall quality
Lee et al. [59]	<i>N</i> = 2157 Mean age = 54.8 Diagnosis: SSC Setting: community Country: Australia, Canada, France, Mexico, Spain, UK, and USA	Cross-sectional	Unspecified	Dichotomised as: none/ mild and moderate-severe	Presence of joint contractures: none/ mild ($\leq 25\%$) and moderate/severe ($> 25\%$) limitation in ROM	Pain	–	87.5%
Malhotra et al. [60]	<i>N</i> = 30 Median age = 70.5 Diagnosis: stroke Setting: hospital Country: UK	Secondary analysis	Wrist	PROM and stiffness measured using a custom-built device	An increase in stiffness and a reduction in ROM	Arm function	–	69.2%
Mardand et al. [61]	<i>N</i> = 390 Mean age = 44.3 Diagnosis: post-operative elbow fracture Country: USA	Retrospective cohort	Elbow	ROM documentation (goniometer)	Arthrofibrosis: elbow flexion contracture $> 45^\circ$ or flexion- extension arc of motion $< 100^\circ$	Duration of immobilisation; age; gender	Tobacco use; diabetes; surgical factors; types of fractures	81.8%
Matzinhos et al. [16]	<i>N</i> = 76 Median age = 66 Diagnosis: stroke Setting: hospital Country: Brazil	Prospective cohort	Shoulder, elbow, wrist	PROM by goniometer and gravity indinometer	Minimum loss of 10° between measures obtained within the first 4 weeks and at 3-month follow-up	Upper limb function; muscle strength; pain, manual dexterity, spasticity	–	88.9%
Noonan et al. [62]	<i>N</i> = 77 Mean age = 40 Diagnosis: CP Setting: residential long-term care Country: USA	Cross-sectional	Hip	Hip ROM (tool unspecified)	Hip FC $> 30^\circ$	Pain; pressure ulcers	–	50%
Pandyan et al. [63]	<i>N</i> = 22 Mean age = 64 Diagnosis: stroke Setting: hospital Country: UK	Secondary analysis	Wrist	PROM measured using a custom- built device	–	Functional recovery	–	69.2%
Pohl and Mehrholz [15]	<i>N</i> = 110 (50/60) Mean age (patients)=58.2 Mean age (controls)=50 Diagnosis: ABI Setting: rehabilitation centre Country: Germany	Case-control	Shoulder	Manual measurement with a ruler in cm	1 – severe contracture: hand in neck is not possible 2 – moderate or clinically relevant contracture: the hand in the neck position is possible, but the mean distance between the olecranon and underlay is $>$ age- and sex-related referent values of the control group 3 – no or clinically nonrelevant contracture: the hand in the neck position is possible, and the mean distance between the olecranon and underlay is $\leq$ to the age- and sex-related	Spasticity	Illness duration; diagnosis	40%

(continued)

Table 1. Continued.

Reference	Sample	Design	Joints assessed	Measurement/ assessment of contracture	Operational definition for contracture	Included factors	Excluded factors	Overall quality
Pohl et al. [65]	<i>N</i> = 55 (45:10) Mean age = 41 Diagnosis: ABI Setting: unspecified Country: Germany	Case-control	Knee	Photographic measurement	referent values of the control group Knee joint contractures were defined as clinically relevant if normal PROM was >10° reduced	Involuntary muscle activity	–	90%
Pua et al. [66]	<i>N</i> = 100 Mean age = 62 Diagnosis: OA Setting: community Country: Australia	Cross-sectional	Hip	PROM by digital Inclinometer	Decreased hip PROM	Physical function; muscle strength; pain	–	87.5%
Takai et al. [64]	<i>N</i> = 171 Mean age 85.4 Diagnosis: mixed Setting: nursing homes Country: Japan	Cross-sectional	Unspecified	Unspecified	–	Pain	–	42.9%
Vanderwee et al. [67]	<i>N</i> = 235 Median age = 87 Diagnosis: mixed Setting: nursing homes Country: Belgium	Secondary analysis	Unspecified	Dichotomised as: yes/no	–	Pressure ulcers	–	53.8%
Vogel et al. [68]	<i>N</i> = 216 Age range = 24–37 Diagnosis: SCI Setting: community Countries: USA and Canada	Cross-sectional	Elbow, ankle, hip	Interviews	–	Ethnicity; gender; functional independence; spasticity; muscle weakness	Age at injury; age at follow up; duration of injury; level of injury	50%
Wagner et al. [9]	<i>N</i> = 273 Mean age = 83.7 Diagnosis: mixed Setting: nursing homes Country: USA	Secondary analysis	Shoulder, elbow, wrist/hand, hip, knee, ankle/foot	Unspecified	–	Age; gender; ethnicity; functional status; mobility; fall risk; pain; cognition; behavioural symptoms; urinary incontinence; physical restraint; healthcare insurance; nursing home LOS	Stroke; arthritis; fracture; use of pain medication; psychoactive drug use	71.4%
Wiese et al. [69]	<i>N</i> = 200 Mean age = 50 Diagnosis: SSC Setting: scleroderma centres Country: USA	Prospective cohort	Shoulders, elbows, wrists, fingers, knees	Unspecified	–	Functional disability; QOL	Physician and patient global health; tendon friction rubs; CPK	55.6%
Wojciek et al. [70]	<i>N</i> = 1903 Mean age = 54.8 Diagnosis: SSC Setting: community Countries: Australia, Canada, France, Mexico, Spain, UK, and USA	Prospective cohort	DIP, MCP, PIP	Dichotomised as: moderate or severe	No	Pain	–	44.4%

PROM: passive range of motion; SSC: systemic sclerosis; MCP: metacarpophalangeal; PIP: proximal interphalangeal; DIP: distal interphalangeal; ATA: anti-topoisomerase; ABI: acquired brain injury; ROM: range of motion; SCI: spinal cord injury; CP: cerebral palsy; USA: United States of America; OA: osteoarthritis; KFC: knee flexion contracture; BMI: body mass index; FC: flexion contracture; WOMAC: Western Ontario and McMaster Universities Arthritis Index; ICU: intensive care unit; IMV: invasive mechanical ventilation; LOS: length of stay; DM: diabetes mellitus; NM: neuromuscular; APACHE: Acute Physiology and Chronic Health Evaluation; QOL: quality of life; ADL: activities of daily living; MUA: manipulation under anaesthesia; CPM: continuous passive motion; NICU: neurosurgical intensive care unit; TKA: total knee arthroplasty; MS: multiple sclerosis; AKS: American knee society; UK: United Kingdom; CPK: creatine phosphokinase.

40,45,47,49–51,54–56,61]. Of these, one also utilised a gravity inclinometer along with the goniometer [16]. The second most common mode of identification of contractures was utilisation of either an ordinal or nominal scale to establish the presence and/or severity of contractures [12,17,18,36,41,44,46,57–59,67,70] (12 studies). Four studies utilised photographic or radiographic measurement method to identify contractures [21,31,32,65]; three studies used a custom-built device to measure the PROM [34,60,63]; two studies utilised physical examination to assess the PROM [35,62]; two studies used a manual measurement method [15,38]; one study used a digital inclinometer to quantify PROM [66]; one study in addition to using an ordinal scale also assessed PROM of specific joints at standardised torque [17]. Seven studies documented contractures through the patient medical records [42,43,52,61], filled survey responses of participants [44,48], and telephonic interviews of patients [68]. Four studies did not specify the methods used to identify or document contractures [9,53,64,69].

Methodological quality

Table 2 provides the risk of bias and quality assessment of the included studies with scores according to the research design. The overall score was calculated for each checklist and expressed in percentage. Ten studies were rated with an average score between 80 and 100% (excellent) [16,39–41,55,56,59,61,65,66], 22 studies were rated between 60 and 79% (good) [9,12,17,18,33–37,43,45–54,60,63], 13 were rated between 40 and 59% (fair) [15,21,32,42,44,57,58,62,64,67–70], and two studies were rated below an average score of 40% (poor) [31,38]. The most common area for high risk of bias for studies with low average scores was the lack or unclear use of valid and reliable tools for outcomes and exposures and the lack of identification of the confounding factors.

Identified factors

A detailed list of factors evaluated in the included studies with their statistical findings is provided in the [Supplementary information \(B\)](#). The identified factors were broadly grouped into three main domains: sociodemographic factors, physical factors, and proxies for bed confinement. A summary of the review findings according to the evidence is presented in Table 3.

Domain 1: sociodemographic factors

Age

Out of a total of 47, 18 studies included ageing as a potential factor [9,12,17,38–40,42,44–46,48–51,53,56,58,61] of which two reported a significant association of age with contractures [40,46]. In two studies, the association depended on specific planes of movement [17,45], e.g., significant association with shoulder flexion and abduction but not external rotation [45]. One study demonstrated no significant association between age and the severity of contracture but a moderate positive correlation with any contracture [51]. One study demonstrated that older age was an independent risk factor for the development of a new contracture for participants who already had a contracture [58]. The remaining 12 studies failed to establish any significant association of contractures with age [9,12,38,39,42,44,48–50,53,56,61].

Gender

Fourteen studies included gender as a possible associated factor [9,35,38–40,42,45,49,50,54,56,58,61,68]. Of these, 12 studies found no association of either gender with contractures. One study demonstrated that males are more likely to develop new joint contracture through univariate analysis, but multivariate analysis showed that the male gender was not an independent risk factor for contractures [58]. One study found no correlation of contractures with gender after TKA; however, it demonstrated that the recurrence rate of flexion contracture (FC) after TKA was significantly higher in males than in females [54].

Ethnicity

Five studies evaluated ethnicity as a potential factor [9,38,40,50,68]. One study identified a statistically significant association between the occurrence of contractures among African American participants compared to white American participants [9]. The remaining four studies found no association with the ethnic backgrounds of participants [38,40,50,68].

Weight, height, and body mass index

Three studies investigated weight, height, and body mass index (BMI) as potential factors [39,40,56]. One study reported that participants with FC were heavier, taller, and had a greater BMI than those without FC [40]. The remaining two studies reported no association with contractures [39,56].

Education and employment status

One study evaluated the association of education status (illiterate, literate, primary school, high school, or university graduate) and employment status (unemployed, working part-time, or working full-time) with joint contractures and reported moderate correlations for both [53].

Accommodation

One study evaluated accommodation (whether the participants lived alone, with their family, spouse, or caregiver) as an associated factor for joint contractures and reported no significant correlation [53].

Laterality

One study evaluated laterality (dominant vs. non-dominant side) as a potential factor and reported a significant positive association with small hand contractures [35].

Healthcare insurance

One study evaluated healthcare insurance as a potential factor in nursing homes and reported that residents with healthcare insurance (Medicaid) were significantly more likely to have contractures [9].

Domain 2: physical factors

Functional ability

Functional ability in this review is operationally defined as the ability to perform basic and instrumental ADLs. Nineteen studies evaluated the association of functional ability with contractures [9,12,16,21,32,35,38,44,46,47,51,55–57,60,63,66,68,69]. Fourteen studies reported significant association of poor or reduced overall functional ability with contractures [9,16,21,32,35,38,46,47,51,55,57,60,63,66]. Among others, Kwah et al. [12] reported a significant association of contractures with poor combined upper limb motor function and “sit-to-stand” activity but did not

Table 2. Quality of evidence of included studies.

Checklist for randomised controlled trials															
	Q1. Randomisation	Q2. Allocation	Q3. Baseline similarity	Q4. Participant blinding	Q5. Therapist blinding	Q6. Assessor blinding	Q7. Identical treatment of both groups	Q8. Follow-up	Q9. Intention to treat	Q10. Outcomes in both groups	Q11. Valid and reliable outcomes	Q12. Statistical analysis	Q13. Trial design	Total score	% Score
Malhotra et al. [60]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	N	Y	9/13	69.2%
Vandenwee et al. [67]	Y	N	Y	N	N	N	Y	N	N	Y	Y	Y	Y	7/13	53.8%
Pandyan et al. [63]	Y	Y	Y	N	N	Y	Y	Y	N	Y	N	Y	Y	9/13	69.2%
Checklist for cohort studies															
	Q1. Similarity of groups	Q2. Similarity of exposures	Q3. Valid and reliable exposures	Q4. Confounding Factors	Q5. Strategies to deal with confounding factors	Q6. Free of outcome at the start of study	Q7. Valid and reliable outcomes	Q8. Sufficient follow up	Q9. Reasons to loss to follow up	Q10. Strategies to address Incomplete follow up	Q11. Statistical analysis	Total score	% Score		
Ada et al. [32]	NA	NA	Y	Y	N	Y	Y	Y	N	N	N	5/9	55.6%		
Baagøe et al. [34]	Y	Y	Y	Y	Y	U	Y	Y	Y	N	N	8/11	72.7%		
Ballint et al. [35]	NA	NA	Y	Y	N	N	Y	Y	Y	Y	Y	7/9	77.8%		
Buni et al. [38]	NA	NA	Y	N	N	U	U	Y	N	N	Y	3/9	33.3%		
Clavet et al. [42]	NA	NA	Y	Y	N	U	U	Y	Y	N	Y	5/9	55.6%		
Clavet et al. [43]	Y	Y	Y	Y	N	U	U	Y	Y	N	Y	7/9	77.8%		
Diong et al. [17]	NA	NA	Y	N	N	N	Y	Y	Y	Y	Y	6/9	66.7%		
Ertis-Hoogland et al. [45]	NA	NA	Y	Y	Y	N	Y	Y	Y	Y	Y	7/9	77.8%		
Fheodoroff et al. [46]	NA	NA	Y	Y	Y	U	N	Y	Y	U	Y	6/9	66.7%		
Haller et al. [49]	NA	NA	Y	Y	N	U	Y	Y	NA	NA	Y	5/7	71.4%		
Hamzah et al. [50]	NA	NA	Y	Y	N	Y	Y	Y	Y	U	Y	7/9	77.8%		
Harmer et al. [52]	Y	Y	Y	N	N	U	N	Y	Y	NA	Y	6/10	60%		
Koh et al. [56]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	10/11	90.9%		
Kwah et al. [12]	NA	NA	Y	Y	N	Y	N	Y	Y	Y	Y	7/9	77.8%		
Kwakkenbos et al. [57]	NA	NA	Y	Y	N	U	N	Y	U	N	Y	4/9	44.4%		
Lam et al. [58]	Y	Y	U	N	N	Y	N	Y	NA	NA	Y	5/9	55.6%		
Marchand et al. [61]	Y	Y	Y	Y	U	Y	Y	Y	Y	N	Y	9/11	81.8%		
Matosinho et al. [16]	NA	NA	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9	88.9%		
Wiese et al. [69]	NA	NA	Y	Y	N	N	U	Y	Y	N	Y	5/9	55.6%		
Wojeck et al. [70]	NA	NA	Y	Y	U	U	U	Y	U	N	Y	4/9	44.4%		
Checklist for case-control studies															
	Q1. Similarity of groups	Q2. Matching	Q3. Same criteria for cases and controls	Q4. Valid and reliable exposures	Q5. Exposure measured same way for cases and controls	Q6. Confounding factors	Q7. Strategies for confounding factors	Q8. Valid and reliable outcomes	Q9. Length of Exposure period	Q10. Statistical analysis	Total score	%Score			
Avouac et al. [21]	Y	N	N	Y	Y	U	U	N	U	Y	4/10	40%			
Pohl and Mehrholz [15]	N	N	N	Y	Y	N	N	Y	U	Y	4/10	40%			
Pohl et al. [65]	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	9/10	90%			
Checklist for quasi experimental studies															
	Q1. Clear cause and effect	Q2. Baseline similarity	Q3. Similarity of treatment/care other than exposure	Q4. Control group	Q5. Multiple measurements	Q6. Follow-up	Q7. Outcomes measured in same way in comparisons	Q8. Valid and reliable outcomes	Q9. Statistical analysis	Total score	% Score				
Wagner et al. [9]	Y	Y	NA	N	Y	Y	NA	N	Y	5/7	71.4%				

Checklist for analytical cross-sectional studies

	Q1. Clearly defined inclusion criteria	Q2. Description of subjects and setting	Q3. Valid and reliable exposure	Q4. Standard criteria for measurement of condition	Q5. Confounding factors	Q6. Strategies for confounding factors	Q7. Valid and reliable outcomes	Q8. Statistical analysis	Total score	% Score
Ada and O'Dwyer [31]	Y	Y	U	Y	N	N	N	U	3/8	37.5%
Aras et al. [33]	N	Y	N	Y	Y	N	Y	Y	5/8	62.5%
Bossuyt et al. [36]	Y	Y	N	Y	Y	N	N	Y	5/8	62.5%
Brantmark et al. [37]	Y	Y	Y	Y	N	N	Y	Y	6/8	75%
Campbell et al. [39]	Y	Y	Y	Y	Y	Y	Y	N	7/8	87.5%
Campbell et al. [40]	Y	N	Y	Y	Y	Y	Y	Y	7/8	87.5%
Castle and Engberg [41]	Y	Y	N	NA	Y	Y	Y	Y	6/7	85.7%
Clavet et al. [44]	Y	Y	Y	NA	N	N	N	Y	4/7	57.1%
Frye et al. [47]	Y	Y	Y	U	N	Y	Y	N	5/8	62.5%
Ghazali et al. [48]	Y	Y	U	Y	Y	N	N	Y	5/8	62.5%
Hardwick et al. [51]	Y	Y	Y	Y	N	N	Y	Y	6/8	75%
Hoang et al. [18]	Y	Y	Y	Y	N	N	Y	Y	6/8	75%
İçağas, Ölu et al. [53]	Y	Y	Y	Y	N	N	U	Y	5/8	62.5%
Kinoshita et al. [54]	Y	Y	Y	Y	N	N	Y	Y	6/8	75%
Kodic et al. [55]	Y	Y	Y	U	Y	Y	Y	Y	7/8	87.5%
Lee et al. [59]	Y	Y	Y	Y	Y	Y	N	Y	7/8	87.5%
Noonan et al. [62]	Y	Y	Y	Y	N	N	U	U	4/8	50%
Pua et al. [66]	Y	Y	Y	Y	Y	Y	N	Y	7/8	87.5%
Takai et al. [64]	N	Y	Y	NA	N	N	N	Y	3/7	42.9%
Vogel et al. [68]	Y	Y	N	Y	N	N	N	Y	4/8	50%
Average % score										66.8%

Y: yes; N: no; U: unclear; NA: not applicable.

Table 3. Summary of review findings.

Evidence for association with contractures	Factors
Consistent evidence	Bed confinement Functional ability Muscle weakness Pain Physical mobility
Inconsistent evidence	Age Spasticity
Weak evidence	Gender Ethnicity Height Weight BMI Laterality Education and employment status Healthcare insurance Level of cognition Clonus Spastic dystonia Ethnicity Urinary incontinence Pressure ulcers Manual dexterity
No evidence	Accommodation status Involuntary muscle activity Anxiety Behavioural symptoms Quality of life

report any significant relationship between reduced walking function and contracture. Two studies reported differences between the types of joints affected by lack of function; Vogel et al. [68] reported a significant association of poor functional ability with hip and elbow contractures but not with ankle contractures. The remaining three studies did not report any significant association of functional ability with contractures [44,56,69].

Pain

Of the 18 studies that examined the relationship of pain with contractures [9,12,16,17,33,36,39,44–46,52,56,58,59,62,64,66,70], 13 reported significant association between pain and contractures [9,16,33,36,39,45,46,56,59,62,64,66,70]; one reported that the association depended on specific plane of movement, i.e., significant association with ankle dorsiflexion but not with wrist and elbow extension [12]. The remaining four studies did not report any significant association of pain with contractures [17,44,52,58].

Muscle weakness

Nine studies evaluated the association of muscle weakness with contractures [12,16–18,32,45,51,66,68]. Eight out of nine studies reported significant association of contractures with muscle weakness [12,16–18,32,51,66,68]. Of these, one reported a significant association of contractures with muscle weakness but not with innervation status [51]. The remaining study did not report any significant association between the two [45].

Muscle tone

Spasticity: Nine studies evaluated the association of spasticity with the development of contractures [12,15,17,32,45,50,68]. Six studies reported significant associations with contractures [12,15,17,32,45,50]; however, two of these only identified joint-specific positive associations: a significant association between spasticity with elbow and wrist contractures was identified in one study [17] but was non-significant in another study [12]. Interestingly, one study reported an inverse relationship between spasticity and contractures [34]. The remaining two studies

reported no significant association of spasticity with contractures [16,68]. **Spastic dystonia and clonus:** One study evaluated spastic dystonia and clonus as potential factors and reported a statistically significant association with contractures [50].

Physical mobility

Physical mobility in this review is operationally defined as an individual's ability to move independently and safely in different environments to perform ADLs. Eight studies evaluated the association of reduced physical mobility with contractures [9,18,37,40,43,44,53,58], and all of them reported a significant association.

Skin changes

Three studies evaluated the association of changes in the skin with the occurrence of contractures [35,62,67]. Balint et al. [35] included skin hypo/hyperpigmentation as a possible associated factor; however, no statistically significant association was found. Noonan et al. [62] and Vanderwee et al. [67] evaluated the association of pressure ulcers with the development of contractures, and both studies demonstrated a significant association.

Involuntary muscle activity

Two studies investigated the association between contractures and involuntary muscle activity/associated reactions and showed no significant association [31,65].

Psycho-cognitive functions

Cognition: Wagner et al. [9] evaluated the association of level of cognition with contractures; univariate analysis demonstrated a significant association of cognitive decline with contractures. **Learning disability:** Kaçgasi Ölü et al. [53] evaluated the association of mental retardation with contractures in adults with CP and found a moderate correlation between the two. **Anxiety:** Clavet et al. [44] assessed the association of anxiety with contractures and demonstrated no significant association. **Behavioural symptoms:** Wagner et al. [9] included behavioural symptoms as a possible associated factor for contractures, but the findings did not reach significance.

Urinary incontinence

Wagner et al. [9] included urinary incontinence as a potential associated factor. Univariate analysis revealed a significant association with contractures, but multivariate analysis showed no significant association.

Manual dexterity

Matozinho et al. [16] evaluated manual dexterity as a potential risk factor. It was reported to be an independent predictor for the development of joint contractures.

Domain 3: proxies for bed confinement

In this review, proxies for bed confinement are operationally defined as any extrinsic factors limiting an individual's mobility or confining them to bed.

Seven studies evaluated different proxies for bed confinement as potential associated factors for joint contractures [9,41–43,50,58,61]. Marchand et al. [61] evaluated the association of length of immobilisation with contractures and demonstrated a statistically significant association. Clavet et al. [43] investigated the difference in contracture occurrence between patients mobilised in the ICU and those who were not; they reported a

significant difference between them. Lam et al. [58] evaluated *dependency for bed mobility* as a possible risk factor and demonstrated it to be an independent predictor of new upper limb contractures. Three studies investigated physical restraints as a potential factor associated with joint contractures in long-term care residents [9,40,57]. All of them reported that physically restrained residents have a significantly higher chance of developing contractures. Wagner et al. [9] identified *nursing home length of stay* (LOS) as a potential factor. There was a statistically significant difference between the mean LOS of residents who developed contractures and those who did not. Two studies evaluated the association of the *LOS in ICU* with contractures identifying a significant association between the two [42,43]. Two studies investigated the association of the *LOS in hospital* with the development of contractures [42,50]; one of which [42] reported a weak association, and the other reported no significant association [50]. Two studies evaluated the association of the *duration of invasive mechanical ventilation* with the development of contractures within the ICU setting [42,50]. One study demonstrated that the odds of developing contractures were 7.7 times higher in mechanically ventilated patients for more than two weeks than those who were mechanically ventilated for two or less weeks [50]. The other study showed a weak association between contractures and the duration of mechanical ventilation [42].

Discussion

The identified factors in this review were broadly categorised into three main domains: sociodemographic factors, physical factors, and proxies for bed confinement. The factors which provided the most consistent evidence for association with contractures were poor functional ability, pain, muscle weakness, reduced physical mobility, and bed confinement.

Methodological quality

The overall methodological quality of the studies was rated good, with an average of 66.8%. The most frequent area of the potential risk of bias in the low-quality studies was the unclear use of gold-standard tools to assess contractures and the failure to identify confounding factors. The assessment of contractures was variable across the studies because no gold standard assessment tool exists to identify their presence. However, most studies defined and documented contractures as a limitation in the joint PROM. Therefore, the variability of the assessment methods does not directly influence the identification of factors associated with contractures. On the other hand, confounding factors play an essential role in a multifactorial condition such as joint contracture. Therefore, it is difficult to make inferences about the direct causal implications of most of the factors associated with contractures when other potential influences are not accounted for. Therefore, the findings of the review should be interpreted with caution.

Factors with consistent evidence of association

Findings across studies on reduced functional ability, pain, muscle weakness or paralysis, physical mobility, and bed confinement were generally consistent and found strong correlations with joint contractures. In theory, the relationship of contractures with these factors could be explained by the notion that the presence of any of the above-mentioned factors reduces the overall functionality and places the joint(s) in a static position for extended periods

due to a lack of active movement. This leads to a reduced number of sarcomeres, decreasing the overall muscle mass and length. The connective tissues, in turn, lose their elasticity and undergo fibrosis, potentially predisposing the muscle to shorten and form a contracture [7,22,24,71]. In case of pain, the patients tend to adopt a particular position that relieves the associated discomfort. For instance, patients with anterior knee pain tend to adopt a position of partial flexion for prolonged periods to avoid pain and discomfort, potentially leading to the reduced functional use of the knee joint and the potential development of knee FCs [56].

Factors with inconsistent evidence of association

Age

Evidence regarding age was inconsistent across the studies. The associations identified in five studies [17,40,45,46,51] could be attributed to other musculoskeletal disorders and typical degenerative changes associated with increasing age leading to reduced joint ROM rather than contractures occurring as a part of the normal ageing process [24].

Spasticity

Spasticity was identified as a potential factor for contractures in six out of nine studies that evaluated the relationship between the two variables. This is supported by the underlying theory that abnormal muscle activity associated with spasticity could lead to abnormal posturing resulting in muscle and soft-tissue shortening and, consequently, forming a contracture [72]. However, the evidence provided by these studies is questionable because the methods utilised to measure or evaluate the presence of spasticity were not consistent. There is sufficient evidence that while conventional clinical scales are easy to administer, they also lack clinical sensitivity and have limited validity and reliability to document the abnormal muscle activity associated with spasticity [73,74]. On the contrary, neurophysiological measurements provide a direct measure of muscle activity to quantify spasticity according to the existing definition [74]. In this review, the only study that utilised a neurophysiological measure to identify the presence of spasticity and found a significant association with contractures lacked statistical power ($n \leq 30$) [32]. In addition, the study failed to consider the evaluation of confounders alongside spasticity and weakness, such as upper limb function, which could be the primary factor for the development of contractures [60].

Additionally, because current neurophysiological measures are not feasible as assessment tools for clinicians in everyday practice, the relationship between spasticity and contractures remains inconclusive. Further evidence is required, and this is likely to depend on developing a practical assessment method of spasticity that can also differentiate between contractures and spasticity.

Factors with weak or no evidence of association

Sociodemographic factors like gender, ethnicity, height, weight, BMI, laterality, education and employment status, healthcare insurance, and accommodation status showed either no or insufficient evidence of association with contractures. Among physical factors, involuntary muscle activity, anxiety, QOL, and behavioural symptoms also failed to provide any evidence of association with contractures. Other physical factors like clonus, dystonia, manual dexterity, pressure ulcers, urinary incontinence, and level of cognition demonstrated correlations with contractures, but there was insufficient evidence to make any inferences.

Strengths and limitations of the review

This is the first systematic review to identify the factors associated with joint contractures targeting adults aged 18 and above.

The development and progression of joint contractures usually involve a complex interplay of factors. Once developed, contractures are followed by a chain of physical impairments such as loss of function, limited mobility, pain, and deconditioning. This potentially leads to further immobility, predisposing to exacerbating existing or developing new contractures resulting in a vicious cycle [75]. For this reason, this review was not just limited to longitudinal studies which aim to establish the risk factors and temporal relationships. Rather, all types of studies that addressed ultimate, proximate, or associated factors linked with progressive joint contractures were included, regardless of their temporal occurrence. The associations found in this review, therefore, could arise from factors either contributing to or occurring as a consequence of joint contractures.

A comprehensive search strategy was employed as part of this review to capture most of the evidence. However, it may be subjected to retrieval bias as the search was limited to the year 1999 and the English language only. This might have led to the exclusion of substantial evidence published before this date and in other languages.

There was a lack of consistency in the definitions and outcome measures used for contractures and the associated factors; the lack of a uniform definition and assessment methods made it difficult to compare the findings across the studies and understand the direction of the relationship.

Conclusions

The factors which provided consistent evidence on association with joint contractures in this review were poor functional ability, pain, muscle weakness, reduced physical mobility, and bed confinement. These factors do not necessarily qualify as independent predictors for the development of joint contractures. However, considering the multifactorial aetiology of joint contractures, the evidence for different associations can be used to design targeted and effective prevention and management strategies to reduce the incidence of joint contractures.

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Disclosure statement

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The following supplementary materials are included in Appendix II:

- A. PROSPERO protocol
- B. Search Strategy for MEDLINE
- C. Detailed list of factors evaluated in the included studies with their statistical findings

3.3 Link to Delphi Study

The systematic review provided a clear foundation for key factors associated with contractures and informed the design and development of the subsequent Delphi survey.

The review identified five factors with consistent evidence of association with contracture: reduced functional ability, pain, muscle weakness, impaired physical mobility, and bed confinement. Eight additional factors demonstrated either inconsistent or insufficient evidence of association. The study team discussed and reached a consensus on a total of 12 foundational factors that need further exploration through the Delphi survey: reduced functional ability, pain, muscle weakness, impaired physical mobility, bed confinement, age, spasticity, clonus, dystonia, pressure ulcers, urinary incontinence and impaired cognition.

The next chapter presents the Delphi survey which was conducted to achieve this goal by gathering insights from domain experts.

Chapter 4: Delphi survey

4.1 Chapter overview

This chapter presents an integrated paper of a published modified Delphi-consensus survey, constituting the second stage of the multiphase research design. The study aimed to systematically establish the components of ORACLE for care home residents based on multidisciplinary healthcare expert consultation and consensus. In addition, the study also identified contextual factors that may influence the practical implementation of ORACLE within a care home setting. The manuscript provides a brief background and rationale for the Delphi technique, followed by a description of the participant recruitment, data collection procedures, and analysis. The findings of the two-round iterative survey are presented in three main sections: the first section described the panel characteristics, the second section was further categorised into a) development of joint contractures, b) progression of joint contractures, c) identification of joint contractures and d) contextual factors. Finally, the third section presents the findings on contracture preventative care approaches.

4.2 Integrated paper

This section presents the integrated paper titled, *‘The Delphi of ORACLE: An Expert Consensus Survey for the Development of the Observational Risk Assessment of Contractures (Longitudinal Evaluation)’* published in *‘Clinical Rehabilitation’* as part of the integrated thesis format.

See: Tariq, H., Collins, K., Dunn, J., Tait, D. and Porter, S., 2024. The Delphi of ORACLE: An Expert Consensus Survey for the Development of the Observational Risk Assessment of Contractures (Longitudinal Evaluation). *Clinical Rehabilitation*, 38(5), pp.664-677. DOI: [10.1177/02692155241229285](https://doi.org/10.1177/02692155241229285)

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Link to Full-text PDF file: [The Delphi of ORACLE: An Expert Consensus Survey for the Development of the Observational Risk Assessment of Contractures \(Longitudinal Evaluation\)](#)



Original Research Article

 **CLINICAL
REHABILITATION**

The Delphi of ORACLE: An Expert Consensus Survey for the Development of the Observational Risk Assessment of Contractures (Longitudinal Evaluation)

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Abstract

Objective: Despite rising prevalence rates, no standard tool is available to identify individuals at risk of developing contractures. This study aimed to gain expert consensus on items for the development of the Observational Risk Assessment Tool for Contractures: Longitudinal Evaluation (ORACLE) for care home residents.

Design: A two-round, online modified Delphi study.

Participants: Panellists were qualified healthcare professionals with a background in physiotherapy, occupational therapy, nursing, and rehabilitation medicine.

Main outcome measures: In the first round, the experts were asked to rate the predesigned list of items on a Likert scale while in the second round, consensus was sought in the areas of disagreement identified in the previous round.

Results: The two rounds of the Delphi survey included 30 and 25 panellists, respectively. The average clinical and academic experience of the panellists was 22.2 years and 10.5 years, respectively. The panel demonstrated a high level of consensus regarding the clinical factors (10 out of 15 items); preventive care approaches (9 out of 10 items), and contextual factors (12 out of 13 items) ranging from 70% to 100%.

Conclusion: This Delphi study determined expert consensus on items to be included in a contracture risk assessment tool (ORACLE). The items were related to factors associated with joint contractures, appropriate preventive care interventions, and potentially relevant contextual factors associated with care home settings. The promise of a risk assessment tool that includes these items has the capacity to reduce the risk of contracture development or progression and to trigger timely and appropriate referrals to help prevent further loss of function and independence.

Keywords

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Contractures, risk assessment, joint mobility, care homes, adults

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Introduction

Contractures, commonly defined as restrictions in the passive joint range, are preventable but debilitating consequence of prolonged immobility, eventually leading to structural abnormalities within the impacted joint.¹ This can lead to further deterioration in the limb and joint flexibility and physical mobility, potentially leading to further physical impairments, decreased independence with everyday activities, and reduced quality of life.^{2,3} Contractures may vary from marginal restriction at a single joint to severe limitations in the range of motion affecting several joints simultaneously.⁴ Based on the severity of functional loss at a joint, contractures can be categorised as (i) severe, (ii) moderate or clinically relevant, or (iii) clinically non-relevant.⁵ The development of progressive joint contractures often follows an insidious pattern, and their initial progression is neither painful nor disabling. Joints only become painful when stretched beyond the point of soft-tissue restriction. For this reason, contractures are often unrecognised by individuals and their caregivers until they become clinically relevant, that is, start interfering with daily functional activities.⁶

Evidence suggests that individuals living in long-term care facilities are predominantly sedentary⁷; hence, they are at a higher risk of developing contractures.⁸ Long-term care settings demonstrate a considerable variation in the prevalence of contractures spanning from 22% to 75% in at least one joint.^{4,9–12} Contracture prevalence was found to be higher in the upper extremities compared with the lower extremities,^{4,10} with the shoulder and knees being the most commonly affected joints.⁴ When considering the impact of mobility on contracture development, there is evidence that 70.5% of non-ambulatory care home residents developed a contracture compared with the ambulatory group, which developed none.¹³

Structured risk assessments play an important role in referring patients to the appropriate healthcare

practitioner and enacting early treatment strategies to reduce the risk of the condition progressing. In addition, standard risk assessments are also vital to offer appropriate guidance for risk protection and to have confidence in the tool being used.¹⁴ The need for a structured and systematic risk assessment of individuals at risk of developing contractures has been identified in the literature.¹⁵ Despite the reported high prevalence rates, there is a clear lack of a standard, evidence-based measure that can actively identify individuals at risk of developing contractures or worsening of existing contractures in long-term facilities and trigger appropriate and timely referrals to healthcare professionals.

The aim of the current study was to systematically establish the components of Observational Risk Assessment for Contractures: Longitudinal Evaluation (ORACLE) for care home residents, based on multidisciplinary healthcare expert consultation and consensus. The aimed users of the tool will be a range of staff, including healthcare assistants and registered nurses, who are the primary care providers in a care home. During the delivery of care, their regular clinical observations are vital in order to identify the individuals at risk of developing contractures. ORACLE will potentially translate the clinical observations of the care home staff in a systematic fashion, thereby ensuring consistency in identifying the risk, calibrating that risk, helping them prescribe a set of actions in response to the level of risk, and tracking subsequent changes in the risk regularly.

Methods

This study presents the second stage of a research project which employs the three-stage method for the development and validation of a scale.^{16,17}

The purpose of the proposed tool is to support the care home staff in assessing the risk of joint contractures to residents through the application of algorithms to professionally appropriate clinical observations and to respond appropriately to their

assessments. Rather than involving a one-off assessment, it is proposed that the tool will be applied repeatedly over time as part of standard clinical observations. In order to tailor it to the care home context where thorough medical assessments might not always be feasible, it has been developed with an emphasis on observable and physically examinable factors rather than on the identification of medical conditions and comorbidities that could contribute to the development of contractures.

A prototype of the tool was originally drafted by a cross-organisational and multi-disciplinary working group led by Dorset Healthcare including physiotherapists, occupational therapists, and registered nurses.

Study team

The study team comprised the authors of this study, who were responsible for developing and reviewing the proposed questionnaire items and making collective decisions related to the methodology and data analysis. The team consisted of a PhD student, a physiotherapy academic, two nursing academics, and a clinical physiotherapist.

Study design

This study used the Delphi technique to achieve consensus on the components of ORACLE for care home residents. The Delphi method¹⁸ is an iterative approach seeking expert opinions and collective agreement from a panel of experts on complex health problems through a series of structured questionnaires.¹⁹ This study conforms to guidelines for Conducting and Reporting of Delphi Studies.²⁰

For this study, a modified Delphi method of two rounds was employed to achieve consensus on different elements of ORACLE. In contrast to the classical Delphi technique, which utilises an initial idea generation phase with open-ended questions, this study employed a pre-designed list of items for the first round.

This list was developed on the basis of the findings of a consensus-based clinical workgroup which developed a prototype tool, a previously conducted systematic review of studies identifying factors associated with joint contractures in

adults²¹; standards of proficiency for nursing care²²; a scoping review of previous reviews of contracture management and prevention^{15,23–25}; and the agreement of study team members. This is a commonly accepted modification for the first round of Delphi with a pre-determined list of items based on research evidence or previous knowledge.^{18,26,27}

Participants

There are no guidelines on optimum sample sizes for the Delphi survey; however, previous research has indicated that 64% of Delphi studies included between 11 and 50 participants.²⁸ Given the specific focus of this research, this study aimed to recruit up to 30 international panellists representing different geographical and cultural settings to ensure gathering a broad range of opinions.

Expert panellists were invited based on purposive sampling and their expertise in research and clinical practice related to joint contractures. Their eligibility was pre-defined in line with the recommendations for Conducting and Reporting of Delphi Studies (CREDES).²⁰

The study invited qualified healthcare professionals with backgrounds in physiotherapy, occupational therapy, nursing, and rehabilitation medicine if they fulfilled one of the following eligibility criteria:

1. At least five years of clinical experience in providing frequent (once every six months) care to adults with joint contractures or
2. Published at least one peer-reviewed research paper on joint contractures.

Healthcare professionals involved in the development of the prototype tool and study team members were excluded. Where contact details could be obtained, authors of research papers identified in stage one (systematic review) were invited to participate. Additionally, the study team members sent email invitations to practising clinicians with recognised clinical expertise in joint contractures. The invitation email contained a summary of the proposed research and the significance of participating in both rounds to reduce attrition bias.²⁹ A reminder

email was sent if there was no response to the first invitation after three weeks. If there was no response after the second invitation, it was assumed that the participant was unavailable, and no further attempts were made to contact the participant.

Definition of consensus

Consensus was defined a priori as a percentage agreement threshold $\geq 70\%$ for both Likert and binary scale responses. This agreement threshold is consistent with other Delphi studies.²⁸ The Likert scale scores ranging from 5 to 7 and 1 to 3 were grouped as important/relevant and unimportant/irrelevant, respectively. For example, if $\geq 70\%$ of the panellists rated an item between 5 and 7, a consensus was reached that the item under consideration was important for the tool. Items that achieved consensus in the first round were excluded in the second round and if agreement was not achieved after two rounds, the items were excluded from the tool.

Ethics and consent

Ethics approval was obtained from the Research Ethics Committee at Bournemouth University (Ethics identification number: 36403). Participants were given a participant information sheet and provided written informed consent prior to the first round of the survey.

Data collection procedure

A step-by-step process of the study and an overview of the Delphi rounds can be found in Figure 1 and Table 1, respectively.

The draft of the survey questionnaire and the participant information sheet was piloted with six physiotherapists before the commencement of the first round. The aim was to obtain input on content, survey design, clarity of instructions, language, ease of completing the survey, estimated time taken, and other general comments. The feedback received was collated, minor revisions were made accordingly, and the first round of the survey was launched.

JISC (<https://www.jisc.ac.uk/online-surveys>), an encrypted online survey platform, was used to construct and distribute both rounds of the Delphi survey.

The first iteration of the Delphi survey was conducted from May 2021 to July 2021. The questionnaire was structured into three sections: (1) development, progression, and identification of joint contractures, (2) preventive care approaches, and (3) panel demographics. After each question, the panellists had the opportunity to suggest additional items and add comments.

1. *Development, progression, and identification of joint contractures:* This section was further categorised into four sub-sections: (A) development of joint contractures, (B) progression of joint contractures, (C) identification of joint contractures, and (D) contextual factors. In subsections A and B, the panellists were provided with a pre-determined list of factors associated with the development and progression of joint contractures separately based on the findings of a previously conducted systematic review²¹ and were asked to rate their importance. A 7-point Likert scale was used: from 1 (extremely unimportant) to 7 (extremely important). These factors build the first part of ORACLE, identifying individuals at risk of developing or worsening contractures. In subsection C, the panellists were asked if different healthcare professionals (physiotherapists, occupational therapists, nurses, and healthcare assistants), families, and informal carers have the ability to identify the clinical factors listed in sections a and b during informal clinical observations. In subsection D, the panellists were provided with a pre-determined list of contextual factors based on the literature^{15,23,24} that may be relevant in the development or progression of joint contractures in a care home setting. Contextual factors are characteristics of the environment or unique factors that have the potential to influence health outcomes.³⁰ Panellists were asked to rate the relevance of

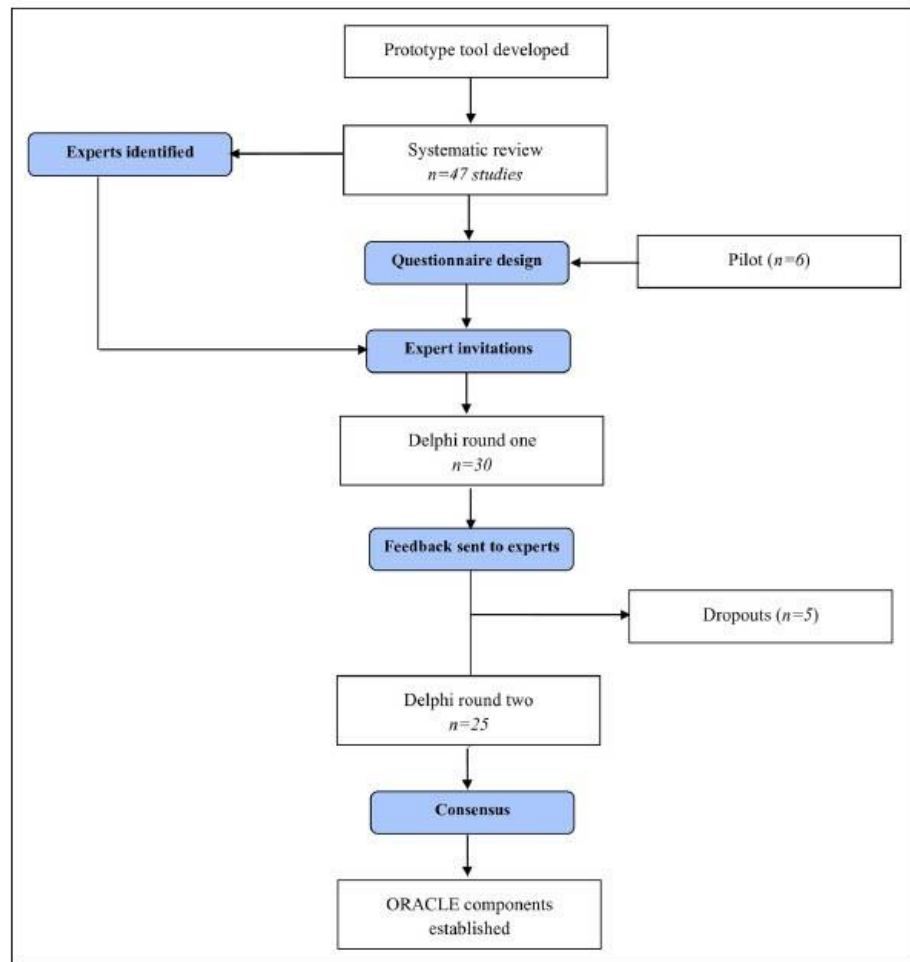


Figure 1. Delphi flow diagram.

the contextual factors on a 7-point Likert scale from 1 (extremely irrelevant) to 7 (extremely relevant). Identification of relevant contextual factors will improve the usability and practical implementation of ORACLE in a care home setting.

2. *Preventive care approaches:* In this section, the panellists were asked to rate different

evidence-based preventive care approaches^{22,25} important in preventing the development or progression of joint contractures in a care home setting. A 7-point Likert scale was used: from 1 (extremely unimportant) to 7 (extremely important). These care approaches build the second part of ORACLE which provides guidance for the

Table 1. Overview of the Delphi rounds.

Round 1: Consultation round	Panellists rated the pre-determined list of items Panellists suggested additional items
Round 2: Consensus round	Panellists received structured feedback on a previous round Panellists reviewed their ratings in the context of the given feedback and overall group results to reach a consensus Panellists rated the additional items identified in the previous round

care home staff to intervene in response to the level of risk identified in the first part.

3. *Participant demographics:* Panellists in the last section indicated their country of origin, professional background, highest completed qualifications, practice setting, and years of clinical and academic experience.

After the first iteration was completed, the data was analysed as described below. The second iteration was piloted again with two physiotherapists and the study team for feedback. Accordingly, the required changes were made before launching the second round. Panellists were then sent a summary of the results table including a reminder of their responses, overall group response, and a new survey questionnaire to complete approximately 8 weeks after the first round.

The second iteration was conducted from September 2021 to November 2021; the aim was to seek consensus in the areas of disagreement ($\leq 70\%$) identified in the first round. Second, additional items suggested by panellists in round one were also presented for the panellists to rate. In case of disagreement, they were also asked to specify the reasoning behind their choice.

Data analysis

Data analysis involved generating descriptive statistics (frequency and median) using a statistical package for the social sciences version 28.0. Missing data were dealt with by calculating an average score for the particular item and then

replacing the missing data point with the average score.

Results

Response rates

The first round consisted of 30 qualified international experts from seven countries. Of these, 25 completed the second round. Therefore, the response rate for the second round was 83.3% (25 out of 30), and the attrition rate between the two rounds was 16.7% (5 out of 30).

Panel characteristics

Table 2 summarises the panel's demographic characteristics for each iteration. During the first round, the panellists' average clinical and academic experience was 22.2 years (standard deviation ± 12.3 ; range: 4–45 years) and 10.5 years (standard deviation ± 10.7 ; range: 2–35 years), respectively.

During the second round, the panellists' average clinical and academic experience was 22.1 years (standard deviation ± 11.8 ; range: 5–45 years) and 10.6 years (standard deviation ± 10.2 ; range: 2–35 years), respectively.

Development, progression, and identification of joint contractures

Development of joint contractures

Table 3 presents the panellists' agreement levels regarding the importance of clinical factors associated with the development of joint contractures during each round. During the first round, 9 out of 12 items met consensus for inclusion in the core set which were: bed confinement, clonus, dystonia, impaired cognition, muscle weakness, pain, spasticity, physical function, and functional mobility. Of these 9 items, overall levels of agreement ranged between 70% and 100%. Items on which the panel consensus was below the 70% threshold in the first round were: (1) ageing, (2) pressure ulcers, and (3) urinary incontinence.

Suggested items: The newly suggested items by the panellists in the first round: (1) postural

Table 2. Panel's demographic characteristics.

Demographic information		Round 1 (n = 30)		Round 2 (n = 25)		Total dropouts (%)
		Frequency	%	Frequency	%	
Country of origin	UK	11	36.7	8	32	3 (10)
	USA	7	23.3	6	24	1 (3.3)
	Australia	6	20	5	20	1 (3.3)
	Germany	3	10	3	12	0 (0)
	Denmark	1	3.3	1	4	0 (0)
	Malaysia	1	3.3	1	4	0 (0)
	Singapore	1	3.3	1	4	0 (0)
Academic background	Physiotherapy	19	63.3	16	64	3 (10)
	Nursing	6	20	5	20	1 (3.3)
	Rehabilitation medicine	3	10	2	8	1 (3.3)
	Occupational therapy	2	6.7	2	8	0 (0)
Qualifications	Bachelors	11	36.7	8	32	3 (10)
	Masters	7	23.3	7	28	0 (0)
	FRCP	2	6.7	1	4	1 (3.3)
	PhD	8	26.7	8	32	0 (0)
	Associateship	1	3.3	1	4	0 (0)
	Diploma	1	3.3	0	0	1 (3.3)
Practice setting	Community (e.g. residential care or patient's home)	13	43.3	10	40	3 (10)
	Higher education/university	6	20	6	24	0 (0)
	Hospital (acute care)	3	10	2	8	1 (3.3)
	Hospital (long-term)	2	6.7	1	4	1 (3.3)
	Long term facility	1	3.3	1	4	0 (0)
	Rehabilitation centre	1	3.3	1	4	0 (0)
	Other	4	13.3	4	16	0 (0)

asymmetry, (2) inability to engage in activities, and (3) hypertonia, were included in the second round.

In the second round, the panellists reviewed their responses in the context of the average group responses in areas of disagreement ($\leq 70\%$) and rated the importance of newly suggested items. Pressure ulcers reached consensus (agreement level of 76%), while ageing and urinary incontinence still failed to reach the agreement threshold ($< 70\%$). Among the newly suggested items, inability to engage in activities and hypertonia reached an agreement level of $> 70\%$ while postural asymmetry did not reach the required consensus level (68%).

Progression of joint contractures

Table 3 presents the panellists' agreement levels regarding the importance of clinical factors associated with the progression of joint contractures during each round. The first round identified

consensus for 10 out of 12 items. Of these, four items, including bed confinement, muscle weakness, pain, and reduced functional mobility, reached 100% agreement. On the other hand, items on which the panel consensus was below the 70% threshold were: (1) pressure ulcers and (2) urinary incontinence.

Suggested items: The newly suggested items by the panellists in the first round, (1) postural asymmetry, (2) inability to engage in activities, and (3) hypertonia were included in the second round.

In the second round, consensus was reached for pressure ulcers (84%), whereas urinary incontinence fell short of the agreement threshold ($< 70\%$). Among the newly proposed items, inability to engage in activities and hypertonia reached an agreement level of over 70% while postural asymmetry did not reach the required consensus level (64%).

Table 3. Agreement levels on clinical factors.

Clinical factors	Round one		Round two	
	Median (Average group response)	Agreement level (%)	Median (average group response)	Agreement level
Development of contractures				
1. Ageing	5	65.5	5	80%
2. Bed confinement	7	100	—	—
3. Clonus	5	70	—	—
4. Dystonia	6	86.3	—	—
5. Impaired cognition	5	80	—	—
6. Muscle weakness	6	100	—	—
7. Pain	6	100	—	—
8. Pressure ulcers	5	63.3	5	76%
9. Spasticity	7	96.7	—	—
10. Reduced physical function	6	96.7	—	—
11. Reduced functional mobility	6	100	—	—
12. Urinary incontinence	3	16.7	3	4%
13. Postural asymmetry	—	—	5	68%
14. Inability to engage in activities	—	—	5	76%
15. Hypertonia	—	—	6	100%
Progression of contractures				
1. Ageing	5	75.8	—	—
2. Bed confinement	7	100	—	—
3. Clonus	5	73.4	—	—
4. Dystonia	6	86.7	—	—
5. Impaired cognition	6	83.4	—	—
6. Muscle weakness	6	100	—	—
7. Pain	6	100	—	—
8. Pressure ulcers	5	66.7	5	84%
9. Spasticity	7	96.7	—	—
10. Reduced physical function	6	96.7	—	—
11. Reduced functional mobility	6	96.7	—	—
12. Urinary incontinence	3	20.3	3	12%
13. Postural asymmetry	—	—	5	64%
14. Inability to engage in activities	—	—	5	76%
15. Hypertonia	—	—	5	100%

Identification of joint contractures in care homes

Figure 2 shows the agreement levels of the panelists on the ability of different healthcare professionals and family/informal carers to identify the factors presented in the previous questions in adults residing in care homes. The following items failed to reach the threshold of 70% agreement for either Yes or No in round one:

- Identification of clonus, dystonia, and spasticity by nurses.
- Identification of cognitive changes and muscle weakness by care assistants.
- Identification of muscle weakness and pressure ulcers by family/informal carers.

The items which lacked consensus were sent again to the panellists to review their responses. In the second round, it was also clarified that the identification of the factors in a care home

setting would be based on informal observation during the delivery of care rather than a formal clinical assessment undertaken by a specialist professional. The factors that reached consensus regarding their identification (yes) in the second round were:

- Identification of cognitive changes and muscle weakness by care assistants.
- Identification of muscle weakness, and pressure ulcers by family/informal carers.

Of the new factors suggested by the panellists namely, postural asymmetry, activity engagement, and hypertonia reached an agreement for all healthcare professionals except the identification of

postural asymmetry by healthcare assistants and family/informal carers.

Contextual factors

Table 4 presents the expert panel's agreement levels regarding the contextual factors relevant to the development of joint contractures during each round. During the first round, there was a group consensus for 8 out of 9 items. Of these 8 items, overall levels of agreement ranged between 86.6% and 100%. Diet was the only item on which the panel consensus was below the 70% threshold in the first round. Panellists were also asked to specify any other contextual factors that were missing from the list in their opinion. The newly suggested items were (1) education and training of caregivers, (2) staffing levels in the care home, (3) service user training and

	Physiotherapists	Nurses	Occupational Therapists	Healthcare assistants	Family/Informal Carers
Clonus					
Yes	96.7%	50.0%	73.3%	6.7%	23.3%
No	3.3%	50.0%	26.7%	93.3%	76.7%
Cognition					
Yes	83.3%	96.7%	96.7%	63.3%	73.3%
No	16.7%	3.3%	3.3%	36.7%	26.7%
Dystonia					
Yes	100.0%	43.3%	76.7%	6.7%	13.3%
No	0.0%	56.7%	23.3%	93.3%	86.7%
Muscle weakness					
Yes	100.0%	82.8%	86.2%	62.1%	44.8%
No	0.0%	17.2%	13.8%	37.9%	55.2%
Pain					
Yes	96.7%	100.0%	90.0%	80.0%	86.7%
No	3.3%	0.0%	10.0%	20.0%	13.3%
Pressure Ulcers					
Yes	75.9%	100.0%	72.4%	75.9%	55.2%
No	24.1%	0.0%	27.6%	24.1%	44.8%
Spasticity					
Yes	100.0%	50.0%	80.0%	23.3%	13.3%
No	0.0%	50.0%	20.0%	76.7%	86.7%
Physical function					
Yes	93.3%	93.3%	90.0%	83.3%	80.0%
No	6.7%	6.7%	10.0%	16.7%	20.0%
Functional mobility					
Yes	90.0%	90.0%	86.7%	83.3%	76.7%
No	10.0%	10.0%	13.3%	16.7%	23.3%

Figure 2. Agreement levels for the ability of healthcare professionals and carers to identify the clinical factors in care home residents.

involvement, and (4) timely access to and quality of in-reaching services. In round two, diet still did not reach the agreement threshold (<70%), while all newly suggested items gained consensus (92%).

Preventive care approaches

Table 5 presents the expert panel's agreement levels regarding the care approaches important in the prevention of the development and progression of joint contractures during each round. During the first round, there was a consensus for 7 out of 8 care approaches. Of these seven approaches, overall levels of agreement ranged between 70% and 100%. The only care approach on which the panel consensus was below the 75% threshold in the first round was 'passive exercises'.

Expert panellists were also asked to specify any other preventive care approaches that were missing from the list. The most common new approaches identified were a 24-hour postural management program and caregiver/service user education and training.

In the second round, passive exercises remained below the agreement threshold (<70%), while both

newly suggested items gained consensus (76% and 84%, respectively).

Discussion

This e-Delphi survey generated expert opinions and consensus on items providing a provisional framework for the development of a contracture risk assessment tool (ORACLE) for adults in care homes.

This Delphi survey sought expert opinion and consensus on three aspects of the ORACLE: (1) *Clinical factors* that form the first part of ORACLE, (2) *Preventive care approaches* that form the second part of the ORACLE, and (3) *Contextual factors* that will be used to develop a guidance manual for ORACLE to improve its usability and practical implementation in a care home setting. Table 6 shows a list of finally agreed items for ORACLE by the study team.

The category, clinical factors encompassed factors associated with the development and progression of joint contractures. Of the total 15 items, ≥70% of panellists provided agreement on 10 items of which spasticity is one.

Table 4. Agreement level on contextual factors.

Contextual factors	Round one		Round two	
	Median (average group response)	Agreement level (%)	Median (average group response)	Agreement level
1. Diet	4.5	50	4	24%
2. Inappropriate design of assistive devices	5	89.6	–	–
3. Lack of regular social engagement (friends, family, community members)	5	70	–	–
4. Lack of support from immediate family	5	86.6	–	–
5. Lack of support from healthcare professionals (physiotherapists, nurses, occupational therapists)	7	96.7	–	–
6. Lack of support from healthcare assistants	6	93.3	–	–
7. Medication	6	93.1	–	–
8. Organisation and policies of the care home	6	90	5	–
9. Resources of the care home	7	100	–	–
10. Education and training of caregivers	–	–	6	92%
11. Staffing levels	–	–	6	92%
12. Service user training and involvement	–	–	6	92%
13. Timely access to and quality of in-reaching services	–	–	6	92%

Table 5. Agreement levels on preventive care approaches.

Preventive care approaches		Round one		Round two	
		Median (average group response)	Agreement level (%)	Median (average group response)	Agreement level
1.	Encouraging to sit, transfer, move around, exercise, and perform activities of daily living with minimal possible assistance	7	100	–	–
2.	Ensuring adequate nutrition and hydration.	6	73.3	–	–
3.	Identifying and managing skin irritations and rashes	6	70	–	–
4.	Performing passive exercises	6	66.7	5	60%
5.	Performing stretching exercises	6	76.7	–	–
6.	Postural management /positioning techniques	7	90	–	–
7.	Taking appropriate action to reduce or minimise pain or discomfort.	7	100	–	–
8.	Using appropriate products to prevent or manage skin breakdown	7	90	–	–
9.	24-h postural management program	–	–	6	76%
10.	Caregiver/service user education and training	–	–	6	84%

However, there was insufficient panel consensus regarding spasticity being recognisable by the care assistants, the aimed primary users of the tool in the care home. Spasticity is a commonly reported secondary complication following chronic neurological conditions (e.g. stroke) in care home residents.³¹ Identifying changes in muscle tone, including spasticity, requires physical and neurological examination by a trained practitioner; the primary care providers at the care home facilities might lack the appropriate training to recognise it³²; therefore, it was excluded from the final list of items for ORACLE. Interestingly, our systematic review also reported that the evidence on the relationship between spasticity and contractures remains unclear and inconclusive.²¹

The category, preventive care approaches included approaches important in preventing contracture development and progression. This forms the second part of ORACLE, which provides guidance to the care home staff to prescribe a set of actions in response to the level of risk identified in the first part. The panel demonstrated a high level of consensus for 9 out of 10 care approaches. The only care approach which failed to reach adequate panel consensus was 'performing passive exercises'. Passive exercises are a

common intervention for individuals at risk of developing contractures.³³ When asked by the panellists about the reasoning behind their choice, a few stated that there is insufficient evidence to support its effectiveness in preventing contractures. The panel views are consistent with the findings of a systematic Cochrane review which provides inconclusive evidence of passive movements as an effective treatment approach to prevent or manage contractures.³³ Moreover, a recent systematic review that investigated nonsurgical treatment options for muscle contractures in neurological disorders could not provide convincing evidence for using passive movements.³⁴ Therefore, 'passive exercises' were excluded from the final list of items. Contrastingly, panellists provided consensus in favour of stretching; however, recent systematic reviews have substantiated that stretching did not produce clinically important short-term effects on joint mobility.^{34,35} Further research is needed to investigate the long-term effects of stretching on joint mobility and the prevention of contractures. Given this contradiction, the study team suggested that it was not appropriate to recommend that non-physiotherapeutic staff engages in the application of stretching exercises on their own; therefore, it was also excluded.

Table 6. Finally agreed items for Observational Risk Assessment Tool for Contractures: Longitudinal Evaluation (ORACLE).

Clinical factors	Contextual factors	Preventive care approaches
1. Ageing	1. Inappropriate design of assistive devices	1. Encouraging to sit, transfer, move around, exercise, and perform activities of daily living with minimal possible assistance
2. Bed confinement	2. Lack of regular social engagement	2. Ensuring adequate nutrition and hydration
3. Impaired cognition	3. Lack of support from immediate family	3. Identifying and managing skin irritations and rashes
4. Muscle weakness	4. Lack of support from healthcare professionals	4. Performing stretching exercises
5. Pain	5. Lack of support from healthcare assistants	5. Postural management /positioning techniques
6. Pressure ulcers	6. Medication	6. Taking appropriate action to reduce or minimise pain or discomfort.
7. Reduced physical function	7. Organisation and policies of the care home resources of the care home	7. Using appropriate products to prevent or manage skin breakdown
8. Reduced functional mobility	8. Education and training of caregivers	8. 24-h postural program
9. Inability to engage in activities	9. Staffing levels	
	10. Service user training and involvement	
	11. Timely access to and quality of in-reaching services	

While contextual factors are not included in the tool, they are relevant to its successful implementation. The internal quality of an intervention is only one factor in its effectiveness, which will also depend upon the intervention's interaction with the environment in which it has been introduced and upon the responses of the actors involved.³⁶ This is especially the case in complex environments such as care homes.³⁷ A growing body of evidence supports the need for context-specific research studies to successfully implement complex interventions.^{38,39} A recent systematic review by Peryer et al.³⁷ has reported that several large-scale studies evaluating complex interventions in care homes have demonstrated inconclusive or neutral findings. It is unclear whether the findings are linked solely to the ineffective interventions or contextual barriers around their implementation.³⁷ The contextual mechanisms identified by the panellists in this study will be included in the ORACLE guidance manual with a view to mitigating their inhibitive effects on the effectiveness of the tool. Panellists provided agreement on 12 out of 13 contextual factors.

The current study has several key strengths. It included panellists from diverse geographical locations, cultural settings, and academic backgrounds, with 50% having at least a higher degree and 50% having at least one research publication on joint contractures, indicating a broad range of representation of skills and diversity of expertise. The number of rounds, consensus method, and the level of agreement were defined a priori which is in line with recommendations for conducting and reporting of Delphi studies.²⁰ Two iterations ensured that the panellists could revisit their opinions on the pre-determined list of items, suggest additional items that were missing in their opinion, and reach an agreement. Another strength of the current study was that the survey questionnaire was designed using a pre-determined list of items derived from a range of sources, including peer-reviewed research evidence, which may have reduced the researcher bias. Moreover, this study piloted the survey questionnaire prior to the launch of the study to ensure good face and content validity.

One of the limitations of this study was that the selection of the panel experts was restricted to those who could understand and write English. As a

result, potential non-English panel experts were excluded.

Building on the extant research literature, this Delphi study determined expert consensus on items to be included in a contracture risk assessment tool (ORACLE). The next step is to evaluate the reliability, acceptability, and usability of the tool within care homes. A valid and reliable contracture risk assessment tool might have the potential to trigger timely and appropriate referrals. Timely referrals may aid in prompt escalation of early interventions by the specialists aiming to reduce the risk of contracture development or progression of existing contractures.

Clinical messages

- An important strategy to prevent joint contractures is to systematically identify the risk of their development.
- The expert panel identified the key clinical factors that contribute to this risk and provided strategies to prevent their development and progression.
- The expert panel highly recommends the preservation of mobility and functional independence as a key priority for reducing risk of contractures.
- Notwithstanding the strength of the evidence generated by this survey, an effective risk assessment tool is required to ensure a systematic approach to early intervention and prevention of joint contractures.

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Author contributions

All authors contributed to the conceptualisation, methodology and design of the study. HT and JD sent out Delphi invitations. HT conducted the data collection and analysis and all authors contributed to the drafting, critical reviewing, and final revision of the article.

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4.3 Development of ORACLE

The findings from the Delphi study informed the further development and refinement of the two parts of ORACLE: (1) the risk assessment tool and (2) the response actions, which provide guidance to care staff on how to intervene in response to the identified level of risk. The figure below summarises the items identified through a systematic review and two rounds of the Delphi survey for part one of ORACLE (Figure 6). By the end of the second Delphi round, consensus was achieved on the inclusion of nine items for the risk assessment tool.

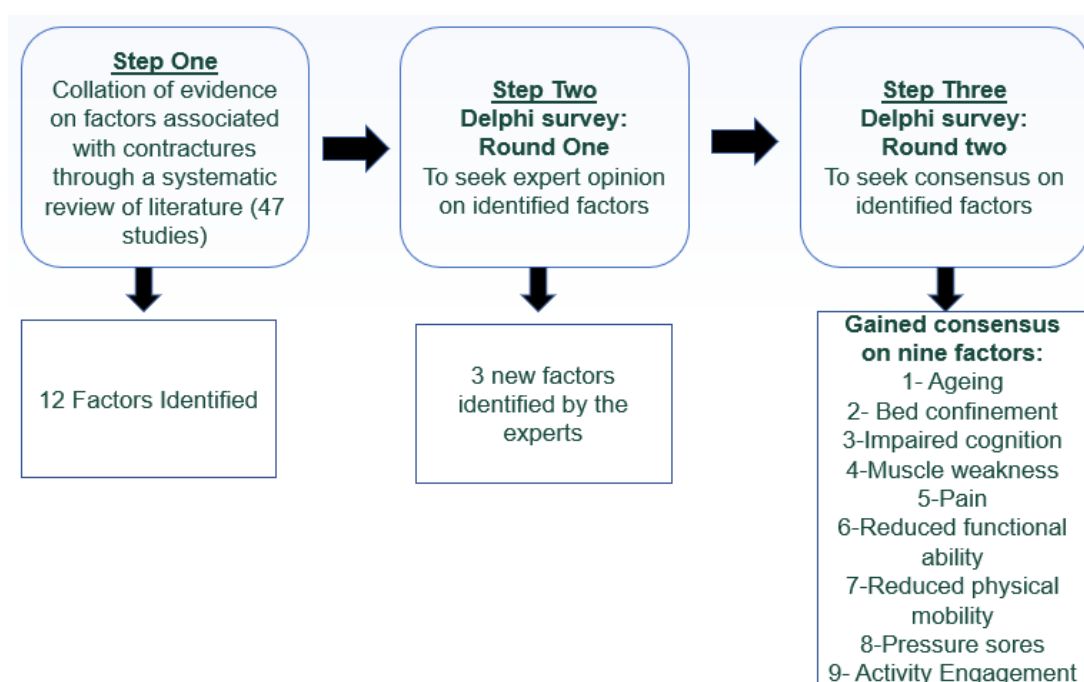


Figure 6 Development process of ORACLE

Recognising the critical role of mobility limitations in the development of contractures through combined findings of Study 1 and Study 2, the items of bed confinement and limited physical mobility were operationalised within the tool by assessing three key aspects of mobility: bed mobility, transfers and walking. The nine items were, therefore, integrated into the tool and organised into ten subscales, each scored on a 3-point ordinal scale: (1) age category, (2) bed mobility, (3) transfers, (4) walking, (5) functional ability, (6) muscle weakness, (7) pain, (8) pressure sores (9) cognition and (10) activity engagement.

The second part of ORACLE was further developed and refined using preventative care approaches and contextual factors identified through the Delphi survey with a

focus on restorative nursing approaches to prevent contractures. Restorative nursing care focuses on maximising the resident's physical function by reinforcement of increased independence in activities of daily living (ADLs) (Resnick and Fleishell 2000; Wagner et al. 2008). It fosters increased social interaction and encourages residents to perform as many ADLs as possible on their own (Wagner et al. 2008). Evidence suggests that most residents gain psychological and physical benefits from engaging in a restorative care program (Resnick and Fleishell 2000).

4.4 Patient and Public Involvement (PPI)

The guidance of the public members, including people with lived experience of contractures and Healthcare assistants (HCAs) who are the aimed users of the tool, has been fundamental in the design of the tool and the study. Their involvement has been invaluable to ensuring the study topic, aims are relevant, tool design and communication with the target population and participants is clear and agreeable. Following the development of ORACLE, two Public and Patient Involvement (PPI) sessions were conducted. The first PPI session, facilitated by BU Public Involvement in Education and Research (PIER) team was with an adult female, diagnosed with rheumatoid arthritis (RA) and lived experience of bilateral hip, knee and finger contractures. The second session was conducted with five HCAs and a lead occupational therapist (OT) at a local care home.

Session One:

An online one-to-one session was conducted on Zoom with the adult female (aged 50+). A detailed presentation about the background of contractures, the study and ORACLE was given.

Summary of the session:

- The proposed study is very important as it not only highlights the importance of timely recognition of contractures but also addresses the risk factors.
- Contractures contribute to limited movement and the ability to take part in exercise. Managing the painful and disabling symptoms earlier could have prevented the subsequent development and progression of contractures.

- The items listed within the tool (e.g., pain, bed and transfer mobility, functional ability) were relatable, providing a clear insight into how they contribute to the development of contractures.
- She felt a tool like ORACLE might have helped her identify the risk earlier in the disease progression.
- The tool's language, layout and scoring system is straight forward and easy to understand.

Session Two:

A face-to-face PPI session was conducted with five HCAs at a local care home. A presentation about the background of this study and the newly developed ORACLE was provided, and the HCAs were asked to provide both written and verbal feedback in the end.

The following is a summary of the feedback received from the care assistants and lead OT:

- All participants found the presentation engaging and educational.
- They felt this study is important because residents with contractures have poorer mobility and increased dependence on carers for their everyday tasks.
- Care demands for residents with contractures were perceived to be significantly higher than for those without.
- They found that the language used in the tool is clear and easy to understand.
- The scoring system is straightforward and easy to interpret.
- The length of the tool is appropriate and should not take more than 10 minutes to complete.
- No aspects of the tool were found to be unclear or confusing. However, participants reported a lack of training around contractures, and there should be some training for the HCAs before the formal and regular use of the tool as part of the routine clinical assessments.
- One HCA expressed uncertainty about the tool's sensitivity in identifying upper limb or hand contracture risks.

Considering the input and feedback received, the following adjustments were made to the research approach:

1. Develop a short training package for the care home staff covering the background on contractures, and clear instructions on how to use the ORACLE.
2. Examples of upper limb functions were added to ORACLE to enhance its sensitivity in identifying risks associated with upper limb contractures (Appendix III).

The following supplementary materials are included in Appendix III.

- A. Delphi questionnaire
- B. ORACLE full tool with scoring system (first revision)

4.5 Link to the Educational Video (Quality Improvement Study)

For the tool to be effectively implemented in the care homes, a training resource for the care staff to improve their understanding of contractures and to use ORACLE effectively and confidently was needed. The following chapter presents the development of an educational video created as part of a quality improvement initiative with NHS Dorset.

Chapter 5: Educational Video

5.1 Chapter overview

This chapter presents an integrated published research paper detailing the development and evaluation of a Quality Improvement (QI) educational video on joint contractures for care home staff. The content of the educational video was based on the findings of Study 1 and Study 2 (Chapters 3 and 4). The paper provides a background to the problem, followed by a detailed description of the QI methodology, intervention design, data collection procedures and analysis. After that, it presents quantitative and qualitative findings, concluding with a discussion of lessons learned and limitations to guide future improvements.

5.2 Integrated paper

This section presents the integrated paper, titled, '*The Development and Evaluation of a Quality Improvement Educational Video on Joint Contractures for Care Home Staff*', published in the journal '*BMJ Open Quality*' as part of the integrated thesis format.

See: Tariq, H., Dunn, J., Forrester, S., Collins, K. and Porter, S., 2024. Development and evaluation of a quality improvement educational video on joint contractures for care home staff. *BMJ open quality*, 13(4). DOI: [10.1136/bmjopen-2024-002923](https://doi.org/10.1136/bmjopen-2024-002923)

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link to full-text PDF file: [Development and evaluation of a quality improvement educational video on joint contractures for care home staff](https://www.bmjopenquality.com/content/13/4/e2024002923)

Dorset Healthcare University NHS Foundation Trust, 2023. Joint Contracture Awareness Video [video]. YouTube. Available from:

<https://www.youtube.com/watch?v=aITUZ63khr0>

Development and evaluation of a quality improvement educational video on joint contractures for care home staff

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ABSTRACT

Background Contractures are a debilitating problem for individuals living in long-term care settings. However, there is a lack of education and training among the care staff regarding the identification of risk factors related to contractures and the preventive strategies that can decrease their development or progression. Addressing this knowledge gap has the potential to improve the quality of care provided to residents in care homes. The objective of this quality improvement (QI) project was to investigate the impact of a newly developed educational video on the awareness, knowledge and understanding of contractures among the care staff.

Methods This QI project involved two sequential Plan-Do-Study-Act cycles and employed a pre and post-test design to evaluate the impact of the contracture educational video. Primary outcomes were assessed using paper surveys to capture prevideo and postvideo levels of knowledge and understanding of contractures. Furthermore, both verbal and written feedback from participants were gathered to identify areas of strengths and improvement.

Results Baseline data revealed that about 56% of the care staff lacked knowledge and understanding of contractures with another 33% reporting possessing only basic knowledge. Following the video intervention, percentage of care staff who reported good knowledge and understanding increased to 67% while 22% reported basic knowledge and understanding of contractures. The care staff suggested changes to the video to improve accessibility of the information, this was incorporated in the refilming of the video.

Conclusion This QI project demonstrated that the introduction of a contracture educational video is a feasible and positively received method of enhancing awareness, knowledge and understanding of contractures among care staff. Educating care staff about the risk factors and prevention strategies for contractures will potentially improve their ability to identify the risk of contractures and help prevent their occurrence, ultimately enhancing the quality of care of the residents.

INTRODUCTION

Current evidence indicates a high prevalence of joint contractures among residents of long-term care facilities ranging from 20% to 75%,¹ however, they remain an important healthcare challenge that has not received sufficient attention.²

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Contractures are a preventable but common consequence of immobility among individuals living in long-term care settings.
- ⇒ Contractures are associated with increased dependence and poorer quality of life.
- ⇒ There is a lack of education and training on contractures among the care staff.

WHAT THIS STUDY ADDS

- ⇒ After watching an educational video care home staff increased their knowledge, understanding and awareness of contractures.
- ⇒ This is the first quality improvement project that evaluates the knowledge and understanding of contractures among care staff after watching an awareness video.
- ⇒ Education and training on the key risk factors and preventative strategies for contractures will equip the care staff with the ability to identify contracture risk, initiate early interventions within the care home setting, escalate timely referrals to the healthcare professionals and consequently improve the quality of care of the residents.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Improved knowledge, understanding and awareness of contractures can help to prevent contractures.
- ⇒ More research is needed to identify longer term retention of the educational information and if the new knowledge impacts on care home residents' the care and development or progression of contractures.
- ⇒ If a contracture education tool can contribute to earlier intervention and prevention of contracture development or progression, this education can be incorporated into health and social care policy.

The primary risk factor associated with the onset of contractures is immobility.³ A significant proportion of individuals residing in long-term care facilities exhibit sedentary behaviour, which consequently leads to a higher incidence of developing contractures.⁴ A study by Selikson *et al* revealed that

70.5% of non-ambulatory care home residents developed contractures in contrast to the ambulatory group, which did not develop any.⁵

Most direct care to care home residents, including mobility assistance is provided by the care staff.⁶ The nursing staff at these facilities are increasingly becoming reliant on care staff to monitor and report changes in the health and behaviour status of the residents.⁶ Fisher and Ellwood, in their study, reported that physiotherapists, working in a care home setting, have observed poor postural management and limited opportunities for physical activity for the residents under their care.⁷

The initial onset and progression of contractures typically do not cause pain or disability; residents only experience pain in the joints when they attempt to move them beyond the soft-tissue restrictions.⁸ Consequently, both individuals and their caregivers often fail to identify the development of contractures until they significantly interfere with their activities of daily living. Once developed, contractures tend to lead to a cascade of irreversible impairments perpetuating a vicious cycle that further worsens the condition.³ This escalation leads to an increased burden of care, difficulty in moving and handling tasks for the carers and increased financial costs for the care home as the needs of the affected individual increase.³

For the caregivers to recognise the risk associated with limited mobility and contractures in a timely manner, and to escalate early interventions at the care home level and timely referrals to healthcare professionals if required, it is necessary for them to acquire training on contracture awareness. In addition, the provision of advice and guidance on physical activity and effective positioning to the care staff will help maintain the independence of frail people or those with a disability and improve their quality of life. It would also serve to support caregivers, reduce care costs through efficiency savings and reduce hospital admissions.⁷

This quality improvement (QI) project supported by NHS Dorset aimed to develop an educational video to improve the awareness, knowledge and understanding of contractures among the care staff at local care homes.

METHODS

This report conforms to the Standards for Quality Improvement Reporting Excellence (SQUIRE) 2.0 guidelines.⁹

Study design and setting

This project adopted QI approach with a pre and post-test design to evaluate a video-based educational intervention for care home staff caring for residents with contractures or at risk of contractures. The project followed the framework outlined by the Institute for Health Care Improvement's model for improvement,¹⁰ which consists of two components: three core questions and the Plan-Do-Study-Act (PDSA) cycle which is used to test changes in

actual work contexts to see if they lead to improvement.¹⁰ This in turn informed the three phases of this project: (1) analysis of the problem and development of the interactive training session, (2) implementation of the training session and (3) evaluation of the training session's impact on care staff knowledge and understanding of contractures.

The project was conducted at two local care homes in Dorset, both of which offer residential, nursing, dementia, palliative/end of life and respite care.

Participants

The population included the carers who provide or organise the care of the residents with contractures or at risk of developing contractures.

Patient and public involvement

NHS Dorset conducted an educational needs survey locally with the healthcare professionals focusing specifically on contractures. The survey aimed to identify the current gaps in areas where staff may lack training and educational resources related to the prevention and management of contractures. The findings highlighted poor awareness of contractures among care staff. Additionally, the survey findings indicated that most respondents (73%) favoured bite-sized educational videos as the preferred method for virtual training on contractures.

The educational video in this QI project was developed to increase the knowledge and understanding of risks and prevention of joint contractures among the care home staff. The methods reported here demonstrate engagement with the care staff who are the end-users from baseline through to the conclusion of this project. The initial PDSA cycle involved testing the educational video with care staff who then provided feedback to inform the required changes tailored to their needs. The changes were subsequently incorporated into the refilling of the video before its final dissemination.

Service improvement team and analysis of the problem

The service improvement team comprised two expert physiotherapists (HT and JD) and one occupational therapist (SF) who was also working as a QI engagement and development facilitator.

The script of the video was mainly developed by HT and JD and was based on previous research evidence gathered by HT, KC, JD, DT, SA and SP.^{3,11}

SF and three other volunteers who featured in the video (one nursing practitioner, one rehabilitation assistant and one care staff member) also gave their input during the development of the script. All team members collaborated closely to analyse the problem, design the video intervention, assist with data collection, analyse and generate change ideas.

A fishbone analysis allows the service improvement team to fully understand the nature of the problems, the underlying causes contributing to the problem and as a result producing outcomes, which reflect the solution of

the problem.¹² The service improvement team utilised fishbone analysis to identify and assess the potential causes of minimal or no training for care home staff supporting residents with contractures or at risk of developing contractures (online supplemental material 1). A series of meetings were held among the service improvement team members and with the gatekeepers (senior care staff members) of the care homes to address the solutions to major causes of the problem.

Strategy and processes

PDSA cycle 1

Plan:

- ▶ Define the goals of the QI project: using an interactive session and educational video to create awareness and confidence of care home staff in Dorset, when supporting people who have contractures or are at risk of developing contractures.
- ▶ Establish-specific learning objectives of the training session.
- ▶ Develop video training material using the latest research evidence.
- ▶ Ensure that the language of the training material is tailored to the target audience, that is, care home staff.
- ▶ Peer review the training material with healthcare professionals with experience of working with residents with contractures.
- ▶ Incorporate interactive elements such as animations, pictures and useful acronym to enhance learning retention.
- ▶ Engage relevant stakeholders in the planning process to ensure their support and collaboration throughout the project. In this cycle, we collaborated with two care homes, therefore the learning and development managers at both facilities were engaged.

Do:

- ▶ Conduct the planned interactive video training sessions at selected care homes (intervention).
- ▶ Administer pre and post-training survey to measure the increase in staff knowledge and understanding of contractures.
- ▶ Gather qualitative feedback via open-ended questions in the training survey from the care home staff regarding the video content, and overall experience including any areas of confusion and suggestions for improvement.

Study:

- ▶ Analyse the results to explore the change in knowledge and understanding of contractures after watching the educational video.
- ▶ Review feedback to identify strengths, weaknesses and areas for improvement in the educational video.

Act:

- ▶ Incorporate feedback from the care home staff to revise and refine the training material.
- ▶ Modify and adjust delivery approach based on the identified areas for improvement.



Figure 1 The figure presents selected images from the educational video on contracture awareness for care home staff.

- ▶ Disseminate the educational video to a wider audience on media platforms.

Intervention

The training session was delivered face-to-face by HT and SF. The training was a 30 minute interactive session, which consisted of a PowerPoint presentation, a contracture awareness video (figure 1) and administration of a paper-based pre and post-survey. The PowerPoint presentation started with Introduction of the trainees and overview of the session, which was then followed by administration of the pre-video survey measuring the baseline knowledge of the care staff. The care staff were asked about their demographics, rate their current knowledge and understanding of contractures on a Likert scale from 0 (no knowledge and understanding) to 3 (extensive knowledge and understanding) and how much they agreed with the statement, *I provide care for residents with contractures* from 0 (never) to 3 (always). They were also asked if they had previously attended any training on contractures and if they ever used a tool/method to assess the risk of contractures in the residents.

Training video

The video script was written in plain English and non-technical language to accommodate the care staff with no medical background. The video employed a slide show format and featured two physiotherapists, one occupational therapist, one rehabilitation assistant and one nursing practitioner as trainees, which reflects a multidisciplinary input in contracture prevention and management. The contracture knowledge concepts addressed in the video included a clear description of contractures, levels of severity of contractures, the impact of contractures on the individual, the carers and on the care home, the conditions in which contractures are most prevalent, most common risk factors and how contractures can be prevented in a care home. An acronym, Strength, Treatment, Opportunity to engage, Positioning (STOP) was utilised to describe the prevention strategies that can be utilised by the care staff to prevent contractures. S for strength, T for treatment, O for opportunity to engage and P for positioning (figure 1). The video also added

Table 1 Demographic characteristics

ID	Job role	Years of experience	Specialty
1	Learning and development facilitator	1–5 years	Elderly care
2	Learning and development manager	5–10 years	Elderly care
3	Healthcare assistant	1–5 years	Elderly care
4	Healthcare assistant	20+ years	Elderly care
5	Clinical support manager	20+ years	Elderly and complex care
6	Healthcare assistant	1–5 years	Dementia care
7	Senior healthcare assistant	1–5 years	Elderly care
8	Well-being assistant	1–5 years	Elderly care
9	Care practitioner	20+ years	End of life care, dementia care, nursing care

useful links to easy resources for physical activity and strengthening exercises that are accessible by the care homes. Useful animated pictures and videos were incorporated into the video to demonstrate the prevention strategies (figure 1).

Post-video survey

A post-video survey was employed to measure the change in knowledge and written and verbal qualitative feedback was gathered to identify areas of strengths and improvement.

Analysis

Descriptive statistical analyses were used to report on the categorical variables while the qualitative feedback on the training was analysed using thematic analysis.¹³

RESULTS

Quantitative results

A total of nine care staff participated in the training. The demographic characteristics of the participants are presented in table 1.

Pre-video survey

The pre-video survey (figure 2) demonstrated that four out of nine participants had no knowledge and understanding of contractures (44.44%), four had basic knowledge and understanding of contractures (44.44%) and one had good knowledge and understanding of contractures (11.11%). When asked, how much you agree with the following statement: 'I provide care for residents with contractures', six reported, 'never' (66.66%), two reported, often (22.22%) and one reported, always (11.11%).

When asked if they ever used a tool or method to assess the risk of contractures for their residents, eight out of nine respondents, reported, 'no' (88.88%) while one reported, 'yes' (11.11%) (with the help of the occupational therapist and allocated forms). All nine participants reported that they had never received any training related to contractures or postural management before (100%).

Post-video survey

Post-video survey (figure 2) demonstrated that six out of nine participants reported good knowledge and understanding of contractures (66.66%), two reported basic knowledge and understanding of contractures (22.22%) and one reported extensive knowledge and understanding of contractures (11.11%). When asked, how much you agree with the following statement: 'I provide care for residents with contractures', five reported 'often' (55.55%), three reported 'sometimes' (33.33%) and one reported 'always' (11.11%).

Qualitative findings

The following key themes emerged from the qualitative analysis of the feedback provided by the care staff supported by the quotes:

(1) Improved understanding of contractures.

Participants expressed a greater understanding of contractures through the training.

This training has been very beneficial..... this training gave me an understanding of contractures which I didn't have before.

This training session has been very useful and helped me gain an understanding of what contractures are and how to help prevent them from occurring.

(2) Positive feedback on training material

Most participants found the training content useful and informative and appreciated the correlation of important clinical aspects with contractures.

I liked the way this learning cross-references with other core aspects such as pressure ulcer care improving and positioning etc.

I believe the resources mentioned in the learning are also beneficial. Pillows used in care homes are easy to source and other prevention ideas such as squeeze balls.

Participants found the STOP acronym and the vicious cycle of contractures very helpful and informative.

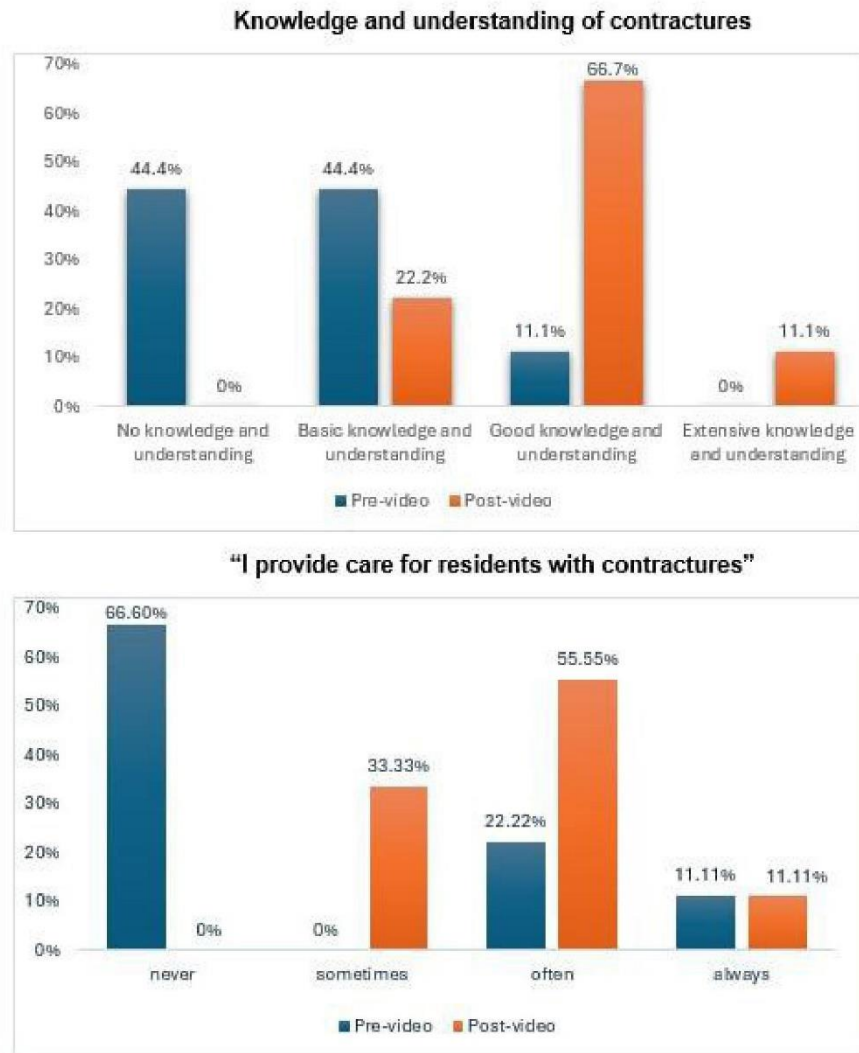


Figure 2 The figure compares pre-video and postvideo survey results on contracture knowledge and understanding among care home staff.

I have more knowledge about: vicious cycle of contractures, STOP—Key to prevent contractures: Strength, Treatment, Opportunity to engage, Positioning.

(3) Engaging presentation and design

Participants found the overall training material engaging and designed to maintain attention.

Well presented and designed in a way to keep attention.

(4) Areas for improvement

Some participants suggested some weaknesses and areas for improvement in the educational video. There were suggestions around the inclusion of pictures related to contractures to enhance better understanding, to increase the size of text in certain visuals (eg, in the vicious circle diagram) for better readability. Moreover, avoiding academic language in some areas and making the script more relatable to the carers to ensure accessibility and relevance to care home staff.

Relate it to carers so that it feels a bit more personal than clinical. Use, you, and your staff/colleagues instead of a third person (care home and their staff)

Clearer messages that support the care staff and they are able to do this without clinical opinion.

In addition, there were suggestions to feature the care home staff in the educational video along with other healthcare professionals to provide a more authentic and relevant perspective.

Include healthcare assistants in the videos.

PDSA cycle 2

In response to the feedback received from the care staff on areas of improvement, the video was refilmed incorporating the suggested modifications. This included a thorough review and redrafting of the script to personalise it for the care home staff and improving the font size of the text for improved readability. Moreover, following the suggestions provided, we also invited a member of the care staff to participate in the video, further enhancing its relevance and relatability.

The refilmed video was shown to 10 care staff members of another local care home. The pre-video survey demonstrated that four out of 10 participants had no knowledge and understanding of contractures (40%), five had basic knowledge and understanding of contractures (50%) and one had good knowledge and understanding of contractures (10%). When asked, how much you agree with the following statement: *I provide care for residents with contractures*, seven reported, 'never' (70%), two reported, 'often' (20%) and one reported, 'always' (10%).

When asked *if they ever used a tool or method to assess the risk of contractures for their residents*, all participants reported, 'no' (100%) and all participants reported that they had never received any training related to contractures or postural management before (100%).

The post-video survey showed that 7 out of 10 participants reported good knowledge and understanding of contractures (70%), two reported basic knowledge and understanding of contractures (20%) and one reported extensive knowledge and understanding of contractures (10%). When asked, how much you agree with the following statement: *I provide care for residents with contractures*, six reported 'often' (60%), two reported 'sometimes' (20%) and two reported 'always' (20%).

The qualitative feedback received was positive and care staff suggested no further changes in the video.

Dissemination

The refilmed video was disseminated via the official YouTube channel of NHS Dorset and is freely and easily accessible.¹⁴ The distribution of the video was further amplified through widespread sharing on social media platforms like Twitter/X. The video gained additional recognition by being featured in the frontline magazine of the Chartered Society of Physiotherapy.

LESSONS AND LIMITATIONS

Lessons

The findings of this project suggest that a training based on an educational video has a positive impact on the knowledge and understanding regarding contractures among the care home staff. To our knowledge, this is the first QI project that developed and tested an educational approach specifically for care home staff.

In the first PDSA cycle, the video was developed and tested with the care home staff, and their feedback was incorporated into the second PDSA cycle, which involved refilming of the video. The refilmed video included a more personalised and relatable language for the care staff in the delivery of the training featuring a care staff member as a trainee. A key lesson learnt in this project was the importance of meaningful and active inclusion of the target group in the development process, which was missing from the initial video. This approach aligns with the principle of *Nothing about us, without us*, which is usually applied to patients but is equally relevant here. Allowing the care staff to see themselves in the video ensured that the content resonated with the target audience, potentially empowering them and improving their confidence in utilising appropriate measures to identify the risks associated with contractures and taking timely action.

Our results also indicate that a video-based intervention is an effective way to communicate and educate the care home staff about contractures. This has also been confirmed by the previous studies that video-based interventions have a positive impact towards encouraging a behavioural change.¹⁵

A duration of 9–10 min of video length was selected to deliver the most important topics relevant to contractures within a context of a care home while maintaining engagement and attention.

Moreover, the STOP acronym used as part of the 'Let's STOP contractures' campaign in the educational video emerged as the most popular and easy to recall feature of the training. This acronym covers all important aspects of contracture prevention strategies that can be utilised in a care home. Research studies have demonstrated that the use of 'to-be-remembered' material such as mnemonic acronyms in the learning phase improves the learning and has a long-lasting effect on the retention of the educational material.¹⁶

The lessons learnt will be used to gradually widen the scope of this project and improve and implement this project in other clinical settings, for example, hospitals and other target populations, informal carers or relatives who care for people with contractures or at risk of developing contractures.

Limitations

The primary limitation of the project revolved around the small sample size across two sites, which hindered the possibility of conducting an advanced statistical analysis of the data; therefore, limiting the generalisability.

Another limitation was the pre-post-test design that did not include a control group and because specific elements of the video could not be isolated, it cannot be ascertained which parts of the video were the most important and easy to retain.

CONCLUSION

This QI project demonstrated that the implementation of an educational video is a feasible and well-accepted way of increasing awareness and improving knowledge and understanding of contractures among care staff. It serves as a cost-effective, easy to retain, transferable and potentially sustainable way to address the lack or poor awareness of contractures among the care home staff. This can ultimately trigger early identification and prevention of contractures and improve the quality of care of the care home residents. Further research is required to identify long-term retention of educational information and evaluate the impact of other educational materials. Also, understanding how the new knowledge acquired by the care staff affects the quality of care provided to the residents and early identification and prevention of contractures.

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Contributors HT, JD and SF were involved in the project design and methodological planning. HT and SF collected and analysed data. HT, KC and SP wrote, organised and edited the manuscript. All authors read and approved the final manuscript. HT is the guarantor for the study.

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Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

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The following supplementary materials are included in **Appendix IV**:

- A. Fishbone analysis
- B. Questionnaire
- C. Educational video snapshots

5.3 Link to Quantitative Study

The educational video developed through the QI study was integrated into the training material developed for care home staff for the quantitative study which formally tested the psychometric properties of ORACLE. The following chapter presents the results of the psychometric testing of ORACLE.

Chapter 6: Psychometric Testing

6.1 Chapter overview

This chapter presents an integrated paper prepared for publication for the quantitative study to evaluate the psychometric properties of ORACLE. The manuscript provides a background to the research problem and study rationale, followed by a detailed description of the methods, including the study design, the participants, the outcomes and outcome measures. The psychometric properties assessed and described for ORACLE include convergent validity, inter-rater and intra-rater reliability, and observed floor and ceiling effects. Additionally, a receiver operating characteristic (ROC) analysis was conducted to establish a cut-off score or threshold which could assist the care home staff in identifying residents at high risk of developing contractures, enabling timely referrals to specialists.

6.2 Integrated paper

This section presents the integrated paper, '*Psychometric properties of the Observational Risk Assessment of Contractures (Longitudinal Evaluation) tool: The ORACLE study*', in preparation for publication as part of the integrated thesis format.

Title:

Psychometric properties of the Observational Risk Assessment of Contractures (Longitudinal Evaluation) tool: The ORACLE study

Introduction

Joint contractures refer to any loss of passive range of motion caused by structural changes in the articular and non-articular tissues around the joint, including muscles, ligaments, fascia, tendons and skin (Wagner and Clevenger 2010). These changes typically occur when the normal elastic tissues are replaced by the inelastic tissues, which results in the stiffening of the joints, causing permanent structural abnormalities (Offenbächer et al. 2014).

Factors contributing to the development of contractures can be intrinsic, extrinsic or a combination of both. Intrinsic factors involve changes within the tissues such as fibrosis, change in sarcomere length, or number of stem cells (Skalsky and McDonald 2012; Mathewson and Lieber 2015). Examples of extrinsic factors, on the other hand, include bed confinement, reduced function and mobility, pain, and muscle weakness (Tariq et al. 2023).

Immobility has been reported to be the most common denominator for aggressive and preventable contractures (Fergusson et al. 2007). Research studies have shown that care home residents tend to spend most of their time remaining sedentary (Forster et al. 2017). This reduced mobility or lack of physical activity has an adverse effect on the physical and psychological well-being of the residents, including reduced motivation to engage in physical and social activities, pain, increased risk of pressure sores, contractures, and increased physical dependency (Forster et al. 2017; Graham et al. 2018). Care home residents are commonly reported to be at risk of developing contractures due to limited mobility. Selikson et al. (1988) demonstrated that 71% of immobile care home residents developed joint contractures, compared to mobile residents who developed none (Selikson et al. 1988). Contractures significantly affect the ability of the care home residents to perform activities of daily living (ADLs). Upper extremity contractures impair the ability to perform tasks like dressing, eating, and bathing, while lower extremity contractures limit independent walking, increasing the risk of falls (Bartoszek et al. 2015; Born et al. 2017). These limitations often lead

to further physical deterioration, immobility, and dependency, ultimately leading to further progression of the existing contracture and compromised quality of life (Born et al. 2017). Contractures resulting from immobility can also increase the burden of care on the formal and informal carers, increase the healthcare demands, and contribute to higher financial costs (Thomas et al. 2002).

It's crucial to understand that progressive contractures, regardless of the underlying cause of immobility, are preventable with early and appropriate interventions. (Jamshed and Schneider 2010; du Toit 2018). The development of joint contractures is often associated with the lack of timely preventative measures. This underscores the importance of implementing proactive measures to reduce the risk of contractures (Jamshed and Schneider 2010). The recommended prevention strategies include maintaining or improving functional ability, appropriate positioning techniques, care staff training and timely risk identification of contractures (Dunn et al. 2000; Wagner et al. 2008; Wagner and Clevenger 2010).

Contracture development usually follows an insidious pattern and can go unnoticed until it becomes painful or significantly interferes with daily functioning, making early identification of at-risk individuals essential for prevention (Wong et al. 2015).

Therefore, interventions and prevention strategies based on the timely identification of risks related to joint contractures in vulnerable adults have the potential to prevent or ameliorate their development or progression.

Unfortunately, despite high prevalence rates, no standardised tool is available to screen or assess the risk of contracture development and progression in adults residing in care home settings.

A valid and reliable contracture risk assessment tool that has the potential to be used by a range of healthcare professionals, including the care home staff, to identify the magnitude of risk, calibrate it, help them prescribe a set of actions in response to the level of risk, and to track subsequent changes in the risk is needed. In addition, timely and appropriate referrals may aid in the prompt escalation of early interventions by the specialists aiming to reduce the risk of contracture development or progression of existing contractures. This would potentially impact an individual's ability to maintain independence with daily living and mobility activities, contributing to improved quality of care. In addition, early identification of the risk and subsequent prevention of contractures will also help reduce costs for the care homes and the NHS, UK.

Development and Content Validation of the Observational Risk Assessment for Contractures: Longitudinal Evaluation (ORACLE)

A prototype of the risk assessment tool for contractures was originally designed by a cross-organisational and multi-disciplinary working group led by Dorset Healthcare, which included physiotherapists, occupational therapists, and registered nurses.

To establish its academic validation before widespread use and implementation, Dorset Health Care partnered with Bournemouth University to sponsor a match-funded PhD Project.

In the project's first phase, the Observational Risk Assessment for Contractures: Longitudinal Evaluation (ORACLE) was further developed and modified with a focus on establishing its content validity. Content validation evaluates whether the tool effectively represents the construct being studied (Mokkink et al. 2010) and provides clarity on each item within the tool (Rubio et al. 2003).

First, a systematic review of the literature was conducted to identify evidence-based factors associated with contractures. Following this, a two-round online Delphi consensus survey was conducted with a panel of 30 international experts. The Delphi technique is a systematic process to gather expert opinions and consensus through iterative rounds and feedback (Nasa et al. 2021). The aim of the Delphi survey was to evaluate the relevance of items for inclusion in ORACLE. The collective findings from the systematic review and Delphi survey informed the subsequent development and refinement of ORACLE.

The detailed study methodology and findings for both studies have been described elsewhere (Tariq et al. 2023; Tariq et al. 2024).

Aim

The current study aims to evaluate the convergent validity, intra-rater and inter-rater reliability, and floor and ceiling effects of ORACLE.

Materials and Methods

This study is nested within a larger multi-phase and mixed methods research project (Trial registration: ClinicalTrials.gov NCT06042907), which aimed to develop and validate ORACLE.

Study Design

This study employed a cross-sectional observational design to evaluate the psychometric properties of ORACLE: convergent validity, intra-rater and inter-rater reliability, and floor and ceiling effects.

Care homes were eligible to participate if the manager was willing and able to release care home staff to attend short training sessions and contribute to data collection.

Participants

The inclusion criteria were adults aged 18 or over residing in residential and/or nursing care homes were included in the study; exclusion criteria were care home residents receiving end-of-life care. Eligible participants were recruited from care homes located in Dorset using non-probability convenience sampling. This sampling method was proposed considering the convenient geographical proximity of care homes to the research team. Sample size estimation was based on the proposed primary outcome of the study, i.e., construct validity. To achieve a correlation coefficient (r) = 0.80 between scores of ORACLE and Barthel Index at 95% CI [0.75-0.85], a minimum sample size of 205 was required (Moinester and Gottfried, 2014).

Data collection procedure and consent:

The first contact with the care homes involved sending an email invitation, including a summary of the study, to care home managers who had previously shown interest in participating in this study. This was followed up with a telephone call where no response was received. In addition, the research team also promoted the study by word of mouth, where they had opportunistic contact with the care homes.

Prior to formal data collection, the care home staff received a short training session that covered education on contractures and instructions on how to use the ORACLE and Barthel Index (Wade and Collin 1988).

A screening document was completed by a delegated senior staff member at the care home to assess the eligibility of the care home residents. The study required working with care home residents which included those who lacked the capacity to consent. The mental capacity of the care home residents was assessed in accordance with the provisions of the Mental Capacity Act (2005) and it was not assumed that a person who does not have an impairment of, or disturbance in the functioning of, the mind or brain, lacks mental capacity.

For those who lacked capacity, their personal consultees (relative/friend) were contacted via the care homes and requested to provide advice. If the personal consultees did not respond with assent or denial within seven days of the contact, a nominated consultee were requested to provide advice. The nominated consultee, in this case, was a registered nurse at the care home who knows the care home resident well and will have no connection with the study.

Participation was voluntary; all residents or their consultees could withdraw at any time. The identifiable data of the care home residents could only be accessed by the care home staff, who had access to this confidential information as part of their professional roles. The master sheet that linked the care home residents to their ID numbers was stored separately by a delegated member of staff at the care home and was not made accessible to the research team.

Following consent, a senior staff member completed a general demographic questionnaire asking for personal and health-related information about the resident (e.g., age, gender, pre-existing contractures, location of contractures, co-morbidities, etc.).

Outcomes

Construct validity

Construct validity refers to the extent to which the scores of an outcome measure demonstrate a relationship to other standardised measures based on their theoretical constructs (Terwee et al. 2007).

Convergent validity: Convergent validity is a subtype of construct validity which can be defined as the extent to which scores on the tool are highly correlated to the scores of another tool that measures the same or similar construct and demonstrate a conceptual overlap (Campbell and Fiske 1959). This is assessed by comparing the scores of the ORACLE with those of the modified Barthel Index (BI), which is a standard measure of physical disability and assessment of performance in activities of daily living (Wade and Collin 1988).

Reliability

Reliability refers to the consistency or repeatability of a measure (Fetters and Tilson, 2018).

Intra-rater reliability: Intra-rater reliability refers to the degree of consistency with which an individual rater or observer (R1) measures the same phenomenon across different instances (T1 and T2), assuming no significant clinical change occurs between the observations (Fetters and Tilson 2018). In this study, the healthcare assistants were the raters and intra-rater reliability was assessed by two separate ORACLE administrations by the same healthcare assistant (HCA) on the same resident. To ensure no real clinical change in the observed traits affected the results, the two observations were completed within a short time interval (Watson 2004). Considering the 12-hour shift pattern of the HCAs, one observation was made in the morning, and the second was completed in the evening of the same shift. To minimise the learning effects, the order of the items within the ORACLE was shuffled for the second observation.

Inter-rater reliability: Inter-rater reliability refers to the consistency in observations among different raters (R1 vs R2) for the same participant (Fetters and Tilson, 2018). In this study, it was assessed by two different HCAs administering ORACLE to the same resident at separate instances. Both observations were made on the same day to ensure no clinical change occurred in the resident's condition.

Floor and Ceiling Effects

Floor and ceiling effects occur when the values of the dataset cluster at the lower or upper end of the scale, respectively (Wang et al. 2008; Ho and Yu 2015). The presence of floor and ceiling effects in health status instruments is indicative of limited content validity and suggests an inability to discriminate between the participants' conditions who score at extremes, thereby reducing the overall reliability of the tool (Terwee et al. 2007).

Outcome Measures

ORACLE

ORACLE consists of the following ten subscales that represent the factors associated with contracture development and/or progression: age category, bed mobility, transfer

ability, walking ability, functional ability, muscle weakness, pain, pressure sores, cognition, and activity engagement. Each subscale includes well-defined statements that facilitate precise classification of the individual's risk level. All subscales have three statement choices scored on an ordinal scale between 0 and 2. The highest cumulative score of ORACLE is 20, indicating the highest risk and the lowest possible score is 0, indicating the lowest risk. The face validity of ORACLE has been peer-reviewed by independent expert physiotherapists' review.

Barthel Index

Barthel Index (BI) for Activities of Daily Living (ADL) is a commonly used measure for functional assessment of care home residents (Challis et al. 2000; Darton et al. 2012). In this study, we used a commonly used modification of BI (Wade and Collin 1988). BI consists of ten ordinal subscales which measures the level of functional independence. Of these, two subscales (bathing and grooming) are rated on a two-point scale (0 to 1), six subscales (feeding, dressing, bowels, bladder, toilet use, and stairs) are rated on a three-point scale (0 to 2), and the remaining two subscales are rated on a four-point scale (transfers and mobility). The total possible score ranges between 0 and 20, where lower scores demonstrate higher disability, and higher scores represent a greater level of independence. The sensitivity, validity and reliability of BI has been well-established (Bouwstra et al. 2019)

Conceptual Overlap between ORACLE and BI Items

To demonstrate a conceptual overlap between ORACLE and BI, the items within both tools were compared using the International Classification of Functioning, Disability and Health (ICF) Core Set framework (WHO 2002). ICF is the most comprehensive framework which categorises health-related domains according to a biopsychosocial model of health, functioning and disability (WHO 2002).

The subscales of both ORACLE and BI were linked to the ICF classification, which classified them into three major domains, 1) Body functions and structures: this domain evaluates impairments in physiological and psychological functions and anatomical parts of the body, like limbs. 2) Activities and participation: this domain addresses constructs like carrying out activities of daily living and involvement in daily life scenarios. 3) Environmental factors: this domain refers to the physical, social and attitudinal surroundings, which could either act as a barrier or facilitator to the

individual's functioning. All three domains are further categorised into different chapters and categories for detailed classification (WHO 2002).

The greatest overlap between the two instruments was demonstrated in the ICF domain of 'Activities and Participation' where four out of ten items of ORACLE (bed mobility, transfer ability, walking ability and functional ability) and eight out of ten items of BI (transfers, mobility, stairs, grooming, toilet use, feeding, bathing, and dressing) overlapped (Appendix V).

Data analysis

The data analysis was conducted using SPSS version 27 (IBM Corp., Armonk, NY) statistical software. Descriptive statistics (means, standard deviation, frequency etc) were used to present the participants' characteristics. The significance level was set at $p < 0.05$ for all analyses.

Convergent validity

Convergent validity was assessed using hypothesis testing guided by a priori hypothesis developed based on previous literature. Convergent validity was determined by using Bivariate Pearson's correlation coefficient to calculate the correlation between the total score of ORACLE and the total score of BI. The correlation coefficient values were interpreted as follows: 0.00 to 0.10 (negligible), 0.10 to 0.39 (weak), 0.40 to 0.69 (moderate), 0.70 to 0.89 (strong) and 0.90 to 1.00 (very strong) (Schober et al. 2018). It was hypothesised that the ORACLE scores would have strong or very strong correlations with those of BI. Additionally, the convergent validity between the related items of ORACLE and BI was calculated using Spearman's correlation which is recommended for ordinal data (Schober et al. 2018). It was hypothesised that there would be moderate to strong correlations between ORACLE and BI items that belonged to the same ICF domains and categories. The convergent validity was considered good when at least 75% of the findings aligned with the hypothesis (Terwee et al. 2007)

Intra-rater and Inter-rater reliability

To evaluate the inter-rater and intra-rater reliability, Intra-class coefficient (ICC), Bland-Altman analysis and weighted kappa were used.

The ICC with a 95% confidence interval was used to evaluate the inter-rater and intra-rater reliability of ORACLE's total numeric score. ICC values were interpreted according to the guidelines by Koo and Li (2016): <0.5, 0.5 to 0.75, 0.75 to 0.9, and >0.90, indicating poor, moderate, good and excellent reliability, respectively (Koo and Li 2016).

For intra-rater reliability, a two-way mixed effects model with absolute agreement was used to calculate the ICC_{3,1}. In contrast, a one-way random effects model for absolute agreement was applied to calculate the ICC_{1,2} for inter-rater reliability due to different sets of raters across multiple sites. The selection of the ICC was in line with the recommendations outlined by Koo and Li (2006).

In addition, Bland-Altman plots were produced which provide a visual representation of the bias (average difference between two observed values on ORACLE) and the limits of agreement (LoA), i.e., how much the two observed values on ORACLE can differ within acceptable limits. The plot was visually evaluated for systematic bias and the presence of outliers. Agreement was considered acceptable if the majority of differences fell within the 95% LoA and if the mean difference (bias) was close to zero.

For ordinal subscales of ORACLE, inter-rater and intra-rater reliability was computed using weighted Cohen's kappa with quadratic weighting. Weighted Cohen's kappa values are interpreted as follows: ≤ 0 , 0.01 to 0.20, 0.21 to 0.40, 0.41-0.60, 0.61 to 0.80 and 0.81 to 1.00 indicating no, none to slight, fair, moderate, substantial and almost perfect agreement respectively (Cohen 1960).

Floor and ceiling effects

Floor and ceiling effects in ORACLE were identified if more than 15% of the total participants achieved the lowest or highest possible score (McHorney and Tarlov 1995).

Cut-off scores for ORACLE

To evaluate the discriminant accuracy and appropriate cutoff score of ORACLE for the presence or absence of contractures, receiver operator characteristic (ROC) analysis was conducted. Area under curve (AUC) of at least 0.70 was considered adequate (Terwee et al. 2007).

Ethics

This research study was granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC (IRAS Project ID: 318311) and the Research Ethics Committee at Bournemouth University (Ethics identification number: 45572).

All participants with capacity provided verbal and signed informed consent at the beginning of the data collection. Where participants could not consent, a close other who understood their wishes (personal consultee) or a nominated consultee was asked to assent on their behalf.

Results

Care home characteristics

A step-by-step process of recruitment, screening, inclusion and analysis is presented in Figure 7. Eight care homes in Dorset participated in the study. These facilities represented a diverse range of services, with four providing a mix of services (residential, nursing and Dementia care), two specialising in dementia care, one in learning disability and one in neurological care.

The care home capacity varied from 17 to 81 residents. All participating care homes were rated either good (n=7) or excellent (n=1) by the Care Quality Commission (CQC).

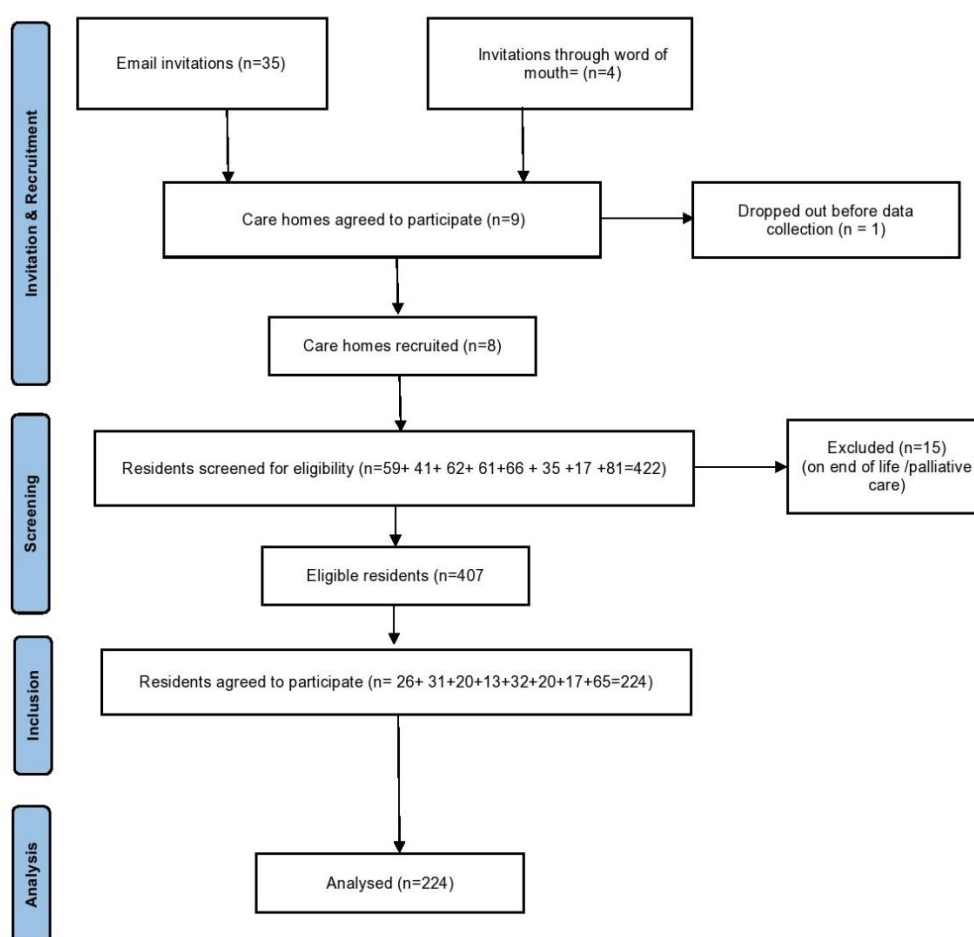


Figure 7 Study flow chart (adapted from Network EQ. CONSORT (2010))

Participant Characteristics

A summary of resident characteristics is presented in Table 4. A total of 224 residents participated in the study. Of these, 31.3% (n=70) had at least one pre-existing contracture. Among those with contractures, 17.1% had a single joint contracture, while 75.71% had multiple contractures. Regarding laterality, 21.4% had unilateral contractures, and 71.4% (n=50) had bilateral contractures. The distribution of contractures was as follows: 42.9% involved the upper limbs, 17.1% the lower limbs, and 32.9% involved both upper and lower limbs. For 7.1% of participants, the number, side or area of contractures was not specified.

Participant Characteristics	Total n=224	Contracture group (n=70)	Non-contracture group (n=154)
Age, years (Mean ±SD)	80.62±12.19 (45-107)	78.29±13.36	81.68 ±11.50
Age group, n (%) Less than 65 years Between 65 and 84 years 85 or older	30 (13.39%) 96 (42.85%) 98 (43.75%)	13 (18.57%) 29 (41.43%) 28 (40%)	17 (11.04%) 67 (43.51%) 70 (45.45%)
Sex, n (%) Females Males	150 (67%) 74 (33%)	52 (74.29%) 18 (25.71%)	98 (63.64%) 56 (36.36%)
Type of care in Care homes, n (%) Mixed services (residential, nursing, dementia) (4 care homes) Dementia care (2 care homes) Learning disability care (1 care home) Neurological care (1 care home)	128 (57.14%) 52 (23.21%) 18 (8.03%) 26 (11.05%)	39 (55.71%) 9 (12.86%) 5 (7.14%) 17 (24.29%)	89 (57.79%) 43 (27.92%) 13 (8.44%) 9 (5.84%)
ORACLE score (Mean ±SD)	9.17 ±4.51	13.31 ±2.63	7.28 ±3.88
ORACLE risk category, n (%) Low risk (0-2) Moderate risk (3-11) High risk (>12)	10 (4.46%) 131 (58.48%) 83 (37.05%)	0 (0%) 11 (15.71%) 59 (84.29%)	10 (6.49%) 120 (77.92%) 24 (15.58%)
Barthel Index score ((Mean ±SD)	7.29 ±6.31	2.44 ±2.97	9.49 ±6.20
Diagnosed neurological condition, n (%) Dementia Stroke Parkinson's disease Multiple Sclerosis Cerebral palsy Spinal Cord Injury Traumatic brain injury Muscular dystrophy	150 (46.87%) 124 (55.36%) 16 (14.29%) 8 (7.62) 5 (4.76%) 4 (3.81%) 4 (3.81%) 4 (3.81%) 2 (1.90%)	60 (85.71%) 34 (56.66%) 9 (15%) 6 (10%) 5 (8.33%) 4 (6.67%) 4 (6.67%) 3 (5%) 2 (3.33%)	90 (58.44%) 90 (100%) 7 (7.78%) 2 (2.22%) 0 (0%) 0 (0%) 0 (0%) 1 (1.11%) 0 (0%)

Down's syndrome	1 (0.95%)	0 (0%)	1 (1.11%)
Becker's muscular dystrophy	1 (0.95%)	1 (1.67%)	0 (0%)
Huntington's disease	1 (0.95%)	1 (1.67%)	0 (0%)
Progressive supranuclear palsy	1 (0.95%)	1 (1.67%)	0 (0%)
Angelman syndrome	1 (0.95%)	1 (1.67%)	0 (0%)
Diagnosed Mental Illness	55 (24.5%)	9 (12.86%)	46 (29.87%)
Depression	31 (56.36%)		
Schizophrenia	18 (32.73%)		
Bipolar affective disorder	3 (5.45%)		
Autism	4 (7.27%)		
Anxiety	1 (1.82%)		
Delirium	2 (3.64%)		
Other Comorbidities			
Cardiovascular disease	101 (45.09%)	18 (25.71%)	83 (53.90%)
Hypertension	52 (51.49%)	11 (61.11%)	41 (49.40%)
Heart disease	49 (48.51%)	7 (38.88%)	42 (50.60%)
Pulmonary diseases	39 (17.41%)	10 (14.28%)	29 (18.83%)
Asthma	26 (66.67%)	9 (90%)	17 (58.62%)
Chronic Obstructive Pulmonary Disease	13 (33.33%)	1 (10%)	12 (41.38%)
H/O Cancer			
Kidney disease	12 (5.36%)	5 (7.14%)	7 (4.55%)
Diabetes	9 (4.02%)	4 (5.71%)	5 (3.25%)
Osteoarthritis	28 (12.50%)	8 (11.43%)	20 (12.99%)
Rheumatoid Arthritis	16 (7.14%)	4 (5.71%)	12 (7.79%)
Blood disorder (e.g., anaemia)	3 (1.34%)	0 (0%)	3 (1.95%)
	6 (2.67%)	1 (1.43%)	5 (3.25%)

Table 4. Participant Characteristics

Convergent validity

A strong statistically significant negative correlation was observed between the total numerical scores of ORACLE and BI, with Pearson's $r = -0.86$ ($p < 0.001$). The results of the convergent validity analysis between overlapping categories of ORACLE and BI (Spearman's correlation) are presented in Table 5. Moderate to strong statistically significant negative correlations between the categories of the two instruments (6 BI, 4 ORACLE) ranging from -0.49 to -0.88 ($p < 0.001$) except for two categories: grooming and bathing (BI) versus functional ability (ORACLE), which demonstrated weak but statistically significant correlations ($p < 0.001$).

As predicted, over 75% of the results were consistent with the hypotheses.

	BI Transfers	BI Mobility	BI Stairs	BI Grooming	BI Toilet use	BI Feeding	BI Dressing	BI Bathing
ORACLE Bed Mobility	-0.74	-0.70	-0.48					
ORACLE Transfer ability	-0.85	-0.84	-0.59					
ORACLE Walking ability	-0.82	-0.88	-0.63					
ORACLE Functional ability				-0.25	-0.52	-0.64	-0.49	-0.28

All correlation coefficients were statistically significant < 0.001

Table 5. Convergent Validity-Spearman's correlation

Reliability

Intra-rater reliability (R1: T1 vs T2)

Intra-rater reliability for the total score of ORACLE was excellent ($ICC_{3,1} = 0.99$; 95% CI=0.99-1.00). Intra-rater reliability of all ordinal subscales of ORACLE demonstrated almost perfect agreement with weighted kappa values ranging from 0.96 to 1.00 ($p < 0.001$) (Table 6).

Item	Rater 1 (time 1) Median	Rater 1 (time 2) Median	Weighted Kappa	P-value

Age category	1	1	1.00	<0.001
Bed mobility	1	1	0.99	<0.001
Transfer ability	1	1	0.99	<0.001
Walking	2	2	0.97	<0.001
Functional ability	1	1	0.97	<0.001
Muscle weakness	0	0	0.99	<0.001
Pain	1	1	0.97	<0.001
Pressure sores	0	0	0.97	<0.001
Cognition	1	1	0.97	<0.001
Activity engagement	1	1	0.96	<0.001
Overall risk category	1	1	0.99	<0.001

Table 6. Weighted kappa findings- intra-rater reliability

On Bland-Altman analysis, there was a strong agreement in ORACLE scores between the two measurements with a mean difference of 0.0, indicating no systematic bias. The LoA were calculated as -1.00 to 1.00, indicating that 95% of the differences between the measurements fall within this range.

Inter-rater reliability (R1 vs R2)

Inter-rater reliability for the total score of ORACLE was excellent ($ICC_{1,2} = 0.99$; 95% CI=0.99-0.99). Inter-rater reliability of all ordinal subscales of ORACLE also demonstrated almost perfect agreement with weighted kappa values ranging from 0.82 to 1.00 ($p < 0.001$) (Table 7)

Item	Rater 1 Median	Rater 2 Median	Weighted Kappa	P-value
Age category	1	1	1.00	<0.001
Bed mobility	1	1	0.93	<0.001
Transfer ability	1	1	0.93	<0.001
Walking	2	2	0.95	<0.001
Functional ability	1	1	0.88	<0.001
Muscle weakness	0	0	0.92	<0.001
Pain	1	1	0.82	<0.001

Pressure sores	0	0	0.85	<0.001
Cognition	1	1	0.87	<0.001
Activity engagement	1	1	0.88	<0.001
Overall risk category	1	1	0.93	<0.001

Table 7. Weighted kappa findings- inter-rater reliability

On Bland-Altman analysis, there was a strong agreement in ORACLE scores between two measurements with a mean difference of 0.0, indicating no systematic bias. The LoA were calculated as -2.00 to 2.00, indicating that 95% of the differences between the measurements fall within this range.

Floor and Ceiling Effects

No floor and ceiling effects were observed, as no resident achieved the lowest (0) or highest (20) scores on ORACLE.

ROC analysis

According to the ROC curve (Figure 8), the ORACLE score of 11.5 was identified as the cut-off value for predicting the risk of contracture(s). The area under the ROC curve was 0.89 (95% CI: 0.84 to 0.93), indicating excellent discrimination between the contracture and non-contracture groups.

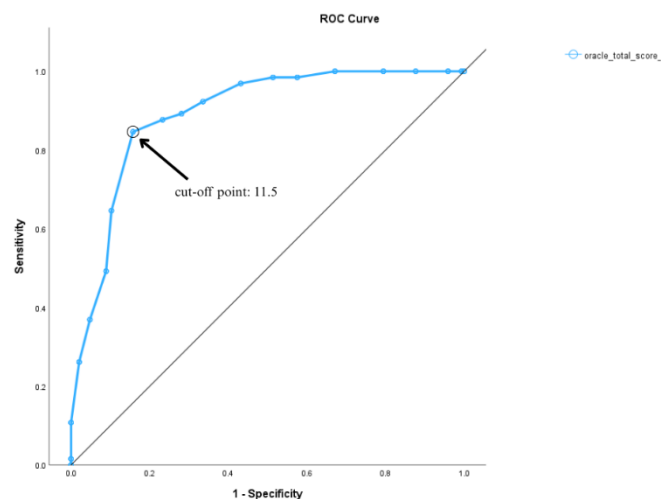


Figure 8. ROC curve

Discussion

The current study aimed to evaluate the initial psychometric properties of ORACLE: convergent validity, intra-rater and inter-rater reliability, floor and ceiling effects and ROC analysis.

ORACLE demonstrated good convergent validity which was supported by a very strong negative correlation with BI ($r=-0.86$; $p<0.001$). BI was selected for convergent validity of ORACLE based on several key factors: First, disability and loss of functional independence are significant predictors of contracture development (Ada et al. 2006; Wagner et al. 2008; Kwah et al. 2012) and BI is a valid and reliable tool for measuring functional independence in long-term care settings (Ohura et al. 2011). Second, there is a conceptual overlap between the sub-scales of BI and ORACLE according to ICF and the scoring system of BI also closely aligns with that of ORACLE. Lastly, it is widely used in care homes to assess residents' levels of function and disability, and the care homes were already familiar with completing it which would contribute to data accuracy. BI has also demonstrated good convergent validity with EuroQoL-5-Dimensions in a similar population, as they both exhibit conceptual overlaps according to ICF framework (Kaambwa et al. 2021).

Although, ORACLE demonstrated good convergent validity overall with the BI, the '*functional ability*' subscale of ORACLE demonstrated weak correlation with the '*grooming*' and '*bathing*' subscales of BI. This could be because the subscales of BI focus on specific self-care tasks, whereas the functional ability subscale of ORACLE assesses the overall or average functional capacity of the resident to perform daily care activities. ORACLE does not assess the specific tasks as its focus is on identifying risk of contractures which can develop when a person's overall functional abilities are compromised. For example, a person who is confined to bed may score good on the '*feeding*' subscale of BI, however, due to limited mobility they could still be at risk of developing lower limb contractures.

The high intra-class correlation coefficients (ICC) and weighted kappa values demonstrated excellent intra-rater and inter-rater reliability for ORACLE total and its subscales. This high level of reliability could be attributed to the short time span between the two measurements conducted by the same rater (i.e., morning and evening of the same shift), which may have facilitated memory effects despite the items being shuffled between the two assessments (Belzak and Lockwood 2024). Interestingly, the inter-rater reliability also exhibited excellent agreement, suggesting that memory effects may not have significantly influenced the results. Furthermore, the high

reliability values could also be linked to the formal training provided to the HCAs prior to data collection, which ensured they understood how to accurately score the specific items within ORACLE.

The main objective of the ROC analysis in this study was to obtain a cut-off score or threshold for ORACLE, which could assist the care home staff in identifying residents at high risk of developing contractures, making timely referrals to healthcare professionals, and triggering timely intervention. A cut-off score of 11.5 was identified through formal analysis; however, given that the ORACLE only computes whole number scores, we selected 11 as the cut-off score to trigger timely referrals.

Strengths

A major strength of this study was the diversity of the study population, which ensured that the results were more representative of the broader population.

Another strength of this study is that the psychometric properties of ORACLE were evaluated using a priori hypothesis.

Limitations

There were a few limitations in the present study. First, the study's cross-sectional design limited our ability to evaluate the predictive validity of ORACLE and accurately predict the development of contractures based on the risk identified. Second, the lack of long-term follow-up restricted our ability to assess ORACLE's effectiveness in tracking contracture progression over time and its impact on reducing the development of new contractures. This was beyond our study's scope due to limited funding and the need to complete the study within a certain time frame. Third, the lack of a gold standard measure for contracture risk assessment restricted us from evaluating ORACLE's criterion validity. Finally, we did not test ORACLE's psychometric properties across various resident subgroups due to large variations in the underlying health conditions and comorbidities.

Conclusion

This study provides preliminary evidence on the psychometric properties of the first evidence-based risk assessment tool for contractures in adults residing in care homes. The results demonstrated good convergent validity and excellent intra-rater and inter-rater reliability with no floor and ceiling effects. The identified cut-off score for

ORACLE would potentially provide a threshold for care home staff to trigger referrals to expert professionals for a more detailed assessment and initiate early intervention. Future research with a longitudinal design is warranted to evaluate the predictive validity and responsiveness of ORACLE and its effectiveness in reducing the incidence and/or ameliorating the severity of contracture development in care home residents.

The following supplementary materials are included in **Appendix V**:

- A. Barthel Index
- B. Screening document and demographics
- C. Participant Information Sheet for residents
- D. Easy-read summary of study
- E. Participant Information Sheet for personal consultees
- F. Participant Information Sheet for nominated consultees
- G. ICF- Conceptual overlap between ORACLE and Barthel Index

6.3 Link to Qualitative Study

The quantitative study provided important evidence on the validity and reliability of ORACLE in care home settings. However, it was vital to understand the care staff's perspectives on its usability and integration into daily work routines. In addition, insights from care staff on contextual factors that may facilitate or hinder ORACLE's practical implementation in real-world settings were also important. The final study presented in the next chapter, therefore, explores these user experiences, offering insights into ORACLE's sustainability and usability in care homes.

Chapter 7: Qualitative Study

7.1 Chapter Overview

This chapter presents an integrated paper, submitted for publication, that details a qualitative study designed to gather insights from care staff on the usability, acceptability, and practical implementation of ORACLE in care homes. The manuscript begins with a background to the research problem and study rationale and aims, followed by a detailed description of the methodology including the study design, participants and setting, specifics of the semi-structured interviews and data analysis approach. Thereafter, the findings with the three emerging themes are discussed in context of the literature. The paper concludes with practice implications focusing on care homes, people, training and support and policy.

7.2 Integrated paper

This section presents the integrated paper, titled, '*Insights from the care home staff on the use of Observational Risk Assessment of Contractures: Longitudinal Evaluation (ORACLE): a qualitative study*' submitted for publication in the journal, *PLOS ONE* as part of the integrated thesis format.

TITLE: Insights from the care home staff on the use of Observational Risk Assessment of Contractures: Longitudinal Evaluation (ORACLE): a qualitative study

ABSTRACT

Background

Contractures, a common but preventable consequence of immobility and inactivity among residents living in care homes, are on the rise. This increasing prevalence and the subsequent impact on care home residents have necessitated the development of a risk assessment tool, the Observational Risk Assessment for Contractures: Longitudinal Evaluation (ORACLE). This qualitative study aims to explore the experience of care staff regarding the usability, acceptability, and practical implementation of ORACLE.

Methods

A qualitative research design was adopted using semi-structured interviews. The care staff members were selected via purposive sampling and were interviewed either through videoconferencing or in person in a private room at care homes. The interviews were recorded and transcribed verbatim. The data collected was coded using NVivo and synthesised using thematic analysis.

Findings

Ten care staff members were interviewed from five care homes (four senior staff members and six healthcare assistants). Three overarching themes were identified: 1) usability of ORACLE, 2) acceptability of ORACLE and 3) contextual factors that can potentially influence the practical implementation of ORACLE in a care home setting. Respondents found the tool to be user-friendly and well-integrated within existing care routines. However, the study also identified factors relating to care home processes, the people involved, the training environment, and the policy context that tend to support or inhibit the effective implementation of ORACLE.

Conclusions

The study offers valuable insights into the usability and acceptability of ORACLE and its application in a care home setting.

Practice Implications

For care homes, key considerations should be given to organisational practices, staffing, regular training, and appropriate and timely specialist support to implement ORACLE effectively. Additionally, policy frameworks and standards must be in place to ensure accountability for care homes and the long-term sustainability of ORACLE

INTRODUCTION

Joint contractures are commonly defined as the partial or complete limitation in passive range of motion (ROM) that results from the shortening of the periarticular structures, including muscles, tendons, ligaments, joint capsules and skin spanning one or more joints (Fergusson et al. 2007; Halar and Bell 2012). Contractures are a common consequence of neurological conditions, e.g. stroke, Parkinson's and Alzheimer's diseases, musculoskeletal conditions like osteoarthritis and fractures and other local conditions such as burns (Fergusson et al. 2007; Jamshed and Schneider 2010; Tariq et al. 2023).

The aetiology of contractures is primarily underpinned by immobility, which could be attributed to an alteration in muscle tone, decreased muscle strength, pain, decreased mobility or function, or impaired cognition (Selikson et al. 1988; Gnass et al. 2010; Tariq et al. 2023). Contractures, once developed, lead to a vicious cycle of impairments, each impacting the next, causing the progression of the original contracture (Jamshed and Schneider 2010). When one or more joints are immobilised in a shortened position for prolonged periods, it leads to fibrotic changes within the muscles, triggering contracture development (James 2001; Halar and Bell 2012). They can increase the risk of additional physical impairments such as pain and discomfort or pressure sores and fractures, contributing to further immobility (Born et al. 2017). Consequently, there is difficulty in performing activities of daily living such as eating, drinking, and dressing; it can also impact the mobility of the residents and how they engage in social activities, increasing the need for nursing care (Fischer et al. 2014; Saal et al. 2019). This, in turn, may lead to further deconditioning, increased dependence on assistive devices and caregivers, worsening of existing contractures, poorer quality of life and increased risk of mortality (Clavet et al. 2015).

Joint contractures are highly prevalent among residents living in long-term care facilities. The prevalence of contractures in care home facilities ranges from 20 to 91% (Yip et al. 1996; Wagner et al. 2008; Fischer et al. 2014; Lam et al. 2022). A study conducted by Lam et al (2022) on long-term care residents reported that a significant

number of residents develop new joint contractures during the first five years of their admission to a care home (Lam et al. 2022). They also reported that approximately 91% of the residents had at least one severe contracture. Of these, 59.4% were affected with severe contractures in more than two extremities, while 40.5% experienced contractures involving all four extremities. The prevalence of contractures in the upper extremities (85.4%) was similar to that of contractures in the lower extremities (75%) (Lam et al. 2022).

The wide variation in the prevalence of contractures could be attributed to the heterogeneous involvement of joint connective tissues in joint mobility, heterogeneous underlying conditions, the lack of a standard definition of contractures, and the lack of a standard outcome measure for contractures (Gnass et al. 2010). The literature has highlighted that nursing home residents should be screened regularly to identify the risk of developing and progressing contractures (Offenbacher et al. 2014; Lam et al. 2022). There is a clear lack of a standard, evidence-based, and systematic risk assessment tool for early identification of contractures and to trigger timely referrals to specialists.

To address this gap, a contracture risk assessment tool for use in care homes, ORACLE (Observational Risk Assessment for Contractures: Longitudinal Evaluation), was recently developed (Tariq et al. 2024). This study aims to explore the experience of care home staff regarding the usability and acceptability of ORACLE and gain insights into its practical implementation.

METHODOLOGY

This study uses a qualitative descriptive design using open-ended, semi-structured interviews (Adeoye-Olatunde and Olenik 2021) to explore the experience of the care home staff on the usability, acceptability and practical implementation of the ORACLE. This study is nested within a multiphase, mixed methods research project (Trial registration: ClinicalTrials.gov NCT06042907), which aims to develop and validate ORACLE in care homes. ORACLE consists of two key components: (a) a 10-item risk assessment tool designed to identify the level of risk of contractures in care home residents and (b) a response algorithm which provides guidance to the care home staff to prescribe a set of actions in response to the level of risk identified to prevent the development or progression of contractures (Tariq et al. 2024). This study

conformed to the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong et al. 2007).

Participants and Setting

The qualitative study was carried out in five care homes that participated in testing the validity and reliability of ORACLE. Two categories of care staff were eligible to participate in the semi-structured interviews. The inclusion criteria were:

- 1) Managers, registered nurses, or senior staff members engaged in coordinating the application of ORACLE in the care homes.
- 2) Healthcare assistants routinely engaged in the care of residents and who conducted ORACLE assessments.

Previous research suggests that theoretical saturation typically occurs after 6 to 12 interviews (Guest et al. 2006). A purposive sample of 10 care staff members was determined, based on available resources and pragmatic considerations. The care staff was purposively selected to capture insights from a diverse range of experiences. The participants included care staff working across a variety of care homes, including nursing, residential, mixed or specialised care facilities (dementia, neurological, etc.). For confidentiality purposes, participating care homes are not named. The care staff primarily cared for elderly residents with minimal support needs or those who required regular assistance with activities of daily living, individuals with cognitive impairments, learning disabilities and chronic health conditions.

Semi-Structured Interviews

The semi-structured interviews were conducted between March and May 2024 either remotely over secure videoconferencing or face-to-face in a private room at the care homes, depending on the convenience of the participants. The interviews lasted between 40 and 60 minutes, interviews were audio and video recorded and transcribed verbatim by HT. HT was a female PhD student who has received training in qualitative research and is also an experienced physiotherapist.

The semi-structured interview guide (see Supporting Information file) was developed based on the research aims through discussion among the research team members and using results from a Delphi survey (Tariq et al. 2024). Participants were asked socio-demographic questions, including their age, gender, and years of experience in care

facilities, as well as questions about the usability of ORACLE. Carers were asked about their experience of completing the ORACLE assessments, e.g. how easy or difficult it was to incorporate the tool into their work routine. Senior staff members, including managers, were asked about their experiences to gain a deeper understanding of the context of the care homes for practical implementation of ORACLE, including whether the care home had the appropriate time, staff and skills resources to perform assessments regularly. Follow-up questions were asked based on the participants' responses and experiences.

Ethics

This research study has been granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC (IRAS Project ID: 318311) and the Research Ethics Committee at Bournemouth University (Ethics identification number: 45572). All participants provided verbal and signed informed consent at the beginning of each semi-structured interview and could opt to withdraw at any time. The data was only accessible by the research team and all transcripts were pseudo anonymised prior to analysis.

Data analysis

HT checked the audio files and corresponding transcripts to correct auto-transcription errors and ensure anonymisation. The transcripts were then imported into qualitative data management and analysis software (NVivo). The transcripts were analysed using reflexive thematic analysis following Braun and Clarke's approach (Braun et al. 2023). A coding framework was developed iteratively during analysis by KC and HT. This was followed by a 5-step process of familiarisation, identifying a thematic framework, indexing, charting, and mapping and interpretation (Braun et al. 2023). Field notes were used to support contextualising and the interpretation of the transcripts. Coding was conducted using a hybrid approach of deductive and inductive reasoning (Fereday and Muir-Cochrane 2006). The deductive approach produced a set of a priori codes derived from the interview guide, while the inductive approach identified new emergent themes. Once coding was complete, overarching themes were developed, and the prominent quotes reviewed were to be extracted based on the themes produced by the research team. Open discussions and iterative revisions were carried out among the research team to reflect on the quotes, thematic coding, and interpretation.

FINDINGS AND DISCUSSION

The average length of the interviews was 40 minutes. Ten care staff members from five private care homes participated in the study. Of these, three specialised in dementia care, neurological care and learning disabilities, while two care homes offered mixed services. The maximum capacity of the care homes ranged from 17 to 69 residents.

Among participants, four were senior staff members who organised the data collection for ORACLE testing, and six were care assistants who completed ORACLE assessments for care home residents. The participants' ages ranged from 21 to 65, and their experience in the care industry ranged from 2 to 16 years. The demographic characteristics of all participants are summarised in Table 8.

Participant ID	Age	Gender	Job role	Speciality	Years of Experience
P1	46	Female	Care Coordinator	Mixed	5
P2	39	Female	Care Coordinator	Dementia	16
P3	44	Male	Care home manager	Learning disabilities + Mental health	15
P4	39	Female	Care Coordinator	Neurological	4
P5	65	Female	Carer	Dementia	8
P6	28	Female	Carer	Learning disabilities + Mental health	2
P7	31	Female	Carer	Learning disabilities	4
P8	29	Female	Carer	Mixed	11
P9	33	Female	Carer	Dementia	3
P10	21	Female	Carer	Mixed	4

Table 8. Participant Characteristics

Overarching themes

From the data analysis, three overarching themes emerged: 1) usability of ORACLE, 2) acceptability of ORACLE and 3) contextual factors that can potentially influence

the practical implementation of ORACLE in a care home setting (Figure 9).

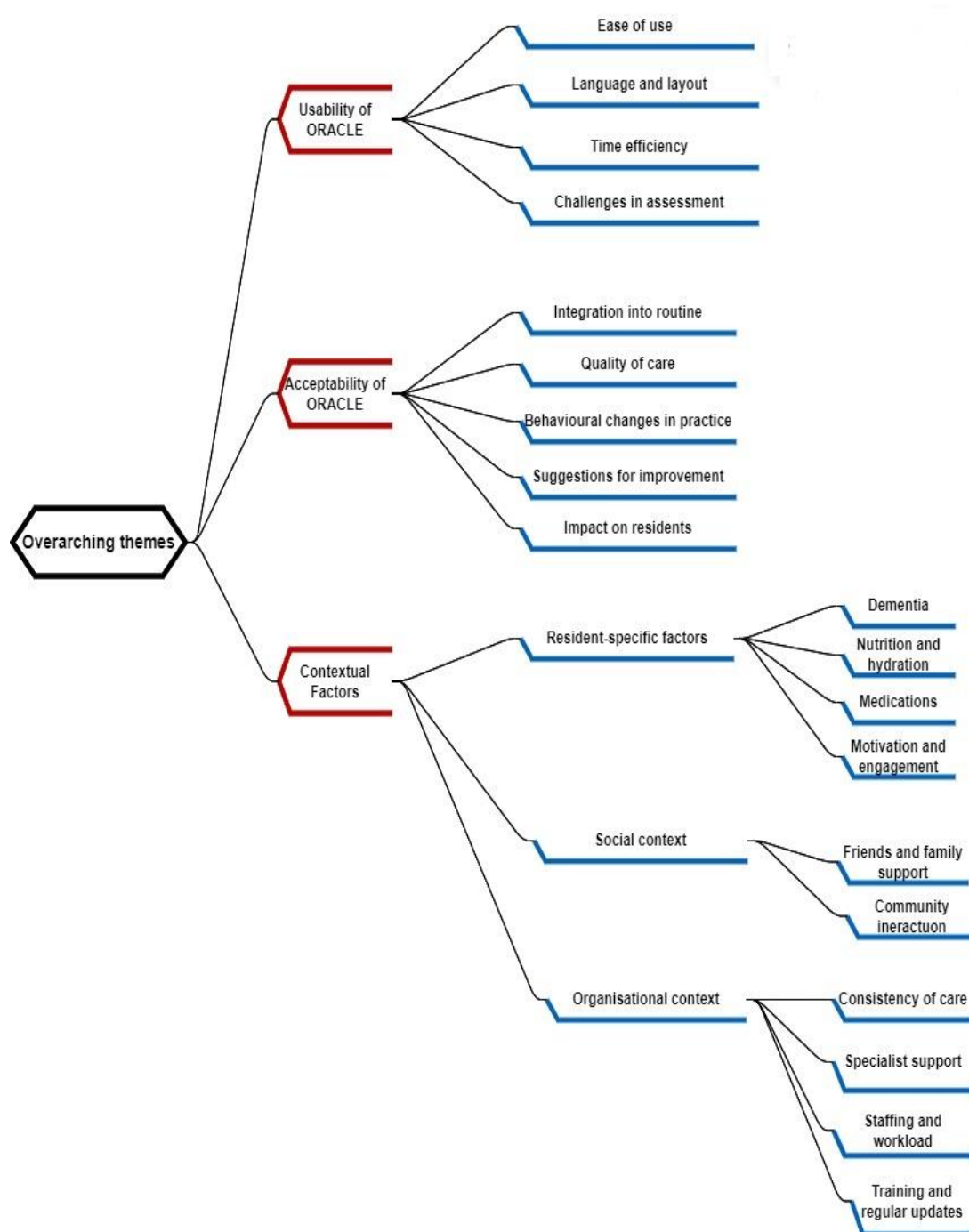


Figure 9. Thematic Map

Theme 1: Usability of ORACLE

Usability of ORACLE is a key consideration in care home settings with demanding work schedules. For successful implementation, the outcome measures must be quick

to use, accessible and easy to integrate into existing workflows (Dunckley et al. 2005). Outcome measures which are time-consuming or have complex scoring systems are difficult to implement in practice and increase the chance of errors in risk assessment (Dunckley et al. 2005; Sanders et al. 2016).

The following sub-themes were identified within this theme:

Usability: *ease of use*

Carers consistently reported ORACLE as a user-friendly tool with a straightforward and easy-to-use scoring system. They appreciated that it allowed them to quickly sum up the scores for contracture risk assessment without complex calculations.

'The scoring was very easy....Just add them all up, and it's straightforward'
(Carer#3)

Some senior staff members highlighted that ORACLE's simplicity and user-friendly interface enhanced its overall usability, ensuring that the tool was easily adapted by the newer staff with minimal training and exposure.

'It was easy to understand. I think it was well set out, and easy to complete...and I think the carers were all quite comfortable using it as well...as if they'd sort of done it before, which was quite good' (Senior staff member #2)

Usability: *layout and language*

All participants found the overall layout and design of the ORACLE simple and effective, enabling easy navigation through different sections of the tool. The use of headings, subheadings, and appropriate font size improved readability and accessibility. In addition, all participants reported that the wording used was simple, clear, and comprehensible for carers with varying levels of experience.

'The language used was clear and easy to understand, and I liked the overall layout of this tool...yeah it was easily readable' (Carer#2)

Usability: *time efficiency*

All carers who completed assessments on ORACLE reported that one assessment typically took 2-5 minutes to complete. One participant believed it might take a little longer for new or agency staff who are unfamiliar with the residents' overall condition.

'Actually, it's been a really long time that I've been working here, so I know the residents here very well. So, for us, it doesn't take that long out there because we are working with them in day-to-day life. So, it only took a couple of minutes for one resident. But yeah, it might not be the same for new or agency staff' (Carer #1)

Usability: challenges in assessment

Despite overall positive reception, a few staff members found it difficult to interpret and assign predefined ranks (zero, one or two) in certain categories of ORACLE. This could potentially lead to inconsistent assessments, potentially affecting ORACLE's ability to identify the risk of contractures accurately. This difficulty in categorising the residents into ranks could be attributed to the significant gap between the training provided to the carers for effective use of the tool and actual data collection, leading to potential lapses in recalling how to effectively rank the categories.

Two carers specifically mentioned the category 'functional ability' because some residents can perform certain activities but not others, making it difficult for them to provide a single rank.

'Where it says if they are able to carry out activities... it was a little bit difficult to judge because some of them can eat themselves but might not be able to dress. So, I feel like maybe there could be a bit of separation or something.' (Carer #5)

'It's really hard to put them into a zero, one, or two because some of them will dress partly, eat partly. You know, some will eat the main meal but then can't eat the pudding. It depends on the cutlery and the bowls. I struggled because some of them could dress their top half but not their lower half. So, yeah, I struggled to categorise them in that box' (Carer#5)

One carer found assigning a rank to the category 'pain' difficult, particularly when judging residents who are unable to communicate.

'A lot of them can't really tell you anything... so that was a bit of a judge...I was like, oh, no pain, but maybe there is pain because people with dementia

can't really express it. So, that will be one that was a little bit difficult to judge."
(Carer# 6)

Theme 2: Acceptability

Acceptability in this study refers to the overall willingness of the care staff to implement ORACLE in existing work routines. It encompasses the following sub-themes:

Acceptability: *integration into routine*

Most participants reported that ORACLE assessments could be easily integrated into their care routines without significantly impacting their usual work responsibilities. One participant, however, also mentioned that it might be difficult to complete the assessment on a daily basis, but it could be easily incorporated into monthly, fortnightly, or weekly routine care assessments.

'You're doing their charts anyway in their room... with this, you could just gauge down to check nothing's changed, and that's it. Incorporate it in when they do the daily records. And then you could do this one as well and do a risk assessment, so you'd know if anything's changed' (Carer #3)

'Day-to-day it would be quite difficult because every day is not the same. Sometimes we can't even spare a couple of minutes. But once a month or once every couple of weeks, it would be fine' (Carer #4)

When asked when the best time to complete the ORACLE assessments was, most carers preferred to do so after the residents' daily care routine, whereas one carer preferred to do so in the midafternoon.

'Probably after they've got up in the morning and we've done all the care.... then we could go through this to make sure if things have changed.. because we would have seen all their body...we would have moved them... we would have done all that is required and spoke to them so then that would be easy to fill out' (Carer #1)

'Morning and evening are quite busy for us, so anytime in mid-afternoon'
(Carer #4)

Acceptability: *quality of care*

The participants believed that ORACLE can potentially improve the quality of care of care home residents. This belief was enhanced by care home staff understanding the purpose of ORACLE, its key components, and how using it in practice can help recognise the risk associated with contractures and support care provision.

'It covers important areas like mobility, hydration, nutrition, pain, and skin health. It all links together to give us a complete picture of the resident's risk and improve their care accordingly' (Senior staff member #3)

Acceptability: *behavioural changes in practice*

Targeted interventions introduced in care homes supported by staff training improve staff confidence and the overall quality of care provided to the residents.

Carers felt that the training sessions and using ORACLE in practice helped increase their awareness of residents' mobility and risk of developing contractures. Two senior staff members also used it to train new staff members on contractures.

'It is harder to deal with contractures than it is if they can move their legs around... because we used to have a lady, her legs were stuck...well, you can't get to do personal care...you can't do nothing because you can't force the legs...once they've developed... So, now we try and get them to at least try and move their leg. Or if they can't, we move them so that at least the muscles still moving' (Carer #1)

'We've had sort of recent recruitment where we've had new people come in. So I have kind of earmarked it to sort of go through with them and just give them a rough outline because I don't want to make it too complex for them'
(Senior staff member #1)

These findings are consistent with those from a previous study by Petyaeva et al (2018) on the feasibility of a pain assessment intervention for care home residents with dementia. The study showed that the intervention improved staff awareness, increased staff confidence and informed decision-making across the staff (Petyaeva et al. 2018).

Acceptability: *suggestions for improvement*

The care staff were asked for suggestions for areas of improvement in the tool. A few respondents suggested that while integrating ORACLE into routine care seems easy, it must also be carefully planned and requires a team effort to implement it effectively.

'I do feel it does need like a network of people to come together. I do feel it's quite a lot for, say, one or two people to do sort of independently. If a group of people, you know, get together and just work on the actual tool itself. I think that would definitely be better to apply the tool in routine care' (Senior Staff member# 4)

Respondents also suggested regular training sessions and updates on contractures, which could improve the tool's effectiveness and the carers' familiarity with it. The agency staff should also be provided with basic training around contractures.

'More training, I was just about to say. Yeah, giving us more training to us would be handy' (Carer #6)

'I've never seen that in any agency staff ever talk about contractures, so there's a missing link there, definitely' (Senior staff member #1)

Some carers also suggested that adding a definition of contracture and/or a picture of a contracture into the tool could be beneficial.

Acceptability: *impact on residents*

Carers did not notice any discomfort or negative reactions from residents during ORACLE assessments.

Theme 3: Contextual Factors

Contextual factors are important in understanding 'what works for whom and under what circumstances' to successfully implement newly developed outcome measures in care homes (Flynn et al. 2021). Care homes are complex environments where the implementation of an intervention or a service depends on its properties and how it interacts with the environment in which it is introduced (Peryer et al. 2022). Identification of these factors, e.g., organisational practices, provides insight into the barriers and facilitators to effective implementation and provides implementation strategies care homes can adopt to enhance the sustainability of the service introduced (Fischer et al. 2016; Goodman et al. 2017; Flynn et al. 2021).

Three sub-themes were developed: resident-specific factors, social context and organisational context.

Resident-specific factors: *Dementia*

Care staff found it challenging to implement the response actions of ORACLE with residents with dementia, especially those with severe cognitive deficits, as these individuals often struggle to follow instructions. They suggested that additional guidance tailored to residents with dementia might help carers provide better care. Severe cognitive impairment not only makes it difficult for residents to follow instructions but also affects their understanding of the importance of physical activity.

'I think that would definitely be a useful tool with some tips on how we could facilitate that with our dementia residents. Maybe that could be displayed in sort of visual cards, you know, explaining what we want to do. It's very difficult sometimes to get that engagement, you know, and get them focused on the task you want them to do' (Senior staff member #3)

Previous research has also shown that using additional material, such as flash cards, to communicate with dementia residents improve care practices (Petyaeva et al. 2018).

Resident-specific factors: *Nutrition and hydration*

Decreased mobility levels in care home residents is a significant risk factor for developing contractures (Wagner et al. 2008). Care staff felt that adequate nutrition and hydration are vital for maintaining energy levels for residents' mobility. While some felt overweight residents also struggle with mobility, therefore indicating a need for balanced diet management.

'So we had a lady [resident] diagnosed with a type of dementia which affected her perception of food, which caused her to stop eating. In the last six months, she started eating again but not full meals, only biscuits and things like that., she gained weight which affected her ability to turn as well' (Senior staff member #1)

'If they're not hydrated, they are going to sleep more...they're going to move less and therefore, we're doing them a disservice... and obviously then, that impacts their skin integrity. ...and if their skin integrity is affected and they've got pressure sores again, they're going to be less likely wanting to move...they might be in pain' (Carer #6)

Resident-specific factors: Medications

Adverse drug reactions like cognitive impairment and falls are one of the major causes for hospital admissions for older adults (MacRae et al. 2021).

Care staff also highlighted the impact of certain medications on mobility and the importance of balancing medication schedules to mitigate these risks.

'You know, if somebody is on furosemide and they're needing the toilet a lot and they're having to get up and go, ok, they're moving... but equally, they probably just want to sleep... they're probably tired. So, they're probably sleeping, toilet sleeping, you know, and again then they might not be eating and drinking as well because they're not having a good, peaceful sleep. So yeah, it has an impact' (Senior staff member #1)

'...,we have residents who are on medications to help with any sort of aggressive behaviour or if they've been anxious. But it also means that they become sleepy and if it's somebody who is quite mobile, then they're at risk of falls. So, getting the timings right for their medications is important. Otherwise, if they fall, then we're going to have problems because that will, you know, have an effect on their mobility' (Senior staff member #3)

Resident-specific factors: Motivation and engagement

Literature suggests a strong association of psychological and emotional well-being of care home residents with physical health and level of disability (Yeung et al. 2013).

Care staff emphasised that overall motivation and engagement in activities are critical in maintaining mobility and thus would significantly impact the effectiveness of the tool, especially for those with dementia and the elderly.

Social context: *Family/friends support*

Family and friends play a key role in enhancing the quality of life for care home residents through visiting, providing emotional support, monitoring their well-being, maintaining social connections and promoting a positive adaptation to care home life (Roberts et al. 2020). Participants in this study also felt that family and friends' support and visits play a key role in keeping the residents motivated and active. They also shared that family members should be more involved in the care process to help the residents stay engaged and motivated.

'You can see the families where the residents whose families come again; it gives them that sense of purpose. Again, the families are also providing their care needs, like, even if it's just, they're coming to talk to them it then it frees the carers up to be able to go and spend time with those other residents that maybe don't have the family and to be able to do the things to help them' (Senior staff member #4)

Social context: *Peer support*

Care staff also shared that regular participation of residents in social activities at the care home keep them engaged and motivated to move around.

'Yeah definitely, even if we're talking, we talk with our hands, don't we? And just moving... its all the little things even if that's anything like getting someone's attention, Oh Hello! And things like that... compared to not having any reason to move' (Senior staff member #1)

These findings are reinforced by a cross-sectional study by Yeung et al (2013) which found a negative correlation of institutional peer support from other residents with physical decline and depressive symptoms in older adults (Yeung et al. 2013).

Organisational context: *Consistency of care*

Care staff viewed that high turnover and reliance on agency staff can lead to inconsistency in care across care homes and less personalised attention for care home

residents, which could be a barrier to the effective implementation of ORACLE in care homes. Moreover, as mentioned earlier, the agency staff may also struggle with ORACLE assessments due to unfamiliarity with residents.

'.. I think in general across the industry, there is a lack of time and lack of staff...like for example we had a lady [carer] who left us, and she's gone to work in another care home, and she said, so far all I've done is work with agency staff. So, there's inconsistency of care, the staff not knowing the care plans, the staff not knowing the residents' (Senior staff member #2)

Organisational context: *Specialist support*

Most of the care staff felt that external services, such as physiotherapy and occupational therapy, are generally quick to respond to referrals. However, some of the care assistants stressed that the specialists could be more involved in providing detailed instructions and guidance to carers so that they could perform the care plan effectively and confidently with the residents.

'I feel like it could be improved. One of the recent ones [physio] was quite good because he actually put some pictures of how he wants us to position the resident and then the pillows, and that has been very handy in comparison with other times that they've come and they just talk to the nurse. We're the ones who do their personal care, so the information gets lost, you know?' (Carer #5)

Organisational context: *Staffing and workload*

Almost all care staff stressed the importance of having more staff to adequately address the needs of all residents, especially those who are less demanding but require significant attention because they are at risk of developing contractures.

Organisational context: *Training and Regular updates*

All participants emphasised the importance of regular training on how to use the tool effectively and training on contractures, especially that includes guidance on identifying risk factors, prevention strategies, and handling dementia residents.

STUDY LIMITATIONS

This study had a few limitations. First, we were unable to recruit any nursing staff from the participating care homes, potentially leading to an incomplete representation of the

diverse experiences of all care staff. Second, there was a time delay between the training and the actual data collection in some care homes, which could have influenced participants' recall and application of the training content. Moreover, although purposive sampling was used, the views of the participants may not be representative of all care staff. All these limitations should be considered when interpreting the findings of the study.

CONCLUSION

The study offers valuable insights into the usability of ORACLE and its application in a care home setting. Respondents found the tool to be user-friendly and well-integrated within existing care routines. However, the study also identified factors relating to care home processes, the people involved, the training environment, and the policy context that tend to support or inhibit the effective implementation of ORACLE.

PRACTICE IMPLICATIONS

Care homes

Care homes that emphasise holistic care approaches, including proper nutrition and hydration, may find ORACLE more effective, as the tool's assessments are integrated into broader care strategies. Additionally, medications and polypharmacy were identified as important factors affecting the mobility levels of the care home residents. Care home staff must understand these effects and coordinate with the General Practitioner (GP) to integrate medications into the residents' routines to minimise their effect on overall mobility and improve ORACLE's efficacy.

People

Both care assistants and residents are crucial in the practical implementation of ORACLE. Care assistants must navigate the complexities of each resident's motivation and engagement levels when using ORACLE. For example, a resident's willingness to participate in activities or mood can significantly affect their assessment outcomes, particularly in areas related to functional ability and mobility. This also highlights the importance of understanding the resident's psychological and emotional states, often influenced by their interactions with care staff, family, and peers.

Family and friends' support is another critical factor that can influence the practical implementation of ORACLE. Residents with strong family ties may show different levels of engagement and motivation, affecting their risk of developing conditions like contractures. Family visits can either motivate residents to be more active or, conversely, lead to emotional distress that impacts their physical engagement. ORACLE's assessments must consider these dynamics, requiring care staff to make decisions that reflect the resident's physical condition and social and emotional context.

Training and Support

Given the challenges identified, particularly with language and categorisation, there is a clear need for enhanced training and support for care staff using the ORACLE tool. Providing additional guidance, such as simplified instructions or examples, could help mitigate confusion and ensure consistent tool use. Organisational support is also essential, such as allocating adequate time for staff to learn and use ORACLE effectively.

Policy

Currently, the Care Quality Commission (CQC) does not explicitly mandate the prevention and management of contractures as part of its regulatory framework for care homes in the United Kingdom (CQC 2024). This contrasts with the Omnibus Reconciliation Act (OBRA) of 1987, which governs long-term care facilities in the United States. It explicitly states that long-term facilities must ensure that a resident who enters a facility without contractures does not experience a contracture without justifiable cause. A resident with contractures receives treatment and services consistent with professional nursing standards designed to increase ROM or maintain existing ROM (Acello 2003).

This represents a significant policy gap, given the severe impact contractures can have on residents' quality of life. While ORACLE offers a practical solution for addressing this issue, its application in practice would be limited by the absence of a formal requirement for care homes to monitor and prevent contractures.

This policy change also would ensure that care homes are held accountable for implementing effective strategies to prevent and manage contractures, thereby promoting consistency of care and improving the overall quality of care.

Additionally, incorporating contracture prevention into CQC requirements would necessitate training and resource allocation changes within care homes. Staff would need to be trained in using tools like ORACLE and understanding the broader factors that contribute to contractures, such as nutrition, hydration, medication management, and psychosocial support.

In summary, effective and successful implementation of ORACLE within the care home setting needs a comprehensive approach that considers several factors, including organisational practices, staffing, training, and appropriate support from specialists. Additionally, policy frameworks and standards must be in place to promote the application and sustainability of ORACLE and improve the overall quality of care.

The following supplementary materials are included in **Appendix VI**:

- A. Interview guides
- B. Participant Information Sheet for senior staff members
- C. Participant Information Sheet for healthcare assistants.

Chapter 8: Discussion and Conclusion

8.1 Chapter Overview

This chapter presents an integrated discussion and analysis of this multi-phase mixed methods research project in relation to the thesis aim and objectives.

The first section offers a concise summary of the research problem, emphasising its importance and offering an overview of its context and significance. It also revisits the overarching aim and objectives that guided this research. A summary of each study is then presented, laying the groundwork for an in-depth examination of the main research findings.

Subsequently, the main findings of this project are explored in the context of the existing evidence base and considered in terms of their practice implications. The contribution to new knowledge is then emphasised, indicating the study's relevance in filling gaps within the literature or offering novel insights.

Lastly, the chapter reflects on the strengths and limitations encountered throughout the project and suggests directions for future research. This is followed by the main conclusions of the project, offering a summary of the research findings and impact.

8.2 Introduction

This project aimed to develop and validate a contracture risk assessment tool to address a critical gap in the literature. Evidence has consistently highlighted the need for structured risk assessments, early intervention, and prevention of progressive contractures (Bartoszek et al. 2015). Once developed, contractures follow a cascade of impairments and lead to further deterioration of contractures, impacting the overall mobility, functional independence, social participation and quality of life of the affected individuals (Müller et al. 2013; Heise et al. 2016). This is of particular importance for care home residents as institutionalised individuals reportedly remain more sedentary and engage in less physical activity (Forster et al. 2017), thus placing them at a higher risk of developing contractures.

The initial development of progressive myogenic or arthrogenic contractures, which involve shortening muscles, tendons, or other surrounding structures, is usually gradual and often overlooked by the resident or their caregivers unless they become

painful or disabling (Campbell et al. 2014). Given their frequent and close interactions with residents during care delivery, healthcare assistants (HCA) play a crucial role in this research. They are ideally suited to screen and identify early warning signs and monitor changes in health, such as mobility issues, pain, or mood, which could indicate an increased risk. With regular and structured risk assessments, HCAs can monitor residents proactively, facilitating timely intervention and prevention. Empowering the non-medical care home staff to assess and monitor the risk would potentially improve the overall quality of care in care homes.

Therefore, ORACLE was specifically designed for care home staff, particularly HCAs, who are the primary caregivers for care home residents. From the outset of this project, it was essential to ensure that the tool would be easily accessible and easy to use for the care staff without formal medical training.

The overarching aim of this project was to develop, validate, and evaluate the feasibility of Observational Risk Assessment of Contractures-Longitudinal Evaluation (ORACLE) in care homes, and to provide an educational video aimed at improving knowledge about contractures and compliance with its use.

The following research objectives were developed to fulfil this overarching aim:

1. To collate and synthesise the available evidence on factors associated with joint contractures in adults through a systematic literature review.
2. To further develop, refine and assess the content validity of ORACLE through expertise and knowledge held by field experts through a modified e-Delphi survey.
3. To develop training material for care staff members on contractures for improved understanding of contractures and effective use of ORACLE.
4. To determine a cut-off score for ORACLE and evaluate the following psychometric properties of ORACLE:
 - a. Convergent validity
 - b. Intra-rater reliability
 - c. Inter-rater reliability
 - d. Floor and ceiling effects
5. To explore the usability and acceptability of ORACLE among the care home staff through interviews with care home staff.

6. To identify contextual factors that may support or inhibit the practical implementation of ORACLE in care homes through interviews with care home staff.
7. To refine the ORACLE tool and develop implementation guidance for care homes based on the research findings to improve its efficiency and usability.

These research objectives were operationalised using a multi-phase mixed methods approach consisting of five consecutive studies, each addressing specific objective(s). The studies were structured into two distinct phases:

Phase I: Content validation

1. Systematic review
2. Delphi survey
3. Educational video

Phase II: External validation:

4. Psychometric testing
5. Qualitative study

8.3. Summary of findings

8.3.1 Overview of each study

Study 1: Systematic review

This review addressed the first objective; it collated and synthesised the available evidence on factors associated with the development and progression of joint contractures in adults, which informed the development of ORACLE (Tariq et al. 2023). The main inclusion criteria were adults aged 18 or above who developed progressive atherogenic or myogenic contractures as a secondary complication of a primary condition (e.g., stroke, SCI, etc.) or after a period of immobility. Studies on children, as well as non-progressive and scar contractures, were excluded. A comprehensive literature search was conducted across four electronic databases (MEDLINE, CINAHL, AMED, and EMBASE), yielding 7,324 unique results. After title and abstract screening by two independent reviewers, 183 full texts were assessed for eligibility; two independent performed data extraction and assessed the quality of evidence. The review finally synthesised evidence from 47 studies (n =

275,631 participants), categorising factors into three main domains: sociodemographic factors, physical factors, and proxies for bed confinement (Figure 10).

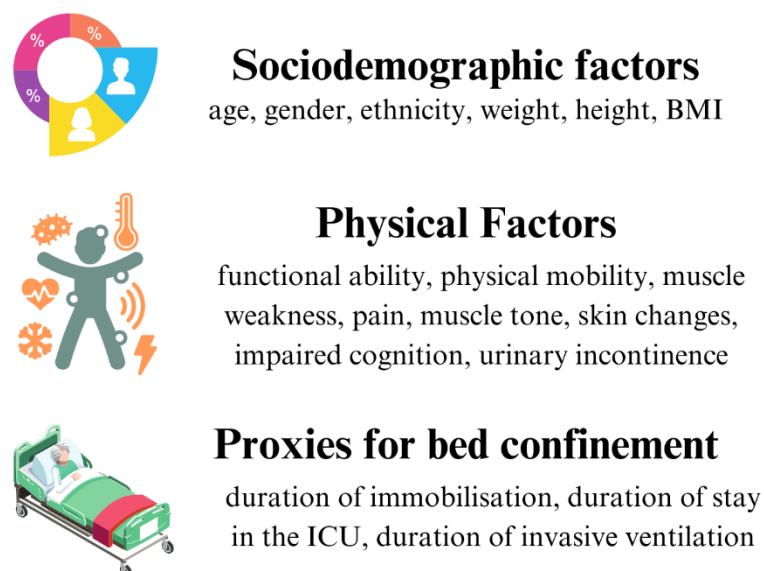


Figure 10 Identified factors from systematic review (Personal Collection 2024)

Notably, sociodemographic factors, such as age and gender, were not consistently associated with contracture development, while physical factors like functional ability, pain, muscle weakness, and bed confinement demonstrated a stronger association. Importantly, the role of spasticity in contracture formation remained unclear, a finding that reflects the mixed conclusions in the broader literature (Tariq et al., 2023). These findings provided a robust evidence base for determining the most relevant items for inclusion in ORACLE.

Study 2: Delphi Survey

Building on the systematic review, the second consecutive study aimed to address the second objective of further developing the main components of ORACLE and establishing its content validity through the expertise and knowledge held by field experts (Tariq et al. 2024). The modified two-round online Delphi survey included 30 and 25 panellists, respectively, with backgrounds in physiotherapy, occupational therapy, nursing, or rehabilitation medicine. In the first round, the experts were asked

to rate the predesigned list of items on a Likert scale, while in the second round, consensus was sought regarding the newly suggested items and areas of disagreement identified in the previous round. The items were related to factors associated with joint contractures, appropriate preventive care interventions, and relevant contextual factors associated with care home settings. Panellists reached a high level of consensus (between 70% to 100%.) on 10 out of 15 clinical factors, 9 out of 10 preventive care approaches, and 12 out of 13 contextual factors (Tariq et al. 2024). The clinical factors identified were used to develop the first part of ORACLE, identifying individuals at risk of developing or worsening contractures. The care approaches identified contributed to the second part of ORACLE, which guides the care home staff to intervene in response to the level of risk identified in the first part. Finally, the identified relevant contextual factors which are later discussed in this chapter, would potentially help to improve ORACLE's usability, practical implementation and sustainability in a care home setting.

Findings from study 1 and study 2 informed the development of a contracture awareness video specifically tailored to address the needs of care staff.

Study 3: Educational video

Based on the evidence from studies 1 and 2, a contracture educational video was developed for the care home staff as part of a QI-driven project supported by NHS Dorset (Tariq et al. 2024). This was the third consecutive study that addressed the third objective of developing contracture training material for care home staff to improve their understanding of contractures and the effective use of ORACLE. The video was co-created as a collaboration between the trust's clinical staff, the QI team and support from staff from two care homes. The study involved two sequential Plan-Do-Study-Act (PDSA) cycles and adopted a pre and post-test design to evaluate the impact of the contracture awareness video. Baseline data revealed that 89% of the care staff had either no knowledge (56%) or only basic knowledge (33%) of contractures. Post-video intervention, the staff reported increased knowledge and understanding of contractures to good (67%) and basic (22%). Additionally, the staff provided qualitative feedback and suggested changes to the video to improve the accessibility of the information for care staff (Tariq et al. 2024). Consequently, the feedback was incorporated into the refilming of the video. The project demonstrated

that introducing a contracture educational video is a feasible and positively received method of enhancing awareness, knowledge and understanding of contractures among care staff who lack formal medical training.

The video with additional instructional materials for ORACLE and other outcome measures was incorporated into a PowerPoint presentation and delivered as a training package to the care staff from participating care homes during the next phase of the project (External validation).

Study 4: Psychometric Testing

The ORACLE tool developed following the Delphi survey entered its external validation phase, where it was formally tested in the care homes. This marked the fourth consecutive study in the project, which addressed objective four by evaluating the psychometric properties of ORACLE.

Building on the contracture awareness video, a training package was developed and delivered to the care staff from the participating care homes before the data collection.

The study employed a cross-sectional observational design to evaluate the following psychometric properties of ORACLE: convergent validity, intra- and inter-rater reliability and floor and ceiling effects. The inclusion criteria were adults aged 18 or over residing in care homes, and the exclusion criteria were care home residents receiving end-of-life care. Eight care homes with 224 care home residents participated in the study, of which 70 residents had existing contractures (31%). The findings demonstrated good convergent validity of ORACLE ($r = -0.86$, $p < 0.001$) with Barthel index (BI) and excellent intra- and inter-rater reliability with no floor and ceiling effects observed. The study also identified a cut-off score for ORACLE, potentially providing a threshold for care home staff to trigger referrals to expert professionals for a more detailed assessment and initiate early intervention.

Study 5: Qualitative study

The final study expanded on the quantitative findings (Study 4) and addressed objectives five and six by exploring the usability, accessibility and practical implementation of ORACLE through interviews with the care staff.

A qualitative research design was employed using semi-structured interviews. The inclusion criteria were a) managers, registered nurses, or senior staff members engaged in coordinating the application of ORACLE in the care homes and b)

Healthcare assistants routinely engaged in the care of residents and who conducted ORACLE assessments.

Ten care staff members were selected using purposive sampling and were interviewed either via videoconferencing or in person in a private room at care homes.

The care staff provided suggestions for improvement, e.g., regular training sessions and adding a definition and/or picture to the tool. ORACLE was generally viewed as a user-friendly tool and well-integrated within the existing care routines. However, the study gained additional insights into contextual determinants like care home processes, the people involved, the training environment, and the policy context that tends to support or inhibit the effective implementation of ORACLE. The findings from this study contributed to further refining of ORACLE and the implementation guidance developed for the care homes (Appendix VII).

8.3.2 Summary of findings across studies

Study	Objective	Key Findings	Implications for ORACLE
 Study 1: Systematic review	To collate the available evidence on factors associated with joint contractures in adults.	Consistent evidence: bed confinement, reduced functional ability, muscle weakness, pain and impaired physical mobility Inconsistent evidence: age and spasticity Weak evidence: impaired cognition, clonus, spastic dystonia, urinary incontinence and pressure ulcers	- Provided the foundational factors for the development of ORACLE.
 Study 2: Delphi survey	To further develop and refine ORACLE and assess its content validity through expertise and knowledge held by field experts.	Consensus was reached on 10/15 clinical factors, 9/10 preventative care approaches and 12/13 contextual factors.	-Validated key components for the development of ORACLE. -Focused on physical and clinical signs that care home staff can assess during informal observations and interactions. -Highlighted key contextual factors that could enhance the usability and sustainability of ORACLE in care home settings.
 Study 3: Educational video	To increase the awareness and understanding of contractures among care home staff	- Baseline: Care staff lacked knowledge of contractures. - Post-intervention: Prominent increase in knowledge and understanding.	- Reinforced the need for contracture training and education alongside ORACLE implementation. - Incorporate the educational video in the training session for ORACLE in the testing phase.
 Study 4: Psychometric Testing	To evaluate the psychometric properties of ORACLE.	-Good convergent validity of ORACLE with Barthel Index. -Excellent inter-rater and intra-rater reliability on both total scores and subscales of ORACLE.	- ORACLE is a valid and reliable tool for assessing contracture risk when used by trained care staff.
Study 5: Qualitative study	To explore the usability and acceptability of ORACLE in care homes.	- Care staff found ORACLE easy to use and easy to integrate into the routine. -Care staff expressed confidence in their ability to use ORACLE after training. -Staff expressed concerns about interpreting subscales like functional ability and pain, especially in people with cognitive deficits.	- ORACLE is feasible and acceptable for use by care home staff. - Staff training is essential for consistent and accurate interpretation of ORACLE. -Care home managers must consider contextual determinants that can facilitate the tool fidelity in the long run.

Table 9 Summary of findings across the studies

Table 9 above provides a synopsis of the five studies, their key findings, and their implications for ORACLE development, validation, and implementation in care home settings. The next section presents a further analysis of the key findings from across the studies in relation to the literature.

8.4. Discussion of main findings

Joint contractures are a significant health challenge in care homes, impacting residents' quality of life and increasing care demands. This section aims to discuss the key findings of the research through the lens of implementation science.

Care homes are a complex system of subsystems where people, tasks, technologies, physical environment and organisational culture continuously interact and influence each other (Peryer et al. 2022). Goodman et al. (2017), in their report on care home readiness, recommended that the organisational context of care homes must be evaluated before new initiatives are introduced (Goodman et al. 2017).

The aetiology and impact of joint contractures are multifaceted and complex; likewise, contracture prevention in care homes is also complex, demanding coordinated practices and systems of care in place for effective implementation (Fischer et al. 2016). Implementation research evaluates how various interventions or approaches are adopted and applied practically in different contexts and outside the controlled research environment (Hwang et al. 2020). Introducing and integrating any new intervention in a care home routine practice would be practical if effective implementation strategies are applied (Waltz et al. 2019). Implementation strategies are methods or approaches adopted to improve a clinical practice or program's integration, implementation and sustainability (Proctor et al. 2013).

The implementation strategy should be tailored to the unique, local and dynamic context of care home facilities. One of the first steps in tailoring effective implementation strategies is to identify and evaluate the factors that can act as barriers or facilitators during the implementation process (Proctor et al. 2013).

8.4.1 Conceptual Framework

The researcher for this project employed the Consolidated Framework for Implementation Research (CFIR) as an overarching conceptual framework to interpret the main findings of this research. CFIR is realist-informed in its design as it acknowledges the dynamic and context-dependent nature of implementation and

focuses on understanding ‘what works for whom and in what circumstances’ (Yakovchenko et al. 2021).

It is one of the most widely used frameworks in implementation science, and it provides an overarching typology of factors that may influence the sustainability and routinisation of interventions or health services (Greenhalgh et al. 2004), making it contextually appropriate for care homes.

It is comprised of five primary domains: 1) intervention characteristics, 2) outer setting, 3) inner setting, 4) individual characteristics, and 5) process of implementation (Damschroder et al. 2022).

Figure 11 illustrates the five domains of CFIR framework as applied within in the context of this research.

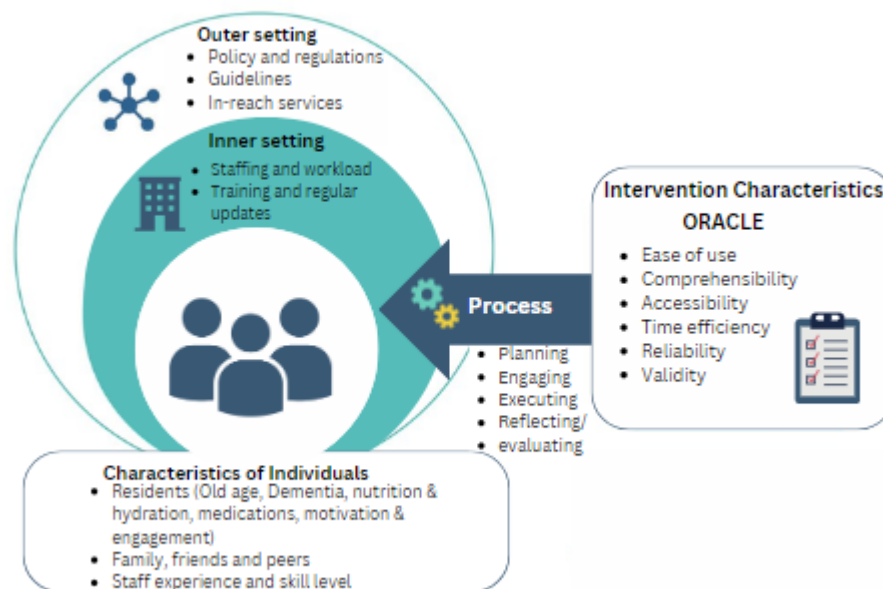


Figure 11 CFIR framework adapted from Damschroder et al (2022)

1. **Intervention characteristics:** The factors under this domain refer to the inherent characteristics of the intervention itself. In this research, the properties of the ORACLE tool, including ease of use, accessibility, time efficiency, validity and reliability are categorised under this domain.

Ease of use and accessibility for care staff

The aimed users of this tool are care staff, particularly the healthcare assistants (HCAs). Given the care home context, where formal medical assessments may

not be feasible or practical for the care staff, ORACLE was developed with an emphasis on observable and physically examinable factors, which HCAs can easily and quickly assess during their usual care routines. Several studies have shown that assessment scales that are easily comprehended across different contexts and populations have broader applicability in implementation science (Khadjesari et al. 2020). Additionally, to ensure ORACLE's accessibility and usability, a public and patient involvement (PPI) activity was conducted with HCAs prior to its formal testing in care homes. This ensured that the tool was easy to comprehend, and that the terminology used was accessible for staff who lacked formal medical training. Literature shows that input from diverse PPI groups can provide valuable feedback on the relevance, helping to make the interventions culturally appropriate and refining the language by eliminating jargon, making it accessible and straightforward for the end-users (Gray-Burrows et al. 2018; Capobianco et al. 2023).

Validity of ORACLE

The quantitative findings from the convergent validity analysis in Study 4 (Chapter 6) demonstrated that ORACLE's total score had a strong negative correlation with the Barthel Index (BI) ($r = -0.86$, $p < 0.001$), supporting the overall construct validity of ORACLE. However, the subscale of functional ability in ORACLE demonstrated weaker correlations with subscales of grooming and bathing in BI. This discrepancy is likely due to a conceptual difference in how the two tools capture and measure the aspects of physical function.

These findings are consistent with the qualitative feedback from care staff in Study 5. Few staff members indicated that while ORACLE was generally easy to use, there were challenges in categorising residents' abilities in certain functional areas. For example, tasks such as dressing or feeding often involve complexities that may be difficult to capture with a single score or rank in ORACLE.

Practice Implications:

These insights suggest that although ORACLE captures functional ability on a broader level, specific tasks may require detailed assessment or clearer criteria to ensure that variations in residents' functional abilities are accurately captured and reflected in the overall contracture risk assessment.

Reliability of ORACLE

The findings from Study 4 (Chapter 6) demonstrated excellent intra-rater and inter-rater reliability for the total score of ORACLE and its subscales. The consistency of assessments is of particular importance due to the heterogeneity of the care homes and the significant variation in residents' demographics and staff skills across multiple sites (Gordon et al. 2014).

On the other hand, the qualitative findings in Study 5 (Chapter 7) provided additional insight into how this consistency could be achieved or challenged in the practical world. While the staff reported that ORACLE was generally an easy-to-use and accessible tool, a few expressed concerns with the interpretation of pain and functional ability subscales, especially in residents with cognitive impairments (e.g., those with advanced dementia). Some staff also suspected that newer or agency staff with limited training or those who lack familiarity with the resident's condition may take longer to complete ORACLE assessments.

Practice Implications

In this research, the intra-rater reliability was assessed over a short interval (morning to evening shift); it is important to consider shift working while doing the risk assessments. The lack of continuity in care home staff contact with individual residents due to staff turnover, lack of experience or shift patterns could potentially hinder the staff's familiarity with the residents' condition, making it difficult to track or monitor subtle changes and capture accurate risk. High staff turnover and shift patterns in care homes have been reported to compromise the reliability of assessments in previous studies (Kane et al. 2005). These findings suggested that while ORACLE is a reliable tool for contracture risk assessment, ongoing training and support are important to maintain consistency, particularly in settings with high staff turnover or limited staff experience.

2. **Outer Setting:** This domain encompasses external factors or influences impacting the implementation of the healthcare intervention, such as policies, guidelines and regulations. In this study, external factors include policies, standards or regulations by external authorities for care practices in care homes, standard guidelines specific to joint contractures and access to external healthcare services.

Policy and regulations: The Care Quality Commission (CQC) is the UK's primary independent regulatory authority for adult health and social care

services. Currently, care homes in the UK are not required to report contractures to the CQC, unlike the incidence of pressure sores, which the care homes are obliged to report. Preventable joint contractures are often considered a key quality indicator in other countries. For example, under the Omnibus Reconciliation Act (OBRA) of 1987, which governs long-term care facilities in the United States, care homes must ensure that measures are taken to prevent contractures (Kelly 1989). Similarly, in Germany, joint contracture risk assessment and prevention have recently been defined as a quality indicator for nursing homes, regulated and monitored by experts from the statutory health insurance system (Müller et al. 2013). According to this regulation, nursing homes in Germany must report whether they regularly carry out risk assessments for joint contractures and implement relevant preventative measures (Müller et al. 2013). This highlights a critical gap in the policy that could impact the implementation of ORACLE as a standard risk assessment tool across care home settings in the UK. If contracture risk assessment and preventative measures become a part of the UK's standard quality indicators and regulatory framework, care homes would prioritise contracture preventative interventions the same way as they do to prevent pressure sores.

Guidelines: There are no guidelines available in the literature for risk assessment, prevention, and management of contractures, which significantly hinders optimal care. With ORACLE offering a practical solution to standard risk assessment practices, there is a dire need for standard guidelines for the care staff and health care practitioners to follow in response to the level of risk identified by ORACLE. Translating the best available scientific evidence into guidelines for care staff and healthcare professionals would ensure the consistency of care practices, promote person-centred care, enhance multidisciplinary collaboration and improve the efficiency of ORACLE. Several reviews have reported significant improvements in the care process with standard guidelines (Lugtenberg et al. 2009).

External support services: External support or in-reaching services provide on-site referral services to care home residents, including physiotherapy, occupational therapy, and other health services. In study 2 (Chapter 4), the Delphi experts identified 'timely access and quality of in-reaching services' as a

relevant contextual factor for contractures in care home settings. This finding was further reinforced when, in study 5 (Chapter 7), care staff expressed that the external services usually respond quickly to referrals; however, they also expressed that the guidance provided by the specialists to the HCAs could be more detailed and improved. Research has consistently demonstrated that high-quality external support services like physiotherapy through targeted exercise plans can help residents in care homes (Khalaily 2023). The services can help enhance their muscle strength, improve joint flexibility, reduce pain, promote their physical activity levels and functional independence (Henskens et al. 2018; Khalaily 2023).

3. **Inner setting:** The factors under this domain pertain to the structures and context within the internal environment that influence the implementation of interventions. In this study, the internal factors are related to the internal environment of the care home, such as staffing, workload, staff training, and regular updates.

Staffing and workload: In both study 2 and study 5, adequate staffing levels and high workload were identified as important contextual factors in contracture prevention and effective implementation of ORACLE within existing workflows. Evidence suggests that staff workloads and turnover rates are high in the care home sector, which may influence the long-term sustainability of a new intervention (CQC 2012). Additionally, care staff in previous research have reported a lack of time due to heavy workloads to incorporate physical activity into the existing work routines (Resnick et al. 2008; Benjamin et al. 2014). Therefore, inadequate staff-to-resident ratios might leave staff members insufficient time to implement ORACLE and the subsequent preventative measures effectively.

Training and regular updates: Study 2 (Chapter 4) identified education and training of caregivers and service users as important contextual factors. Study 3 (Chapter 5) further reinforced the need for training among the care staff in which the baseline survey demonstrated poor knowledge and awareness of contractures among care staff. Furthermore, in study 5 (Chapter 7), the staff highlighted that the training provided to the care staff prior to the formal testing of ORACLE was

useful and helped them complete assessments on ORACLE effectively. They further emphasised the need for further training on contractures, ongoing support and regular refresher sessions, which can potentially increase the effective use of ORACLE across care homes. Previous research has found that upskilling care home staff can improve working practices that may be associated with reduced avoidable harms like falls, pressure ulcers, and urinary tract infections (Damery et al. 2021). Upskilling care staff and raising their awareness regarding contractures could potentially improve their care practices around risk assessment, use of ORACLE and contracture prevention.

4. **Characteristics of individuals:** This domain focuses on all key stakeholders involved in implementing the intervention, such as staff, family members, and service users. In this study, this domain is further classified into residents, family/peers, and care staff members.

Residents: Specific characteristics of residents that may impact the implementation of ORACLE risk assessment and response actions (preventative measures) fall into this category. These include ageing, dementia, nutrition and hydration, medications, and motivation and engagement levels.

- a. ***Ageing:*** The systematic review findings (Chapter 3, study 1) suggested that evidence regarding ageing as a potential risk or contributory factor for contracture development was inconsistent. The research team decided to explore this further in the Delphi survey (Chapter 4, study 2), and interestingly, the panellists identified ageing as a potential factor for the progression of existing contractures but not for the development of new contractures. Interestingly, in study 4 (chapter 7), it was observed that the mean age of individuals in the contracture group (78.29 ± 13.36) was lower than those in the non-contracture group (81.68 ± 11.50). Additionally, further analysis of the age category revealed that the prevalence of contractures in the age category 'between 65 and 84' was slightly higher (41.43%) than in the age category of '85 or older' (40%). These findings suggest that age alone might not be a strong predictor of contractures. This also accords with the findings of a recent longitudinal study conducted by Lam et al. (2022); the study evaluated the rate of developing new contractures and associated risk factors in long-term care residents (Lam et al. 2022). They

reported that for those residents who already have an existing contracture, older age is an additional risk factor for developing a new contracture. These findings underscore the importance of a holistic approach to contracture risk assessment in care homes. For elderly residents, it is important to consider their overall mobility limitations and the presence of existing contracture rather than age alone.

- b. *Dementia*: The systematic review results (Chapter 3, study 1) revealed correlations between cognitive impairment and contractures; however, there was insufficient evidence to make robust inferences. On the other hand, the Delphi experts reached a consensus (>80%) on impaired cognition as a potential contributory factor for developing and progressing joint contractures. In study 4 (Chapter 6), around 55.36% (n=124) of the total participants had a diagnosis of dementia. Of these, only 27.41% (n=34) were in the contracture group, while the majority, 72.58% (n=90), belonged to the non-contracture group. However, there was a higher proportion of residents identified with moderate to high risk of contractures with dementia compared to those without dementia. It is important to note that data related to dementia severity (mild, moderate or severe) or stage (early vs advanced) was also not collected in the current study; therefore, it is difficult to determine the level or severity of cognitive impairment in residents with contractures. A growing body of evidence indicates that severe dementia can lead to significant mobility limitations in care homes; around 89% of the care home residents with dementia demonstrate some degree of mobility limitation, and the mobility limitations are higher in people with severe to very severe cognitive deficits (Williams et al. 2005). This demonstrates that dementia diagnosis may not be an independent predictor for contracture development; however, advanced stages of the disease may lead to significant mobility limitations, which in turn is an established risk factor for the development of contractures (Selikson et al. 1988; Offenbächer et al. 2014) (Offenbächer et al. 2014). Therefore, for residents with dementia, the staff should focus on preventative care strategies targeting potential mobility limitations, especially in the advanced stages of dementia. Moreover, staff found it challenging to implement preventative guidance in response to the risk of contractures assessed on ORACLE (Study 5, Chapter 7), particularly for those with communication

difficulties, such as individuals with severe cognitive impairments. This warranted additional guidance and training with ORACLE for the staff tailored to the needs of people with communication difficulties. Previous research has found the positive effects of using additional material, such as flashcards, to communicate with dementia residents (Petyaeva et al. 2018).

- c. *Nutrition and hydration:* Delphi experts in study 2 did not reach a consensus on diet as a contextual factor for developing contractures. However, they identified adequate nutrition and hydration as one of the preventative care approaches for contractures. In study 5, the staff emphasised the importance of adequate nutrition and hydration in ensuring the residents have appropriate energy levels to move around. Likewise, overweight residents might also struggle to move around. Literature also suggests that both undernutrition and obesity are associated with low mobility levels in care home residents (Fayemendy et al. 2021)
- d. *Medications:* Delphi experts in study 2 identified medications as one of the contextual factors for contractures. The care staff members reinforced this in study 5, who believed that certain medications and polypharmacy significantly impact the residents' mobility levels. This is reinforced by evidence that polypharmacy is associated with mobility problems in care home residents (Koçak et al. 2022).
- e. *Motivation and engagement:* Activity engagement was identified by the Delphi experts as an important factor contributing to the development and progression of contractures. Care staff in study 5 also highlighted the importance of the residents' overall motivation and engagement levels as critical in maintaining mobility. This is in line with the literature, which demonstrates the association of depression with reduced functional mobility in care home residents (Kvæl et al. 2017).

Family, friends and peers: Lack of regular social engagement and lack of support from family was identified as a relevant contextual factor for contracture development and progression. Likewise, in study 5, the care staff emphasised that support from family, friends and peers plays a key role in keeping the residents socially engaged and motivating them to do physical activity, a key preventative

measure for contractures. Evidence supports the role of family, friends and peers in providing emotional support, monitoring their well-being and maintaining social connections, which contributes to the overall social engagement and the motivation of the care home residents (Yeung et al. 2013; Kvæl et al. 2017).

Staff experience and skill level: Accurate and reliable assessments of ORACLE depend on the care staff's clinical observations during daily care routines. In study 5, the staff members expressed that new or agency staff might struggle to complete ORACLE assessments due to unfamiliarity with the residents. Additionally, some staff members found it challenging to rank individuals with different functional and pain levels, particularly those with communication needs.

5) Process: This domain refers to the implementation process of the new intervention introduced (Damschroder et al. 2009). This includes planning, engaging, executing and reflecting. This study considers the care home management responsible for each stage. To successfully implement ORACLE, the care home managers must be receptive to change, supportive of the new intervention, and allocate staff members for systematic planning to introduce ORACLE into existing care routines (planning). They should provide training opportunities to care staff members to raise awareness on the importance of contracture prevention and conducting effective ORACLE assessments (engaging). Allocate trained staff members to monitor residents, conduct regular risk assessments, and trigger timely referrals in response to the identified risk (execute). Finally, the process should integrate ongoing feedback mechanisms and regular check-ins with staff to ensure and maintain ORACLE's fidelity in the long run (reflection).

In summary, the successful implementation of ORACLE in care home contexts relies on key CFIR domains. The domain of '*Intervention Characteristics*' emphasises ORACLE's ease of use, comprehensibility, time efficiency, validity and reliability. The domain of '*Outer Setting*' highlights the importance of external factors like regulatory policies, guidelines and external support services. The '*Inner Setting*' domain encompasses determinants like staffing, workload and training opportunities. The domain of '*Characteristics of Individuals*' focuses on all stakeholders involved in ORACLE implementation, such as care

home residents, family, friends and peers, staff experience, and skill levels. Finally, the domain of '*Process*' captures the strategies and steps that include systematic planning, staff engagement and training. In addition, monitoring the use of ORACLE through ongoing feedback mechanisms to allow for iterative improvement based on staff input would potentially ensure that the implementation can be adapted and refined as it is embedded into routine care.

Together, these CFIR domains provide a realist framework to address inherent properties of ORACLE, external pressures, internal readiness, and individual and staff engagement to ensure seamless and sustainable integration of ORACLE into routine care, ultimately improving the quality of care for residents.

8.4.2 Practice Implications

Based on the CFIR analysis, practice implications for care homes and policy-makers are outlined below:

For Care homes:

- Offer regular training sessions and ongoing support on contracture awareness and ORACLE for care staff, especially those with limited experience, to enhance their ability to conduct accurate and consistent risk assessments.
- Establish efficient referral systems to trigger timely referrals and initiate early intervention for contracture prevention.
- Provide special training opportunities for care staff to develop skills in assessing and implementing preventative strategies for residents with mental illnesses, communication challenges or cognitive impairments.
- Emphasise a holistic care approach that prioritises ensuring residents receive adequate nutrition and maintain proper hydration levels.
- Provide access to appropriate equipment to promote the mobility levels and functional independence of the residents.
- Consider the effects of certain medications and polypharmacy on mobility and coordinate with residents' GP to adjust or reduce medications where possible so that they are timed in a way that does not interfere with their ability to perform daily tasks.
- Offer education and awareness programs for care home residents and informal carers, including relatives, to highlight the importance of physical activity to

prevent contractures. In addition, care homes can offer training sessions or workshops for relatives on engaging residents in physical activities during their visits.

- Organise regular group activities to improve the social and physical engagement of the residents.
- Ensure adequate staff-resident ratios and manage workloads to provide sufficient time for staff to monitor residents, conduct regular risk assessments and follow preventative guidance.

Based on the findings of this research, ORACLE was further refined with special guidance notes for residents with Dementia. In addition, an implementation guide for care homes was developed for effective, accurate and consistent application of ORACLE. This addressed the final objective of this research (objective 7).

For Policymakers:

- Given the policy gap, there is a need for CQC to incorporate contractures as a quality indicator within its regulatory framework. This policy would obligate the care homes to implement systematic and formal risk assessment for contractures and subsequent prevention procedures, ensuring high standards of quality care and accountability.
- Moreover, there is a need to develop general guidelines on contracture prevention and management for care staff and healthcare professionals to ensure consistency of care across the care home settings.

8.5 Additional Findings

8.5.1 Contracture Prevalence

The prevalence of contractures among care home residents provides an insight into the extent of the issue and its practical implications. The current prevalence of contractures highlights the urgency of identifying and addressing key factors contributing to contracture development.

The evidence on the prevalence of contractures in long-term facilities in the UK is minimal. To our knowledge, only one study conducted by Yip et al. (1996) has reported a prevalence of 55% in individuals who received NHS continuing geriatric

care in the UK (Yip et al. 1996). In contrast, the findings of the current study showed that less than a third (31.2%) of the participating care home residents (n=224) had at least one documented joint contracture (Chapter 6, study 4). This difference in prevalence rates could be attributed to the variation in demographic characteristics of the residents included in the respective studies. For example, in the current study, the total number of residents with a stroke diagnosis was only 16 (7.14%), whereas in their study, the total number of diagnosed stroke cases was 120 (54.1%). Notably, the prevalence of contractures among the stroke cases was similar in both studies, i.e. 56.3% (current study) and 55.8% (previous study). This prevalence rate corroborates the observed prevalence of contractures in several studies conducted on individuals affected by stroke (Pohl and Mehrholz 2005; Sackley et al. 2008; Kwah et al. 2012). Regarding the involvement of the upper and lower limbs in the total contracture cases, the findings of the current study show that 75.7% had at least one upper limb contracture, and 50% had at least one lower limb contracture. Interestingly, the study by Yip et al. (1996) also reported a similar pattern, i.e., 72.7% and 55.4% for upper and lower limb contractures, respectively (Yip et al. 1996). The findings suggest that given the demographic differences, the current prevalence of contracture remains high and is a significant problem requiring urgent attention in care homes. The consistency in stroke-related prevalence and limb involvement highlights the need for an individualised approach. Specifically, individualised monitoring of contracture risk, e.g. in stroke and upper limb impairments, could be instrumental in improving the quality of care and support provided in care homes.

The subsequent section focuses on this project's contribution to new knowledge.

8.6 Contribution to knowledge

Contractures are a major health problem, especially for care home residents, severely impacting their mobility, functional independence and quality of life. This comprehensive, multi-phase mixed methods project not only contributed to an improved understanding of contracture risk but also developed a groundbreaking, novel and evidence-based contracture risk assessment tool. Each study provided distinct and original contributions to the field, advancing the current literature on contractures. Several key new knowledge areas were identified to inform future clinical practice within care homes, policy-making, and future research.

8.6.1 A novel and evidence-based tool for contracture risk assessment

This project, initiated in 2019, aimed to address a critical gap in current care practices for care home residents where contracture prevention is often overlooked (Offenbächer et al. 2014) and develop a robust, evidence-based, and scientifically validated contracture risk assessment tool. ORACLE was developed using a rigorous approach: a systematic review of the literature to identify key factors, a Delphi consensus survey with experts to confirm its clinical relevance, and feedback from the care staff to ensure the tool was accessible and practically relevant for the aimed users (PPI).

The tool was psychometrically tested across eight care homes with diverse demographics to establish its reliability and construct validity. Care home staff were also interviewed simultaneously to evaluate the tool's usability, acceptability, and the contextual factors potentially influencing its successful implementation in care home settings.

This rigorous development and validation process aligns with the established evidence-based practices and recommendations for scale development (Boateng et al. 2018; Streiner et al. 2014). In contrast, the Contracture Risk Assessment Tool (CRAT), published in Nursing Times in 2020, was developed using clinical judgment and expertise; however, it lacks evidence-based development and formal psychometric testing (Khudadad et al. 2020). A lack of a systematic development and validation process would mean that CRAT's content validity, accuracy, and reliability remain uncertain, which may limit its practical implementation and effectiveness compared to ORACLE. In addition, unlike CRAT, ORACLE was developed specifically tailored for the care home context where healthcare assistants who spend the most time with the residents lack formal training and may be unable to perform complex medical assessments. It was developed with an emphasis on observable and physically examinable factors rather than on the identification of medical conditions or comorbidities that contribute to contracture development. Moreover, in contrast to CRAT, ORACLE provides a simple scoring system for care staff, which guides them to take further action based on the scores, prompting timely referrals and early intervention.

8.6.2 Identification of aetiological factors for contractures

Previous literature has identified several risk factors for contractures. Given the multi-factorial nature of contracture development and its vicious cycle, the systematic review (study 1) in this project not only expanded on those findings but also identified additional associated factors that may contribute to the development and progression of the contractures. This was the first systematic review that provided comprehensive and in-depth evidence from 47 studies on understanding the role of proximate, ultimate and associated factors for contracture development and progression. Furthermore, the identified factors served as the foundation for the key components of ORACLE. The findings of the Delphi survey further validated the components through expert consensus, which are central to contracture risk assessment in a care home setting. Consolidating evidence-based risk factors and associated factors into a systematic and practical tool like ORACLE enhanced the understanding of contracture development and progression and provided a new framework for its prevention.

8.6.3 Multidisciplinary input

The study team, comprising the researcher and the supervisory team, included a physiotherapy academic, two nursing academics, and a clinical physiotherapist, reflecting multidisciplinary contribution in all project stages.

Moreover, the Delphi survey sought expert consultation and consensus from researchers and practitioners from diverse healthcare professions (physiotherapy, occupational therapy, nursing and rehabilitation medicine). This added to the value of a collaborative and interdisciplinary approach in developing a risk assessment tool.

In addition, in Study 3, the development of the contracture awareness video also employed multidisciplinary input, reflecting the significance of an interdisciplinary approach in the prevention and management of contractures.

In summary, the project highlighted the importance of multidisciplinary collaboration and research in advancing knowledge and identifying holistic approaches to care for improving contracture care.

8.6.4 Development of educational material

Another novel contribution of this project was developing an evidence-based contracture educational video specifically tailored for care home staff. The video was co-created with multidisciplinary input and systematically tested using quality improvement (QI) methodologies. Using the feedback from the care staff in PSDA cycle one, the video was redeveloped, improved and disseminated publicly for broader access. To our knowledge, this presents the first evidence-based educational resource developed for contracture identification, prevention and management, particularly for care home settings.

8.6.5 Identification of contextual factors

In addition to identifying the aetiological factors for developing a risk assessment tool for contractures, this project also identified important contextual factors that may influence the implementation of ORACLE in long-term care settings. These findings contribute to the growing body of evidence on how contextual factors like staff turnover, high workload, training and organisational support can act as barriers or facilitators and influence the implementation of new interventions in real-world contexts, particularly long-term care settings.

8.6.6 Identification of gaps in current knowledge

This project also identified several gaps in the literature where further research is required. The systematic review highlighted multiple potential areas for further exploration. Notably, there was inconclusive evidence to support the relationship between contractures and spasticity. Additionally, although the review identified correlations of impaired cognition, pressure ulcers and urinary incontinence with contractures, there was insufficient evidence to draw robust conclusions. On the other hand, the panellists emphasised that impaired cognition and pressure ulcers are important contributory factors to the risk of developing and exacerbating contractures. This discrepancy between the available evidence and expert opinion underscores a critical literature gap where further research can draw definite conclusions. Furthermore, the Delphi experts introduced a new factor, 'activity engagement', in the first round of the survey, which achieved consensus in the second round. This factor emerged from concerns about the lack of engagement and

motivation among residents to move around, which was seen as contributing to the risk of contractures. The systematic review, however, failed to provide any evidence on the relationship between the behavioural symptoms and contractures. This revealed another gap in the literature where more evidence is required to investigate the relationship of behavioural symptoms or mental illnesses with contractures. Moreover, the project highlighted (study 2) the need for training and educational resources on contractures for healthcare professionals, formal and informal caregivers and service users related to contractures. This was reinforced in study 3, which revealed that the baseline knowledge and understanding of contractures among the care staff was generally poor or fair. Similarly, in study 5, care staff expressed a lack of contracture-related training and educational resources. In summary, using a mixed methods approach, the project contributed to a more nuanced understanding of contractures and their associated risks. The project developed a novel, evidence-based contracture risk assessment tool with a preventative guide for care staff grounded in restorative nursing. Additionally, it identified key facilitators and barriers to ORACLE's practical utility in care homes, which has implications for its implementation and sustainability. The evidence gathered in this project also informed the development of the first educational resource specifically designed for care home staff, addressing an important gap in training. Furthermore, the study revealed important knowledge gaps and areas for future research in the field of contracture prevention and management.

8.7 Strengths and Limitations

Chapters 3, 4, 5, 6 and 7 have already discussed the key strengths and limitations of individual studies. However, there are additional factors that contributed to the overall strengths and limitations of the thesis.

8.7.1. Strengths

The systematic review (Chapter 3) employed a comprehensive search strategy and incorporated keywords from the prototype tool. Two independent reviewers screened the studies against the pre-defined eligibility criteria, performed data extraction and assessed the quality of evidence, which added to the overall quality and reliability of the review.

The Delphi survey involved academic and practitioner experts from seven countries, reflecting the global nature of contractures and the significant gaps in risk assessment practices worldwide. This approach ensured diverse expert opinions, enriching the insights of the survey and providing a more comprehensive understanding of the issue.

A key strength of this project is utilising a multi-phase mixed methods approach, which allowed for a comprehensive exploration and understanding of the topic. Integrating quantitative and qualitative findings provided psychometric validation while offering valuable insights into the real-world context. Each study followed established guidelines and recommendations tailored to the specific methodologies. Another strength of this project was the utilisation of a user-centred approach in the development phase of ORACLE and educational material for care staff. Through PPI and care staff feedback, the researcher gathered insights and feedback directly from individuals with existing contractures and those who provide care to individuals with contractures. Moreover, feedback was also sought from independent physiotherapists and occupational therapists. The feedback allowed for the iterative refinement of ORACLE and strengthened its face validity. The care staff's input was also vital in the refinement and redevelopment of the educational video, ensuring it was tailored to meet the specific needs and challenges faced by staff in their daily roles.

Despite facing several challenges with recruitment and data collection from the care homes in Phase II, the researcher was able to achieve the required sample size for study 4 (Chapter 6) through consistent efforts. By consistently following up with participating care homes and extending invitations to additional facilities, the researcher not only met but exceeded the target sample size. This added to the overall validity of the psychometric testing and strengthened the generalisability of ORACLE. Additionally, all types of care homes were recruited, including residential, nursing, mixed care and those with specialised care services such as dementia, ensuring a diverse representation.

8.7.2 Limitations

A major limitation of this research was that, while it involved the successful development and validation of a risk assessment tool, given the time and funding constraints, it was not possible to evaluate its predictive validity and effectiveness in reducing the prevalence of contractures.

Another limitation was the lack of formal interviews with other stakeholders, including care home residents, informal carers, and healthcare professionals providing external support services to residents at risk of developing contractures. Exploring their perspectives could have offered additional insights into ORACLE's feasibility and practical implementation.

8.8 Recommendations for future research

This project identified several areas of potential research that warrant formal investigation. First, future research studies employing a longitudinal design should evaluate the predictive validity (its ability to predict the occurrence of contractures accurately) and responsiveness to predict meaningful change over time (improvement or deterioration) due to therapy or contracture progression. To support this, an application for NIHR funding is planned to conduct a longitudinal study that will rigorously assess these aspects. Second, the current study should be replicated across different geographical locations and other contexts to enhance the generalisability and robustness of ORACLE and how it can be adapted in diverse settings, considering different contextual factors, resident demographics and healthcare systems.

Moreover, future studies should explore the impact of regular training programs on ORACLE consistency and long-term sustainability. Additionally, qualitative studies exploring the perspectives of the care home residents, informal carers and health professionals may provide valuable insights into the long-term sustainability of ORACLE. Lastly, multisite interventional studies investigating the difference in outcomes, particularly the incidence of contractures, between care homes that implement ORACLE and those that do not could evaluate the effectiveness of ORACLE as a preventative measure.

8.9 Conclusion

Contractures are a common yet preventable consequence of immobility. They significantly impact mobility, functional independence, social participation, and quality of life, particularly among frequently immobile residents of long-term care facilities. A significant gap in the literature highlighted the need for a standard evidence-based risk assessment tool for contractures in care homes.

To address this critical gap, this research project employed a multi-phase research design to develop, validate and evaluate the feasibility of a new contracture risk assessment tool, ORACLE. The systematic development and validation of ORACLE represents a significant contribution to the field of contracture prevention and management. ORACLE is the first contracture risk assessment tool developed through an evidence-based, expert-driven, and psychometrically validated process. This research yielded several notable findings. The systematic review identified and collated evidence on factors associated with joint contractures in adults. Key factors that provided the most consistent evidence of association with contractures were functional ability, pain, muscle weakness, physical mobility and proxies for bed confinement (prolonged immobility).

The Delphi study highlighted consensus on various factors associated with contractures, preventative care approaches, and relevant contextual factors specific to care homes, leading to ORACLE's development and refinement.

The psychometric testing of ORACLE demonstrated good convergent validity, with excellent intra- and inter-rater reliability and no floor and ceiling effects, confirming that it can be used consistently across different raters and over time in care home settings. The qualitative feedback, on the other hand revealed that the care staff generally found ORACLE to be user-friendly, time-efficient and well-integrated within existing care routines.

Moreover, the study highlighted potential challenges in maintaining its reliability in real-world care settings, particularly for less experienced staff or in situations where residents have communication difficulties. These insights point to the need for ongoing staff training and support to ensure that ORACLE's high reliability is maintained outside the context of this research.

In addition to developing and validating ORACLE, the research systematically interrogated how the context in which it is implemented (care homes) and the characteristics of those involved influence its usability and sustainability. These considerations were addressed through creation of educational material for care staff and guidelines to support its implementation. For the care homes, key considerations should be given to organisational practices, holistic, system-level approach to risk assessment, staffing levels, and regular training to support the effective and sustainable implementation of ORACLE.

In summary, this research represents a significant innovation in the care of a heretofore under-served population.

The following supplementary materials are included in **Appendix VII:**

- A.** ORACLE- second revision
- B.** Guidelines for care homes

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Appendices

Appendix I

Prototype tool



CONTRACTURE ASSESSMENT SCREENING TOOL (CAST)

The purpose of the Contracture Assessment Screening Tool is to help to identify people who may be at risk of developing a contracture or identify the risk of developing a worsening contracture due to other health changes. It should be used in conjunction with your professional judgement. It should not be used in isolation to determine a person's level of risk. If a person's ability to move changes throughout the day, please ensure that the form is always completed at the same time of day and record the time.

Complete sections A-H as the person is presenting today. Patient name: Date of birth: NHS number:	A) Joint Movement Does the person have difficulty moving any part of their body? Yes, unable to move even with help = 10 Yes, can move only with help = 8 No, <u>but needs</u> prompting to move = 4 No, moves independently = 0 State area (s) of concern:	B) Positioning Is the person able to roll and move in bed? Unable to move = 3 With help of two = 2 With help of one = 1 Independent = 0	C) Sitting Does the person sit upright and balanced in their usual chair? No, unable to sit at all = 3 Yes, up to 1 hour = 2 Yes, up to 3 hours = 1 Yes, can sit longer than 3 hours = 0	D) Skin Are there any changes to the person's skin? Broken skin = 3 Redness / change of colour/Vulnerable areas = 2 Not at all = 0 Site:
	E) Cognition Does the person have difficulty following instructions to move? Yes, all the time = 3 Yes, sometimes = 2 No or N/A = 0	F) Mobility Is the person able to walk? Not at all = 3 With help or an aid = 2 Independent = 0	G) Pain Is the person in pain despite pain medication? Yes, even at rest = 3 Yes, on movement = 2 Not at all = 0	H) Transfers Is the person able to move from bed to chair? No, remains in bed = 3 Yes, with help or an aid/hoist = 2 Yes, on their own = 0

What is a contracture?

A contracture is a change to a person's ability to move their joints and limbs freely. This can lead to permanent deformity, disability and pain that has a significant effect on their care needs and everyday life. It is VITAL to identify such changes to prevent them from occurring.

The results of the form do not replace the need or importance of professional judgement. Referrals for Occupational Therapy or Physiotherapy, irrespective of the score identified by the form, can be made if the professional assesses a person to be at high risk of developing a contracture.

SCORE	RISK	ACTIONS IF RISK IS DIFFERENT FROM LAST REVIEW (OR NEWLY ASSESSED)	ACTIONS IF RISK IS UNCHANGED SINCE LAST REVIEW
0-6	Low Risk	Monitor and re-assess in one month's time Encourage the person to continue to move Encourage and help food and drink to be taken Review if pain is under control	Continue to follow existing care plan Review in <u>1 month's time</u>
7-11	Medium risk	Monitor and re-assess every 2 weeks until risk is unchanged Encourage the person to move at regular intervals as written in their care plan Encourage and help food and drink to be taken Review if pain is under control If score remains the same for 3 months review frequency of assessment and consider a review by a health professional, e.g. GP, Occupational Therapist, Physiotherapist or Nurse	Continue to follow existing care plan Review in <u>1 month's time</u>
12-22	High Risk	Monitor and re-assess in 1 week Encourage the person to move at regular intervals as written in their care plan Refer to Occupational Therapist/Physiotherapy for assessment using usual process Encourage and help food and drink to be taken Review if pain is under control Consider referring to GP for review of condition	Continue to follow existing care plan Review in <u>1 month's time</u>
23+	Very High Risk	Make URGENT referral to Occupational Therapist/Physiotherapist for assessment using usual process Monitor and re-assess in 1 week until Health Professional has assessed Encourage the person to move at regular intervals as written in their care plan Encourage and help food and drink to be taken Review if pain is under control Request GP to review as soon as possible	Continue to follow existing care plan Review in 1 month's time or as recorded in care plan

Appendix II

- A. PROSPERO protocol
- B. Search Strategy for MEDLINE
- C. Detailed list of factors evaluated in the included studies with their statistical findings

A. PROSPERO protocol

NIHR | National Institute
for Health Research

PROSPERO
International prospective register of systematic reviews

Factors associated with the development and progression of joint contractures in adults: a systematic review

Citation

Hina Tariq, Kathryn Collins, Desiree Tait, Joel Dunn, Shafaq Altaf, Samuel Porter. Factors associated with the development and progression of joint contractures in adults: a systematic review. PROSPERO 2019 CRD42019145079 Available from: https://www.crd.york.ac.uk/prospERO/display_record.php?ID=CRD42019145079

Review question [1 change]

What factors are associated with the development and/or progression of joint contractures in adults?

Searches

The following electronic databases will be comprehensively searched: Database of the National Library of Medicine (MEDLINE), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Excerpta Medica Database (EMBASE), and Allied and Complementary Medicine (AMED) from January 1999 to July 2019. Additionally, references of the retrieved articles will be hand searched to identify further studies of interest. All eligible studies must be in English language and available as full-text. All the retrieved records will be managed using EndNote version 8.

Search Strategy

A comprehensive search strategy was devised with the help of a librarian; an example of which is given below:

((factor* OR element*) ADJ3 (caus* OR influenc* OR etiolog* OR aetiolog* OR determin* OR contribut* OR associat* OR reinforce* OR predispos* OR increas* OR worse* OR risk*)),ti,ab OR (influenc* OR determin* OR etiolog* OR aetiolog* OR caus* OR risk* OR associat*),ti,ab OR (((("joint mobility" OR flexib* OR "range of motion" OR "joint movement*" OR ROM) ADJ3 (reduc* OR decreas* OR restrict*)) OR immobil* OR hypomobil* OR hypomobil*),ti,ab OR ((ton* ADJ3 (hyper* OR increas* OR high*)) OR hyperten* OR spastic*),ti,ab OR (position* OR postur*),ti,ab OR ((skin ADJ3 (chang* OR break* OR broke* OR red* OR integrit*)) OR ((pressure OR bed OR decubitus) ADJ3 (sore* OR ulcer*))),ti,ab OR (((cogniti* OR mental) ADJ3 (function* OR abilit* OR capaciti* OR capabilit*) OR cogniti*),ti,ab OR (mobil* OR ((walk* OR ambulat*) ADJ3 (independen* OR dependen* OR abilit* OR limit* OR difficult*)),ti,ab OR ((pain* OR discomfort*) ADJ3 (acute OR chronic OR rest OR movement*)),ti,ab OR (bedfast OR bedbound OR bedridden),ti,ab)) AND

((contracture* OR ((muscle* OR "soft tissue" OR "soft-tissue" OR "connective tissue" OR "connective-tissue") ADJ3 (shorten* OR tighten* OR stiff*)) OR "adaptive shortening"),ti,ab

Types of study to be included [1 change]

Inclusion Criteria

Analytical quantitative observational studies.

Prospective interventional studies might also be considered.

Exclusion Criteria

Biological studies, qualitative studies, case reports, case series, editorials, commentaries, and letters will be excluded. Studies published in languages other than English will also be excluded due to lack of resources.

Condition or domain being studied [1 change]

The review will aim to identify factors that contribute to the development and/or progression of joint contractures among adults. Joint contractures are described as any degree of reduction in the passive joint range of motion due to muscle or connective tissue shortening, eventually leading to structural abnormalities within the affected joint (Adams and Victor 1993; Wagner and Clevenger 2010).

Participants/population [1 change]

Inclusion criteria

Adults aged 18 years and older who have developed joint contracture(s) as a secondary consequence of a primary condition. Studies with both children and adults will only be included if the results for adults are presented separately.

Exclusion criteria

Conditions in which joint contractures form a part of their primary diagnostic criteria (e.g. Dupuytren's disease, Volkmann's ischemic contracture, adhesive capsulitis)

Conditions in which joint contractures form as a result of skin loss (burns)

Intervention(s), exposure(s)

Not applicable.

Comparator(s)/control

Not applicable.

Context

All settings will be taken into account.

Main outcome(s) [3 changes]

The primary outcome of the included studies will be the development and/or progression of joint contractures in adults. Joint contractures are defined as any degree of reduction in the passive joint range of motion due to muscle or connective tissue shortening and their development and/or progression identified through reduced range of motion at a single or multiple joints.

Measures of effect

Joint contracture development identified through reduced range of motion preceding any intrinsic or extrinsic cause(s).

Additional outcome(s) [1 change]

None.

Measures of effect

Not applicable

Data extraction (selection and coding)

The initial results will be imported from EndNote into a data extraction sheet in Excel. First, two independent reviewers will screen the titles of the extracted results for relevant studies. Following this, the abstracts of the potentially relevant studies will be screened against the inclusion criteria. The full text of potentially eligible studies will be obtained and reviewed independently by two authors. Any disagreements will be resolved through discussion or using a third reviewer where necessary. Data from the recruited studies will be extracted by two independent researchers in an Excel sheet following the recommendations of Cochrane Handbook of Systematic reviews and PRISMA guidelines. The extracted information will include the following: (i) Author, publication date and country of origin (ii) Study characteristics (design, setting, aims/objectives, inclusion and exclusion criteria) (iii) Participant characteristics (sample size, age, gender, disease characteristics, co-morbidities) (iv) Outcome data/ results (factors associated with contractures) and (v) Information related to risk of bias. Any discrepancies or disagreements will be resolved through discussion or using a third reviewer where necessary.

Risk of bias (quality) assessment [1 change]

The methodological quality of studies will be assessed by two independent reviewers using critical appraisal checklists by the Joanna Briggs Institute (JBI). Any discrepancies or disagreements will be resolved through discussion or using a third reviewer where necessary.

Strategy for data synthesis

A narrative synthesis of the extracted data will be undertaken. This will be guided by the framework provided by the Economic and Social Research Council (ESRC) (Popay et al, 2006). The following three elements will be employed in the narrative approach:

- i) Developing a preliminary synthesis of findings of included studies
- ii) Exploring relationships within and between studies
- iii) Assessing the robustness of the synthesis.

Analysis of subgroups or subsets

None planned.

Contact details for further information

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Organisational affiliation of the review

Bournemouth University
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Review team members and their organisational affiliations [2 changes]

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Dr Kathryn Collins. Bournemouth University
Dr Desiree Tait. Bournemouth University
Mr Joel Dunn. Dorset HealthCare University NHS Foundation Trust
Shafaq Altaf. Shifa Tameer-e-Millat University
Professor Samuel Porter. Bournemouth University

Type and method of review [1 change]

Epidemiologic, Narrative synthesis, Prevention, Systematic review

Anticipated or actual start date [1 change]

01 August 2019

Anticipated completion date [1 change]

01 August 2020

Funding sources/sponsors [1 change]

This review is a part of a match funded PhD by Bournemouth University and Dorset Healthcare University NHS Foundation Trust undertaken by the author HT.

Conflicts of interest

Language

English

Country

England

Stage of review [2 changes]

Review Completed published

Details of final report/publication(s) or preprints if available [1 change]

<https://www.tandfonline.com/doi/full/10.1080/09638288.2022.2071480>

Subject index terms status

Subject indexing assigned by CRD

Subject index terms

Contracture; Humans

Date of registration in PROSPERO

28 August 2019

Date of first submission

28 July 2019

Stage of review at time of this submission [2 changes]

Stage	Started	Completed
Preliminary searches	Yes	Yes
Piloting of the study selection process	Yes	Yes
Formal screening of search results against eligibility criteria	Yes	Yes
Data extraction	Yes	Yes
Risk of bias (quality) assessment	Yes	Yes
Data analysis	Yes	Yes

Revision note

Systematic review published

The record owner confirms that the information they have supplied for this submission is accurate and complete and they understand that deliberate provision of inaccurate information or omission of data may be construed as scientific misconduct.

The record owner confirms that they will update the status of the review when it is completed and will add publication details in due course.

Versions

28 August 2019

23 July 2020

28 September 2020

B. Search Strategy for MEDLINE

Search Strategy

MEDLINE (EBSCOhost) Search conducted on 13th January 2022

Search	Query	Records retrieved
#1	(((factor* OR element*) ADJ3 (caus* OR influenc* OR etiolog* OR aetiolog* OR determin* OR contribut* OR associat* OR reinforc* OR predispos* OR increas* OR worse* OR risk*))).ti, ab OR (influenc* OR determin* OR etiolog* OR aetiolog* OR caus* OR risk* OR associat*).ti, ab OR (((("joint mobility" OR flexib* OR "range of motion" OR "joint movement*" OR ROM) ADJ3 (reduc* OR decreas* OR restrict*)) OR immobil* OR hypomobil* OR hypomobil*).ti, ab OR ((ton* ADJ3 (hyper* OR increas* OR high*)) OR hyperten* OR spastic*).ti, ab OR (position* OR postur*).ti, ab OR ((skin ADJ3 (chang* OR break* OR broke* OR red* OR integrit*)) OR ((pressure OR bed OR decubitus) ADJ3 (sore* OR ulcer*))).ti, ab OR (((cogniti* OR mental) ADJ3 (function* OR abilit* OR capacit* OR capabilit*)) OR cogniti*).ti, ab OR (mobil* OR ((walk* OR ambulat*) ADJ3 (independen* OR dependen* OR abilit* OR limit* OR difficult*))).ti, ab OR ((pain* OR discomfort*) ADJ3 (acute OR chronic OR rest OR movement*))).ti, ab OR (bedfast OR bedbound OR bedridden).ti, ab)) OR (MH "Risk Factors") OR (MH "Precipitating Factors") OR (MH "Muscle Spasticity") OR (MH "Dependent Ambulation") OR (MH "Mobility Limitation") OR (MH "Pain+") OR (MH "Cognition Disorders+")	13,097,959
#2	Contracture* or ((muscle* or "soft tissue" or "soft-tissue" or "connective tissue" or "connective-tissue") N3 (shorten* or tighten* or stiff*)) or "adaptive shortening" OR (MH "Contracture+")	33,559
#3	#1 AND #2	18,031
	Limited to date (1999-2019), human and adult	5,119

C. Detailed list of factors evaluated in the included studies with their statistical findings

Supplementary File B

Factor	Source Evidence	Statistical analysis	Statistical Findings	p value	Interpretation
Sociodemographic factors					
<i>Age (years)</i>	Buni et al. [38]	Linear mixed model	Average rate of change in hand extension (-0.001 cm/yr) Average rate of change in hand extension with disease duration <2 yrs (-0.006 cm/yr)	0.60 0.74	No significant interaction between rate of change in hand extension and age
	Campbell et al. [39]	Man-Whitney U test	Difference of mean age (yrs) between contracture and no contracture group: 2.9	0.50	No significant difference of age between contracture and non-contracture group
	Campbell et al. [40]	GEE	Mean age±SD yrs No contracture: 61.0±9.2 Mild knee FC: 62.0±9.1 Moderate FC: 63.3±9.0 Severe FC: 65.2±9.4	<0.001 <0.001 <0.01	Participants with FC were significantly older than participants with no FC
	Clavet et al. [42]	Multiple logistic regression	Age (yrs) Adjusted OR (95% CI) Any contracture <45: 1.00 [ref] 45-65: 0.46 (0.15 to 1.44) >65: 0.82 (0.26 to 2.54) <u>Functionally significant contracture</u> <45: 1.00 [ref] 45-65: 0.57 (0.18 to 1.79) >65: 0.70 (0.22 to 2.23)	-	Age did not affect the risk of any joint contracture or a functionally significant contracture
	Clavet et al. [44]	-	Mean age of respondents with contracture (yrs) : 62.3±11.2 Mean age of respondents without contracture (yrs): 63.8±11.7	-	No significant difference of age between respondents with contracture and without contractures

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Supplementary File B

Factor	Source Evidence	Statistical analysis	Statistical Findings	p value	Interpretation
Sociodemographic factors					
<i>Age (years)</i>	Buni et al. [38]	Linear mixed model	Average rate of change in hand extension (-0.001 cm/yr) Average rate of change in hand extension with disease duration <2 yrs (-0.006 cm/yr)	0.60 0.74	No significant interaction between rate of change in hand extension and age
	Campbell et al. [39]	Man-Whitney U test	Difference of mean age (yrs) between contracture and no contracture group: 2.9	0.50	No significant difference of age between contracture and non-contracture group
	Campbell et al. [40]	GEE	Mean age±SD yrs No contracture: 61.0±9.2 Mild knee FC: 62.0±9.1 Moderate FC: 63.3±9.0 Severe FC: 65.2±9.4	<0.001 <0.001 <0.01	Participants with FC were significantly older than participants with no FC
	Clavet et al. [42]	Multiple logistic regression	Age (yrs) Adjusted OR (95% CI) Any contracture <45: 1.00 [ref] 45-65: 0.46 (0.15 to 1.44) >65: 0.82 (0.26 to 2.54) <u>Functionally significant contracture</u> <45: 1.00 [ref] 45-65: 0.57 (0.18 to 1.79) >65: 0.70 (0.22 to 2.23)	-	Age did not affect the risk of any joint contracture or a functionally significant contracture
	Clavet et al. [44]	-	Mean age of respondents with contracture (yrs) : 62.3±11.2 Mean age of respondents without contracture (yrs): 63.8±11.7	-	No significant difference of age between respondents with contracture and without contractures

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Buni et al. [38]	Linear mixed models	Average rate of change in hand extension (-0.11 cm/year)	0.99	No significant interaction between rate of change in hand extension and female gender.
		Average rate of change in hand extension with disease duration <2 years (-0.20 cm/year)	0.96	
Campbell et al. [39]	Man-Whitney U test	Difference of female gender % between contracture and non-contracture group: 8.7%	0.75	No significant difference of female % between contracture and non-contracture group
Campbell et al. [40]	GEE	Male % No contracture 39.5 Mild knee FC: 47.7 Moderate FC: 50.5 Severe FC: 60.5	>0.01	No significant association found between FC and male gender
Clavet et al. [42]	Multiple logistic regression	Adjusted OR (95% CI) Any contracture Male: 1.00 [ref] Female: 0.75 (0.34 to 1.65) <u>Functionally significant contracture</u> Male: 1.00 [ref] Female: 0.63 (0.28 to 1.41)	-	Gender did not affect the risk of any joint contracture or a functionally significant contracture
Eriks-Hoogland et al. [45]	Multilevel binomial regression	-	-	No significant associations found
Haller et al. [49]	Chi-square test	Male gender % No arthrofibrosis: 59.1% Arthrofibrosis: 74.1%	0.20	No significant difference of male % between those with arthrofibrosis and without arthrofibrosis
Hamzah et al. [50]	Chi square test with Yates correction	YC P: 0.511	0.409	No significant association of ankle contractures with gender
	Univariate logistic regression analysis	OR (95% CI) Male: 1.00 Female 0.31 (0.03 to 2.81)	0.297	
Kinoshita et al. [54]	Wilcoxon signed-rank test	Knee extension angle (Mean±SD) after TKA Males: -0.6±3.4° Females: 0.0±3.3° Post-operative knee extension angle (Mean±SD) Males: -3.8±5.7°	0.22	No significant difference
			<0.01	

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Females: -1.4±2.6°				
Koh et al. [56]	Fisher's exact test	Difference of female % between FC and No FC: 1.8%	0.510	No significant difference of female % between FC and No-FC
Lam et al. [58]	GEE	Univariate analysis (OR 95% CI) No Contracture: 0.94 Contracture on one side: 0.42	<0.05	Univariate analysis showed males are more likely to develop new joint contractures, but multivariate analysis showed male gender is not an independent risk factor.
		Multivariate analysis No Contracture: - Contracture on one side: 1.54	>0.05	
Marchand et al. [61]	Chi-square test	Male gender % Arthrofibrosis: 29/88 (55%) No arthrofibrosis: 169/302 (55%)	0.96	No significant difference of male % between those with arthrofibrosis and without arthrofibrosis
Vogel et al. [68]	Chi-square test	-	-	No significant association of contractures with gender
Wagner et al. [9]	Chi-square test	$\chi^2=0.936$	0.333	No significant association of contractures with gender
Ethnicity	Buni et al. [38]	White (non-Hispanic) Average rate of change in hand extension (-0.11 cm/year) Average rate of change in hand extension with disease duration <2 years (-0.29 cm/year)	0.89	No significant interaction between rate of change in hand extension and race (white-non-Hispanics)
			0.41	

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Healthcare insurance	Wagner et al. [9]	Chi-square test and regression analysis	$\chi^2=5.457$ OR (95% CI) 1.951 (0.694 to 5.482)	0.019 0.205	Residents on Medicaid were significantly more likely to have contractures
Physical factors					
Functional ability	Ada et al. [32]	Multiple linear regression	MAS (upper limb items) $r^2_{contracture} = 0.06$	0.10	Significant negative contribution of contracture to upper limb activity at 6 weeks
	Avouac et al. [21]	Chi square	FC with HAQ High HAQ disability score >1.5: 13/29 Low HAQ disability score: 19/91	0.02	Significant association of high functional disability scores with FC
		Multiple logistic regression	Increased HAQ score >1.5	0.007	
	Balint et al. [35]	Spearman's correlation coefficient	Upper limb disability (DASH) $\rho = 0.341$ Functional status (HAQ-DI) $\rho = 0.386$	<0.001 <0.01	The number of upper or lower limb contractures strongly correlated with functional tests (HAQ-DI and DASH)
	Buni et al. [38]	Pearson's correlation	MHAQ ($\beta=-0.09$) $R^2=0.19$. A decrease of 1 cm in average hand measurement corresponded to a 0.1 increase (worse function) in the MHAQ score. SF-36 PF score	<0.001 <0.001	Average hand extension was inversely associated with worse function The larger the hand extension, the higher(better) the SF-36 function score
	Clavet et al. [44]	Chi-square test	Self-care measured on EQ-5D Usual activities measured on EQ-5D Joint specific functional limitation Shoulder/elbow Hip Knee Ankle	1.00 0.31 0.16 0.66 0.62 0.64	No statistically significant association of contractures with performance of usual activities, self-care, and joint specific limitations.

Frye et al. [47]	Spearman's Rho correlation and Student's t test	SCIM-III and SCI-FI <u>Spearman's Rho</u> <u>Shoulder horizontal adduction</u>	Student's t test
		Total: 0.496	<0.01
		ADL: 0.574	<0.01
		Feeding: 0.491	<0.01
		Grooming: 0.471	<0.05
		Upper body bathing: 0.435	<0.05
		Lower body bathing: 0.288	>0.05
		Upper body dressing: 0.412	<0.05
		Lower body dressing: 0.298	>0.05
		<u>Elbow extension</u>	
		Total: -0.388	<0.05
		ADL: -0.233	>0.05
		Feeding: -0.234	>0.05
		Grooming: -0.262	>0.05
		Upper body bathing: -0.268	>0.05
		Lower body bathing: -0.367	<0.05
		Upper body dressing: -0.083	>0.05
		Lower body dressing: -0.035	>0.05
		<u>Hip flexion</u>	
		Total: 0.292	>0.05
		ADL: 0.541	<0.01
		Feeding: 0.325	>0.05
		Grooming: 0.418	<0.01
		Upper body bathing: 0.469	<0.05
		Lower body bathing: 0.610	<0.001
		Upper body dressing: 0.542	<0.01
		Lower body dressing: 0.454	<0.05
		<u>Knee flexion</u>	
		Total: 0.462	<0.05
		ADL: 0.593	<0.01
		Feeding: 0.429	<0.05
		Grooming: 0.394	<0.05
		Upper body bathing: 0.457	<0.05
		Lower body bathing: 0.477	<0.01
		Upper body dressing: 0.501	<0.01
		Lower body dressing: 0.487	<0.01
		<u>Ankle plantarflexion</u>	
		Total: -0.275	>0.05

		ADL: -0.380 Feeding: -0.103 Grooming: -0.315 Upper body bathing: -0.122 Lower body bathing: -0.436 Upper body dressing: -0.359 Lower body dressing: -0.367 <u>Forefoot eversion</u> Total: 0.332 ADL: 0.309 Feeding: 0.201 Grooming: 0.165 Upper body bathing: 0.172 Lower body bathing: 0.434 Upper body dressing: 0.190 Lower body dressing: 0.372	<0.05 >0.05 >0.05 >0.05 <0.05 >0.05 <0.05 >0.05 >0.05 >0.05 <0.05 >0.05 >0.05 <0.05	
Hardwick et al. [51]	Pearson's product-moment correlation	SCIM-III <u>With any contracture</u> R=-0.4271 <u>With moderate /severe contracture</u> R=-0.4472	0.0094 0.0062	Statistically significant strong negative correlation between functional independence and contractures
Kocic et al. [54]	Univariate linear regression	Oxford Knee and Oxford Hip Scores Knee Poor function vs reduced flexion ROM Hip Poor function vs reduced flexion ROM Poor function vs flexion contracture	0.005 0.003 0.003	Poor self-reported function was associated with reduced flexion ROM and a higher degree of FC in knee and hip OA
Koh et al. [56]	Wilcoxon's sign rank test	Ability to rise from chair and climb stairs	>0.05	No significant differences between FC and No FC groups
Kwahi et al. [12]	Univariate linear regression	Pre-morbid function (Barthel Index) <u>Elbow extension</u> Coefficient: 0.19 (0.03 to 0.36) r ² :0.03 <u>Wrist extension</u> Coefficient: 0.20(-0.02 to 0.41) r ² :0.02 <u>Ankle dorsiflexion</u> Coefficient: 0.06 (-0.06 to 0.19)	<0.05 >0.05 >0.05	Significant association of pre-morbid function with elbow extension but not with wrist extension and ankle dorsiflexion. Significant association of upper limb motor function with elbow and wrist extension. Significant association of sit to stand with ankle dorsiflexion but

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		r ² :0.01 Motor function-combined upper limb <u>Elbow extension</u> Coefficient: 2.25 (1.45 to 3.06) r ² :0.17 <u>Wrist Extension</u> Coefficient: 2.67 (1.70 to 3.63) r ² :0.16 Motor function-sitting to standing <u>Ankle dorsiflexion</u> Coefficient: 0.76 (0.09 to 1.43) r ² :0.03 Motor function-walking <u>Ankle dorsiflexion</u> Coefficient: 0.48 (-0.28 to 1.23) r ² :0.01	<0.01 >0.05	no significant association of walking with ankle dorsiflexion.
Kwakkenbos et al. [57]	Univariate and multiple linear regression	Hand function measured on CHFS Univariate analysis <u>Moderate contractures</u> Coefficient (95% CI): 12.96 (10.72 to 15.18) β=0.31 <u>Severe contractures</u> 18.91 (15.53 to 22.29) β=0.29 Multivariate analysis <u>Moderate contractures</u> Coefficient (95% CI): 8.20 (6.11 to 10.30) β=0.19 <u>Severe contractures</u> Coefficient (95% CI): 13.04 (9.90 to 16.18) β=0.20	<0.001 <0.001	Significant association of small joint contractures with hand function limitation
Malhotra et al. [60]	Mann-Whitney U test	Upper limb function measured on ARAT	<0.01	In the non-functional group the PROM deteriorated significantly

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Matosinho et al. [16]	Spearman's correlation coefficient	Motor function of paretic upper limb on MAS Coefficient: 0.34	0.004	Significant association of poor function with contractures. Regression analysis revealed that it's not an independent predictor for contractures
Pandyan et al. [63]	Friedman's test	Motor Recovery (wk 0 to wk 32) Resting wrist angle PROM	<0.01 0.061	There was a significant decrease in the resting wrist angle in the non-functional group.
Pua et al. [66]	Multiple mediation model	Physical function on SF-36 -Function subscale Correlation coefficient: 0.27 Regression coefficient: 0.39 Physical performance tests Correlation coefficients Step test: 0.25 Stair climb test: -0.30 Gait speed test: 0.17 Physical performance tests Regression coefficients Step test: 0.056 Stair climb test: -0.042 Gait speed test: 0.002	<0.01 <0.01 <0.05 <0.01 0.11 <0.05 <0.01 0.11	Hip flexion ROM was significantly associated with physical function except gait speed test which correlated weakly with hip flexion ROM.
Vogel et al. [68]	T-test	Functional independence on FIM FIM total score with hip contractures FIM motor score with hip contractures FIM total score with elbow contractures FIM motor score with elbow contractures	0.001 0.002 0.010 0.009	Significant association of poor function with hip and elbow contractures; no significant association with ankle contractures
Wagner et al. [9]	T- test Logistic regression analysis	Functional status on PDRS (PF subscale) Mean difference b/w contracture and no contracture: 3.81 OR (95% CI) 0.939 (0.868-1.014) Functional performance tests with contractures 1.Change position in bed 2. Roll to either side	0.001 0.110 0.001 0.001	Functional status was significantly lower among residents with a contracture compared to those without contractures.

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		3. Sit up in bed 4. Transfer from the bed to a chair 5. Transfer from the bed to a standing position	0.001 0.001 0.001	
		Functional ability measured on HAQ-DI <u>Small joint contractures</u> r=0.07 <u>Large joint contractures</u> r=0.07	-	Negligible correlations
Pain	Aras et al. [33]	ANOVA and post hoc Tukey test	Shoulder PROM	0.006
	Bossuyt et al. [36]	Multivariable logistic regression analysis	OR (95% CI) 2.47 (1.91-3.19)	<0.001
	Campbell et al. [40]	GEE	NPRS (Beta coefficient 95% CI) No FC: 0 Mild FC: 0.24 (0.11 to 0.37) Moderate FC: 0.56 (0.34 to 0.78) Severe FC: 1.20 (0.43 to 1.97)	<0.001 <0.001 0.002
	Clavet et al. [44]	Chi-square test	Pain measured on EQ-5D	0.17
	Diong et al. [17]	Multivariate linear regression models	<u>Elbow extension</u> Coefficient (95% CI): 0.99 (-0.54 to 2.53) r ² (%): 2 <u>Wrist Extension</u> Coefficient (95% CI): -0.06 (-2.90 to 2.78) r ² (%): 0 <u>Hip flexion with knee extension</u> Coefficient (95% CI): 0.56 (-0.98 to 2.10) r ² (%): 0 <u>Ankle dorsiflexion</u>	0.20 0.96 0.47 0.20

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			Coefficient (95% CI): 0.71 (-0.39 to 1.80) r^2 (%): 0		
Eriks-Hoogland et al. [45]	Multilevel binomial regression		OR (95% CI) Rt shoulder flexion OR 6.2 (CI 5.54 to 6.68) Rt shoulder external rotation OR 3.7 (CI 3.16 to 4.24) Rt shoulder abduction OR 4.5 (CI 3.74 to 5.26) Lt shoulder flexion OR 11.9 (CI 11.02 to 12.68) Lt shoulder external rotation OR 3.8 (CI 3.24 to 4.36) Lt shoulder abduction OR 6.6 (CI 3.81 to 7.39)	-	Significant associations of pain with shoulder ROM limitations
Fheodoroff et al. [46]	Wilcoxon's rank sum test		Composite contracture score Patients with primary pain goals: 5.9 All other: 4.5	0.008	Patients with primary pain goals had significantly more severe contractures
Harmer et al. [52]	ANOVA		VAS Contracture vs no contracture Discharge pain - mean difference: 0.3 Mean pain - difference: 0.2 Maximum pain-difference: 0.1	0.25 0.24 0.73	No significant difference in mean pain scores of patients who did and did not develop soft-tissue contractures.
Koh et al. [56]	Wilcoxon's sign rank test		Anterior knee pain Difference of pain scores between FC and No FC: 3.7	0.012	Significant difference of pain scores between FC and No FC groups
Kwah et al. [12]	Univariate linear regression		Elbow extension Coefficient: 0.54 (-1.62 to 2.70) r^2 : 0.00 Wrist extension Coefficient: 1.15 (-2.54 to 4.84) r^2 : 0.00 Ankle dorsiflexion Coefficient: -1.37 (-2.52 to -0.22) r^2 : 0.03	>0.05 >0.05 <0.05	Significant association with ankle dorsiflexion but no significant association with wrist and elbow extension
Lam et al. [58]	GEE		Chronic pain (OR 95% CI) Upper limb contractures No contracture 0.69 Unilateral contracture: 0.82	>0.05	Chronic pain was not a predictive factor for the development of new joint contractures.

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			Lower limb contractures No contracture 0.80 Unilateral contracture: 1.18		
Lee et al. [59]	Hierarchical linear regression.		NPRS (0-10) Pain intensity (95% CI) Bivariate R^2 : 0.98 (0.73 to 1.24) Multivariate R^2 : 0.67 (0.39 to 0.94) Pain interference (95% CI) Bivariate R^2 : 3.71 (2.77 to 4.65) Multivariate R^2 : 2.72 (1.69 to 3.74)	<0.05 <0.05 <0.05 <0.05	Presence of moderate or severe joint contractures were independently associated with pain intensity and interference.
Matosinho et al. [16]	Chi-square test		NPRS 0-10 Coefficient: 3.80	0.051	Significant association with contractures and pain was also found to be an independent predictor of contractures
Noonan et al. [62]	Logistic regression T test/ANOVA		β = 1.895 (OR 6.417 (1.217-33.831)) Mean combined abduction with hip pain (50°) vs without hip pain (75°)	0.028 0.01	Significant association of hip pain with reduced ROM and hip FC
			Prevalence of hip pain with a FC (85%) vs without a FC (51%)	0.07	
			Pain medication in hip FC (62%) vs without a hip FC (30%)	0.04	
Pua et al. [66]	Multiple mediation model		SF-36 (bodily pain subscale) Correlation coefficient: 0.39 Regression coefficient: 0.53	<0.001 <0.001	Hip flexion ROM was significantly associated with bodily pain
Takai et al. [64]	Chi-square test and multiple logistic regression analysis		Pain on VDS (0-6) χ^2 = 7.35 OR (95% CI): 3.80 (1.54 to 9.37) Pain on APS-J χ^2 = 5.08	0.006 0.003 0.02	Significant association of contractures with residents' pain
Wagner et al. [9]	T- test and logistic regression analysis		Pain during examination Mean difference (contracture vs no contracture: 59 OR (95%CI) 6.788 (2.194 to 21.000)	0.001 0.001	Residents experiencing pain had significantly higher odds of having contractures

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			<u>Ankle dorsiflexion</u> Coefficient: 1.07 (0 to 2.24)		
	Matozinho et al. [16]	Spearman's correlation coefficient	Muscle Strength on MMT Coefficient: 0.29	0.014	Significant association between contractures and muscle strength
	Pua et al. [66]	Multiple mediation model	Hip extensor strength test Correlation coefficient: 0.22 Regression coefficient: 0.54	<0.05 <0.05	Hip flexion ROM was significantly associated with hip extensor strength
	Vogel et al. [68]	T-test	Association of ASIA motor score with Hip contractures Elbow contractures	0.012 0.016	ASIA motor scores (muscle weakness) were significantly lower in those with contractures. No significant association with ankle contractures
Spasticity	Ada et al. [32]	Multiple linear regression	Mean $r^2_{spasticity}$: 0.23 (0.12 to 0.37)	0.001-0.06	Spasticity made a significant contribution to contracture in the first four months of stroke
	Baagoe et al. [34]	Mixed effects model	Spasticity defined as reflex mediated stiffness and increased tonic stretch reflexes	0.002	Absence of reflex was significantly associated with ROM i.e., significant association of decreased spasticity with contractures
	Diong et al. [17]	Multivariate linear regression models	Univariate analyses Elbow extension Coefficient (95% CI): 24.62 (2.75 to 46.49) r^2 (%): 13 Wrist Extension Coefficient (95% CI): 9.99 (1.07 to 18.90) r^2 (%): 1 Hip flexion with knee extension Coefficient (95% CI): -2.84 (-10.09 to 4.41) r^2 (%): 0 Ankle dorsiflexion Coefficient (95% CI): -0.39 (-5.42 to 4.64) r^2 (%): 0 Multivariate analyses Elbow extension	0.03 0.03 0.44 0.88	Univariate analyses: Statistically significant association with elbow and wrist extension but none showed enough variance of change in range to be clinically useful (r^2 <14%). No significant association with hip flexion with knee extension and ankle dorsiflexion. Multivariate analyses: Spasticity was a significant predictor of wrist extension

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			Regression coefficient (95% CI): 25.00 (0 to 55.89); R^2 of full model: 31 Wrist extension Regression coefficient (95% CI): 12.87 (0 to 28.04); R^2 of full model: 16		
	Eriks-Hoogland et al. [45]	Multilevel binomial regression	OR (95% CI) R Spasticity flexors (R flexion) OR 4.8 (CI 3.49 to 6.11) R Spasticity extensors (R ext rotation) OR 2.5 (CI 1.63 to 3.37) R Spasticity extensors (R abduction) OR 3.8 (CI 2.70 to 4.90) L Spasticity extensors (L shoulder flexion) OR 3.3 (CI 2.08 to 4.52) L Spasticity extensors (L ext rotation) OR 2.9 (CI 2.04 to 3.76) L Spasticity extensors (L abduction) 4.0 (CI 3.07 to 4.93)	-	Several significant associations of extensor muscles with contractures
	Hamzah et al. [50]	Chi square test with Yates correction	YC P <0.001	<0.001	Significant association between spasticity and ankle contractures
		Univariate logistic regression analysis	OR (95% CI) No spasticity (normal + hypotonia) :1.00 Spasticity : 51.67 (7.53 to 354.52) No spasticity (hypotonia group excluded): 1.00 Spasticity : 8.52 (3.00 to 24.18)	<0.001 <0.001	
	Kwah et al. [12]	Univariate linear regression	Univariate analysis Elbow extension Coefficients: -4.00 (-9.59 to 1.58) r^2 : 0.01 Wrist extension Coefficients: -7.53 (-17.29 to 2.24) r^2 : 0.01 Ankle dorsiflexion	>0.05 >0.05 <0.05	Significant association with ankle dorsiflexion but no significant association with elbow and wrist extension

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			Coefficients: -6.14 (-10.79 to -1.49) $r^2=0.04$		
	Matozinho et al. [16]	Chi-square test	Spasticity of medial shoulder rotators, elbow, and wrist flexors on Tardieu scale Coefficient: 0.016	0.899	Spasticity was not correlated with contractures
	Pohl and Mehrholz [15]	ANOVA Post hoc Scheffé tests	Difference of Spasticity (MAS) B/w no, moderate and severe contracture B/w no and severe contracture B/w moderate and severe contracture B/w no and moderate contracture	<0.001 <0.001 <0.001 0.27	Significant differences in spasticity for the factor contracture (no, moderate, severe). Significant difference of spasticity between no and severe contracture and moderate and severe contracture but no difference between no and moderate contracture
	Vogel et al. [68]	Chi square	-	-	No significant association of contractures with spasticity requiring medication
<i>Spastic dystonia</i>	Hamzah et al. [50]	Chi square test with Yates correction Univariate logistic regression analysis	YC P: 0.001 OR (95% CI) No: 1.00 Yes: 27.43 (2.84 to 265.35)	0.001 0.004	Significant association between spastic dystonia and ankle contractures
<i>Clonus</i>	Hamzah et al. [50]	Chi square test with Yates correction Univariate logistic regression analysis	YC P: 0.015 OR (95% CI) No: 1.00 Yes: 4.18 (1.33 to 13.19)	0.009 0.015	Significant association between clonus and ankle contractures
<i>Physical mobility</i>	Brantmark et al. [37]	Chi-square test Relative risk analysis	PROM popliteal angle phi coefficient (r_ϕ) = 0.433 Knee extension $r_\phi=0.449$ Foot df with flexed knee $r_\phi=-0.268$ Popliteal angle <140° (RR=3.2) or knee extension <0° (RR=2.8) foot df with flexed knee <20° (RR=0.6)	≤0.01	Significant association between PROM (popliteal angle, knee extension, foot df with flexed knee and mobility) Participants with limited PROM in popliteal angle, or in knee extension, had an increased risk

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					of supported mobility compared with participants with normal PROM. Participants with limited PROM in foot df with flexed knee, had a decreased risk of using supported mobility compared with participants who had normal PROM
	Campbell et al. [40]	GEE	400-m walk test (β coefficient 95% CI) No contracture: 0 Mild FC: 7.00 (3.60 to 10.40) Moderate FC: 4.20(-1.59 to 9.98) Severe FC: 55.07 (15.33 to 94.82)	0.007 0.115 <0.001	Increasing dysfunction on 400m walk test showed a severity dependent association with FC
	Clavet et al. [43]	Chi-Square test	Ambulatory status at discharge home High level of mobility With joint contractures: 22% Without joint contractures 51% Lower level of mobility With joint contractures 2 or 4 wheeled walker: 47.5% Wheelchair or 2-person assistance: 16.9% Stretcher/mechanical lift: 13.6% Without joint contractures 2 or 4 wheeled walker: 31.4% Wheelchair or 2-person assistance: 5.9% Stretcher/mechanical lift: 7.8%	0.002	At discharge, significantly more patients with joint contractures in ICU had a low ambulator level than patients without joint contractures
	Clavet et al. [44]	Chi-square test	Mobility measured on EQ-5D	0.02	Significant association of contractures with mobility limitation
	Hoang et al. [18]	Spearman's correlation	Six-minute walk test $r=-0.58$	-	Strong negative correlation between presence of any contracture and six-minute walk performance
	İçgäsioğlu et al. [53]	Spearman's rho coefficients	-	<0.001	Strong correlation between reduced mobility and contractures.

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Lam et al. [58]	GEE	Inability to walk (OR (95%CI))		
		<u>New upper limb contractures</u>	1.9 (1.3 to 2.8)	<0.001
		<u>New lower limb contractures</u>	2.4 (1.7 to 3.2)	<0.001
		<u>Subsequent lower limb contractures</u>	4.3 (1.5 to 12.8)	<0.01
Wagner et al. [9]	T test and binary logistic regression analysis	Mobility (bed mobility, transfer ability, ambulation)		
		Mean difference (contracture vs no contracture: 4.01		0.001
		OR (95% CI)	1.077 (0.955 to 1.214)	0.229
		Life Space on LSDS		
Noonan et al. [62]	T test/ANOVA	Mean difference (contracture vs no contracture: 5.25		0.001
		OR (95% CI)	0.943 (0.884 to 1.006)	0.077
		Pressure ulcers		
		Mean combined hip abduction in patients with PU (25°) vs those without PU (62°)		0.02
Vanderwee et al. [67]	Multivariate stepwise backwards Cox regression analysis	Prevalence of PU in patients with windswept hip deformities (17%) vs no PU in patients with neutral hip positioning (0%)		0.01
		Pressure ulcers		
		<u>Univariate analysis</u>	RR 2.25	0.008
		95% CI 1.24 to 4.08		
Vanderwee et al. [67]	Multivariate stepwise backwards Cox regression analysis	<u>Multivariate analysis</u>	$\chi^2=4.207$	
		RR (95% CI) 2.02 (1.03 to 3.95)		0.040

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Skin changes	Balint et al. [35]	Mann-Whitney U-test	Skin hypo/hyperpigmentation	0.304	No significant difference in the number of contractures between cases with and w/o skin hypo/hyperpigmentation
Noonan et al. [62]	T test/ANOVA	Pressure ulcers			
		Mean combined hip abduction in patients with PU (25°) vs those without PU (62°)		0.02	Significant difference of hip ROM between patients with PU and without PU
		Prevalence of PU in patients with windswept hip deformities (17%) vs no PU in patients with neutral hip positioning (0%)		0.01	
		Pressure ulcers			
Vanderwee et al. [67]	Multivariate stepwise backwards Cox regression analysis	<u>Univariate analysis</u>	RR 2.25	0.008	Patients with contractures had significantly higher rate of PU development
		95% CI 1.24 to 4.08			
		<u>Multivariate analysis</u>	$\chi^2=4.207$		
		RR (95% CI) 2.02 (1.03 to 3.95)		0.040	
Involuntary muscle activity/associated reactions	Ada and O'Dwyer [31]	Chi-Square test	$\chi^2=1.19$	0.39	No significant association between contractures and associated reactions
Pohl et al. [65]	ANOVA with post-hoc Tukey- Kramer tests	Group _c : (spasticity w/o contracture)			
		Group _{o,c} : (Spasticity and contracture)			
		Group _c : (contracture w/o spasticity)			
		Group _o : w/o spasticity and contracture			
İçagaşioğlu et al. [53]	Spearman's rho coefficients	Mental state (normal or mild, moderate, or severe MR)		0.001	Moderate correlation between MR and contractures
		rho: -0.388			
		Anxiety measured on EQ-5D		0.34	No significant association
Clavet et al. [44]	Chi-square test	Cognition (MMSE)			
		Mean difference (contracture vs no-contracture): 4.37		0.002	Cognition was significantly lower among residents with a contracture compared with those without. Multivariate analysis did not reach significance
		OR (CI 95%)	0.998 (0.948 to 1.051)	0.947	
		Behavioral symptoms on NHBPS		0.217	No significant association of contractures with behavioral symptoms
Wagner et al. [9]	T-test	Mean difference (contracture vs no-contracture): 1.55			

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<i>Manual dexterity</i>	Matozinho et al. [16]	Spearman's correlation coefficient Logistic regression	Manual dexterity on NHPT Coefficient: 0.38 $\beta = -4.747$ (OR 0.009 (0.000 to 0.193))	0.001 0.003	Significant association with contractures and manual dexterity was also found to be an independent predictor of contractures
<i>Urinary incontinence</i>	Wagner et al. [9]	T-test and logistic regression analysis	Mean difference (contracture vs no contracture): 69 OR (95% CI) 2.623 (0.851 to 8.086)	0.002 0.093	Urinary incontinence was significantly more prevalent among residents with contractures compared with those without. Multivariate analysis did not reach significance
<i>Fall risk</i>	Wagner et al. [9]	T-test	Mean difference (contracture vs no contracture): 4.52	0.075	No significant association of contractures with fall risk
<i>Quality of life</i>	Koh et al. [56]	Wilcoxon's sign rank test	QOL measured on SF-36	>0.05	No significant difference of scores between FC and No FC groups
	Wiese et al. [69]	Pearson's/Spearman's correlation coefficient	QOL on SF-36 (PCS) Small joint contractures r=-0.19 Large joint contractures r: -0.29 QOL on SF-36 (MCS) Small joint contractures r: 0.09 Large joint contractures r: -0.01	-	Negligible correlations of QOL measured with small and large joint contractures. Small correlation of QOL measured on SF-36 (PCS) with small joint contractures. Moderate correlation of QOL measured on SF-36 (PCS) with large joint contractures
	Clavet et al. [44]	Chi-square test	QOL measured by total score of EQ-5D	0.54	No significant difference among groups in self-perceived state of health
Proxies for bed confinement					
<i>Duration of Immobilisation</i>	Marchand et al. [61]	Logistic regression model	OR (95% CI): 1.09 (1.02 to 1.25)	0.001	Significant effect of increasing duration of immobilization; with each extra day of immobilization, the odds of arthrofibrosis increased by 9%
<i>Mobilisation</i>	Clavet et al. [43]	Chi-square test	-	0.03	Significantly fewer patients with contractures than without

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					contractures were mobilized in the hospital ward
<i>Length of stay in ICU</i>	Clavet et al. [42]	Multiple logistic regression	Adjusted OR (95% CI) <u>Any contracture</u> 2-2.99 wks: 1.00 [ref] 3-4.99 wks: 1.02 (0.37 to 2.83) 5-7.99 wks: 1.81 (0.48 to 6.70) > 8 wks: 7.09 (1.29 to 38.9) <u>Functionally significant contracture</u> 2-2.99 wks: 1.00 [ref] 3-4.99 wks: 1.05 (0.37 to 3.03) 5-7.99 wks: 1.05 (0.26 to 4.22) > 8 wks: 5.79 (1.08 to 31.0)	0.02 0.04	LOS in the ICU was a significant risk factor for both development of any joint contracture and functionally significant contracture
	Clavet et al. [43]		Median LOS in ICU (days) with contractures: 28.5 days w/o contractures: 21.5	0.03	In the ICU, median length of stay was longer for patients with joint contractures than for those without joint contractures
<i>Duration of Invasive Mechanical ventilation</i>	Clavet et al. [42]	Multiple logistic regression	Adjusted OR (95% CI) <u>Any contracture</u> <10 days: 1.00 [ref] 10-20 days: 1.67 (0.66 to 4.21) >20 days: 2.88 (0.85 to 9.84) <u>Functionally significant contracture</u> <10 days: 1.00 [ref] 10-20 days: 1.52 (0.59 to 3.94) >20 days: 3.24 (0.93 to 11.3)	-	Duration of IMV did not affect the risk of developing any joint contracture or a functionally significant contracture
	Hamzah et al. [50]	Chi-square test with Yates correction	Mechanical ventilation (Yes/No) YC (P: 0.292) Duration of mechanical ventilation (<2 weeks vs ≥ 2 weeks)	0.240 0.056	The odds of developing contractures were 7.71 times higher in patients mechanically ventilated for >2 weeks compared to those for ≤2 weeks
		Univariate logistic regression analysis	OR (95% CI) No mechanical ventilation: 1.00 ≤2 weeks: 3.18 (0.33 to 30.62) >2 weeks: 7.71 (0.75 to 79.77)	0.317 0.087	
<i>Length of stay in hospital</i>	Clavet et al. [42]	Multiple logistic regression	Adjusted OR (95% CI) <u>Any joint contracture</u> <4 wks: 1.00 [ref] 4-7.99 wks: 1.23 (0.39 to 3.89)	-	Weak association

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			≥8 wks: 1.23 (0.34 to 4.46) <u>Functionally significant contracture</u> <4 wks: 1.00 [ref] 4-7.99 wks: 0.90 (0.27 to 2.94) ≥8 wks: 0.94 (0.25 to 3.54) (<5 weeks vs > 5 weeks) YC P: 0.501 OR (95% CI) ≤ 5 weeks: 1.00 >5 weeks: 1.97 (0.53 to 7.37)	0.328	No significant association of LOS in hospital with ankle contractures
	Hamzah et al. [50]	Chi-square test with Yates correction			
		Univariate logistic regression analysis		0.313	
Dependency for bed mobility	Lam et al. [58]	GEE	OR (95%CI) <u>Upper limb contractures</u> 1.8 (CI 1.2 to 2.8) <u>Lower limb contractures</u> Univariate analysis: No contracture: 1.60 Unilateral contracture: 1.56 Multivariate analysis: No contracture: 1.82 Unilateral contracture: 1.96	<0.001 >0.05 >0.05	Dependency for bed mobility was an independent risk factor for the development of new upper limb contractures but not for lower limb contractures
Nursing home length of stay	Wagner et al. [9]	T test and logistic regression analysis	t=2.64 OR (95% CI) 1.027 (0.912 to 1.156)	0.009 0.663	Nursing home length of stay was significantly greater in those residents who had contractures. Multivariate analysis did not reach significance
Physical restraints	Castle and Engberg [41]	Regression analyses	Contractures (Mean±SD) Not physically restrained: 0.416±0.493 Physically restrained: 0.465±0.499 Difference of mean: 0.049 Unadjusted OR: 1.219	<0.001	Residents who are restrained are 2.3 percentage points more likely to have a contracture.
	Lam et al. [58]	GEE	Trunk or limb restraints <u>Upper limb contractures</u> No contracture: (OR: 2.09) Unilateral contracture (OR: 0.96) Multivariate analysis No contracture: 1.10 Lower limb contractures No contracture: (OR: 2.05)	<0.001 >0.05 >0.05 <0.001	Residents with no contractures at baseline and trunk or limb restraints were more likely to develop new joint contractures. However, trunk or limb restraint was not an independent risk factor in multivariate analysis

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			Unilateral contracture (OR: 1.51) Multivariate analysis No contracture: 1.16	>0.05 >0.05	
	Wagner et al. [9]	T-test and logistic regression analysis	OR (95% CI) 4.078 (0.968 to 17.175)	0.005 0.055	Physical restraints were significantly used more in residents with contractures compared with those without. Multivariate analysis did not reach significance.
Other factors					
Hospital Resource Utilization	Clavet et al. [43]	Chi square test	Physiatry consultations Discharge location First Physical therapy visit Frequency of treatments/week Time to first musculoskeletal assessment	>0.05 >0.05 >0.05 >0.05 >0.05	No significant associations

yr: year; GEE: generalized estimating equations; SD: standard deviation; FC: flexion contracture; OR: odds ratio; CI: confidence interval; Rt: right; Lt: Left; YC: yates correction; TKA: total knee arthroplasty; BMI: body mass index; HAQ: health assessment questionnaire; DASH: the disabilities of the arm, shoulder and hand; HAQ-DI: health assessment questionnaire- disability index; MHAQ: modified health assessment questionnaire; SF-36: short form-36; PF: physical function; EQ-5D: EuroQol- 5 dimension; SCIM: spinal cord independence measure; SCI-FI: spinal cord injury-functional index; ADL: activities of daily living; PROM: passive range of motion; OA: osteoarthritis; CHFS: cochin hand function scale; ARAT: action research arm test; MAS: motor assessment scale; wk: week; ROM: range of motion; FIM: functional independence measure; PDRS: psychogeriatric dependency rating scale; df: dorsiflexion; RR: relative risk; ICU: intensive care unit; LSDS: life-space diameter scale; ANOVA: analysis of variance; NPRS: numeric pain rating scale; VAS: visual analogue scale; VDS: visual descriptor scale; APS-J: Japanese Abbey pain scale; PROMIS-29 v2: patient-reported outcomes measurement information system-29 version 2.0; ASIA: American spinal cord injury association; NR: not reported; MMT: manual muscle testing; PU: pressure ulcers; MR: mental retardation; MMSE: mini mental state exam; NHBPS: nursing home behavior problem scale; NHPT: nine hole peg test; QOL: quality of life; IMV: invasive mechanical ventilation; LOS: length of stay

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Appendix III

- A. Delphi questionnaire
- B. ORACLE first revision

A. Delphi questionnaire

QUESTIONNAIRE

SECTION A

This section will seek your expert opinion on the development and progression/worsening of joint contractures in adults (>18 years). Please rate each factor according to your understanding of the importance of the factors which might influence the development and progression of joint contractures.

Note: The factors are listed in alphabetical order.

1. In your opinion, how important do you think these factors are in the development of joint contractures?	Extremely Unimportant	Very Unimportant	Unimportant	Important	Very important	Extremely important	Unsure
Ageing							
Bed confinement							
Clonus							
Dystonia							
Impaired cognition							
Muscle weakness							
Pain							
Pressure ulcers							
Spasticity							
Reduced physical function (reduced ability to perform basic and instrumental activities of daily living e.g., eating, dressing, transfers, toileting etc.)							

Reduced mobility (reduced ability to move independently and safely in different environments to perform the activities of daily living)							
Urinary incontinence							

2. Based on your expertise and practice with joint contractures, please specify any additional factors that you feel are missing above but are relevant/important to the development of joint contractures and select the relevant checkbox(es) -*Optional*.

Please specify any other factors below:	Extremely Unimportant	Very Unimportant	Unimportant	Important	Very important	Extremely important	Unsure

3. If you have specified any additional factors above, can you please provide a clinical example of how these specific factors can have an impact on the development of joint contractures? -*Optional*

--

Note: The factors are listed in alphabetical order.

4. In your opinion, how important do you think these factors are in the progression/worsening of existing joint contractures?	Extremely Unimportant	Very Unimportant	Unimportant	Important	Very important	Extremely important	Unsure
Ageing							
Bed confinement							
Clonus							
Dystonia							
Impaired cognition							
Muscle weakness							
Pain							
Pressure ulcers							
Spasticity							
Reduced functional independence (reduced ability to perform basic and instrumental activities of daily living e.g., eating, dressing, transfers, toileting etc.)							
Reduced mobility (reduced ability to move independently and safely in different environments to perform the activities of daily living)							
Urinary incontinence							

5. Based on your expertise and practice with joint contractures, please specify any additional factors that you feel are missing above but are relevant/important to the progression/worsening of existing joint contractures and select the relevant checkbox(es) -*Optional*.

Please specify any other factors below:	Extremely Unimportant	Very Unimportant	Unimportant	Important	Very important	Extremely important	Unsure

6. If you have specified any additional factors above, can you please provide a clinical example of how these specific factors can have an impact on the progression/worsening of existing joint contractures? -*Optional*

--

Note: The factors are listed in alphabetical order.

7. In your opinion, how relevant do you think are the following contextual environmental factors in the development and progression of joint contractures?	Extremely irrelevant	Very irrelevant	Irrelevant	Relevant	Very relevant	Extremely relevant	Unsure
Assistive devices /vehicles for personal indoor and							

outdoor mobility and transportation							
Food and Drugs							
Health care services, systems, and policies of the care home							
Regular social engagement with family, friends, and community members							
Temperature Control							
Support of immediate family							
Support of health professionals (doctors, nurses, physiotherapists, occupational therapists, speech therapists, audiologists, orthotist-prosthetists, medical social workers)							
Support from primary care givers							

8. Based on your expertise and practice with joint contractures, please specify any additional contextual environmental factors that you feel are missing above but are relevant/important to the progression/worsening of existing joint contractures in care homes and select the relevant checkbox(es) -*Optional*.

Please specify any other factors below:	Extremely irrelevant	Very irrelevant	Irrelevant	Relevant	Very relevant	Extremely relevant	Unsure

9. If you have specified any additional factors above, can you please provide a clinical example of how these specific factors are relevant in the progression/worsening of existing joint contractures? *-Optional*

SECTION B:

This section will seek your expert opinion on identification of joint contractures and different preventive care approaches of the development and progression of joint contractures.

10. Based on your expertise and practice, which professionals are able to clinically identify the following in adults in a care home setting (Check all options that apply)

Note: The items are listed in alphabetical order.

Clonus

- ☐ Carers
- ☐ Nurses
- ☐ Occupational therapists
- ☐ Physiotherapists

Cognition

- ☐ Carers
- ☐ Nurses
- ☐ Occupational therapists

- ☐ Physiotherapists

Dystonia

- ☐ Carers
- ☐ Nurses
- ☐ Occupational therapists
- ☐ Physiotherapists

Muscle weakness

- ☐ Carers
- ☐ Nurses
- ☐ Occupational therapists
- ☐ Physiotherapists

Pain

- ☐ Carers
- ☐ Nurses
- ☐ Occupational therapists
- ☐ Physiotherapists

Pressure Ulcers

- ☐ Carers
- ☐ Nurses
- ☐ Occupational therapists
- ☐ Physiotherapists

Spasticity

- ☐ Carers
- ☐ Nurses

- ☐Occupational therapists
- ☐Physiotherapists

Reduced functional independence (*reduced ability to perform basic and instrumental activities of daily living e.g., eating, dressing, transfers, toileting etc.*)

- ☐Carers
- ☐Nurses
- ☐Occupational therapists
- ☐Physiotherapists

Reduced mobility (*reduced ability to move independently and safely in different environments to perform the activities of daily living*)

- ☐Carers
- ☐Nurses
- ☐Occupational therapists
- ☐Physiotherapists

11. If you have identified any additional factors in Section A, please specify them below and professionals who are able to clinically identify them in adults in a care home setting (Check all options that apply) (*Optional*)

-
- ☐Carers
 - ☐Nurses
 - ☐Occupational therapists
 - ☐Physiotherapists

- ☐Carers
- ☐Nurses
- ☐Occupational therapists
- ☐Physiotherapists

-
- ☐Carers
 - ☐Nurses
 - ☐Occupational therapists
 - ☐Physiotherapists

-
- ☐Carers
 - ☐Nurses
 - ☐Occupational therapists
 - ☐Physiotherapists

-
- ☐Carers
 - ☐Nurses
 - ☐Occupational therapists
 - ☐Physiotherapists

Note: The care approaches are listed in alphabetical order.

SECTION C: Participant Demographics

15. Current Practice Region (country)

16. Current Practice Setting

(check all that apply)

Academia	
Acute Clinical	
Hospital	
Community	
Other (please specify below)	

17. Job Title

18. Years of Experience

19. Qualification

B. ORACLE first revision

OBSERVATIONAL RISK ASSESSMENT FOR CONTRACTURES- LONGITUDINAL EVALUATION (ORACLE)

+				Q1	
1. AGE <i>Please select the age category for the person</i>		6. MUSCLE WEAKNESS <i>Does the person have difficulty moving any of their limbs?</i>		Q2	
Less than 65	0	No difficulty: can move limbs independently	0	Q3	
Between 65 and 84	1	Some difficulty: can move with assistance	1	Q4	
85 or more	2	Great difficulty: cannot move themselves	2	Q5	
Score		Score		Q6	
2. BED MOBILITY <i>Is the person able to move and roll in bed?</i>		7. PAIN <i>Is the person experiencing any pain?</i>		Q7	
Able to move and roll independently	0	No pain at all	0	Q8	
Able to move and roll with some assistance	1	Yes, but controlled by medication	1	Q9	
Unable to move at all without assistance	2	Yes, despite medication	2	Q10	
Score		Score		Total score	
3. TRANSFER ABILITY <i>Is the person able to move from bed to chair?</i>		8. PRESSURE SORES <i>Are there any changes to the person's skin?</i>			
Able to move independently	0	No, not at all	0		
Able to move with some assistance	1	Change in colour (red, blue, purple, or black)	1		
Unable to move at all without assistance	2	Damaged or broken skin	2		
Score		Score			
4. WALKING <i>Is the person able to walk?</i>		9. COGNITION <i>Does the person have difficulty following instructions?</i>			
Able to walk independently	0	No, not at all	0		
Able to walk with some assistance	1	Yes, sometimes	1		
Unable to walk at all without assistance	2	Yes, all the time	2		
Score		Score			
5. FUNCTIONAL ABILITY <i>Is the person able to carry out activities of daily living (e.g., eating, dressing, bathing etc)?</i>		10. ACTIVITY ENGAGEMENT <i>Is the person motivated to engage in activities?</i>			
Able to carry out ADLs independently	0	Engages without encouragement	0		
Able to carry out ADLs with some assistance	1	Needs encouragement in activities	1		
Not at all without assistance	2	Does not engage at all	2		
Score		Score			

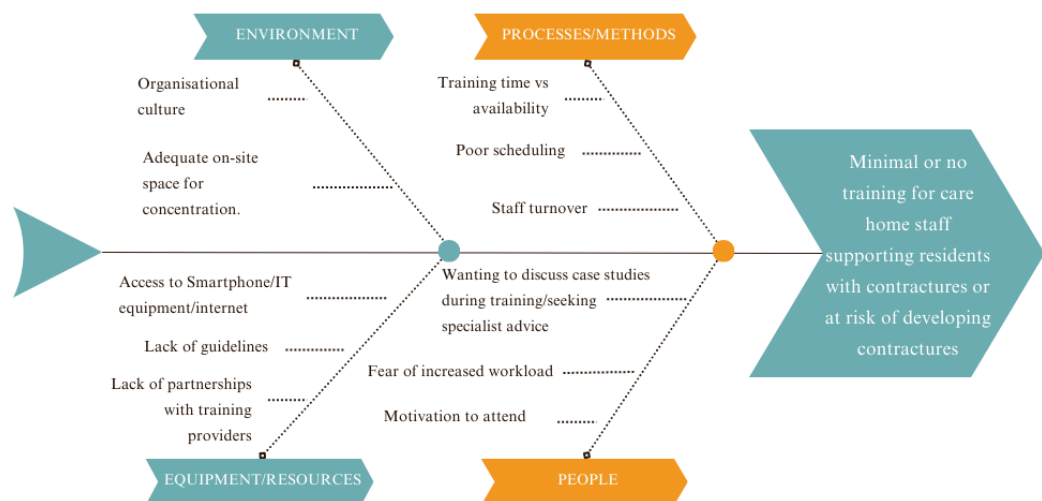
SCORE	RISK
0-2	Low risk
3-11	Medium risk
≥12	High risk

RESPONSE ACTIONS			
SCORE	RISK	ACTIONS IF RISK IS DIFFERENT FROM LAST REVIEW (OR NEWLY ASSESSED)	ACTIONS IF RISK IS UNCHANGED SINCE THE LAST REVIEW
0-2	Low risk	• Encourage the person to move at regular intervals. • Encourage the person to engage in their own care routines, such as dressing, grooming and feeding independently. • Effective use of pillows to support proper positioning • Encourage and help food and drink to be taken • Encourage to engage in social and group activities • Inspect and review vulnerable skin areas. • Review pain control • Review medications • Review assistive devices	• Continue to follow existing care plan • Review in one month
3-11	Medium risk	• Make a NON-URGENT referral to occupational therapist/physiotherapist for detailed assessment • Encourage the person to move at regular intervals. • Encourage the person to engage in their own care routines, such as dressing, grooming and feeding independently. • Effective use of pillows to support proper positioning Encourage and help food and drink to be taken • Encourage to engage in social and group activities • Inspect and review vulnerable skin areas. • Review pain control • Review medications • Review assistive devices	• Continue to follow existing care plan devised by the PT/OT • Review in one month
≥12	High risk	• Make URGENT referral to occupational therapist/physiotherapist for detailed assessment • Encourage the person to move at regular intervals. • Encourage the person to engage in their own care routines, such as dressing, grooming and feeding independently. • Effective use of pillows to support proper positioning Encourage and help food and drink to be taken • Encourage to engage in social and group activities • Inspect and review vulnerable skin areas. • Review pain control • Review medications • Review assistive devices	• Continue to follow existing care plan devised by OT/PT • Review in one month

Appendix IV

- A. Fishbone analysis
- B. Questionnaire
- C. Educational video snapshots

A. Fishbone analysis



B. Questionnaire



Contracture
Training
for Care Staff



Demographics:

What is your job title?

Please tick how many years of experience you have

- 1-5 years ☐
- 5-10 years ☐
- 10-20 years ☐
- 20+ years ☐

Please add your area of specialty if relevant. For example, Dementia Care

Pre-Video: Contracture knowledge & experience:

Please rate (tick) your knowledge and understanding of contractures

- Extensive knowledge & understanding ☐
- Good knowledge & understanding ☐
- Basic knowledge & understanding ☐
- No knowledge & understanding ☐

Please rate (tick) how much you agree with the following statement "I provide care for residents with contractures"

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

Have you ever used a tool or method to assess the risk of contractures for

- Yes ☐
- No ☐

your residents?

If yes, please share which tool or method you have used

Have you ever attended contracture or postural management training?

- Yes ☐
- No ☐

If yes, please tell us about the training

Post Video: Contracture knowledge & experience:

Please rate (tick) your knowledge and understanding of contractures

- Extensive knowledge & understanding ☐
- Good knowledge & understanding ☐
- Basic knowledge & understanding ☐
- No knowledge & understanding ☐

Please rate (tick) how much you agree with the following statement "I provide care for residents with contractures"

- Always ☐
- Often ☐
- Sometimes ☐
- Never ☐

Training feedback:

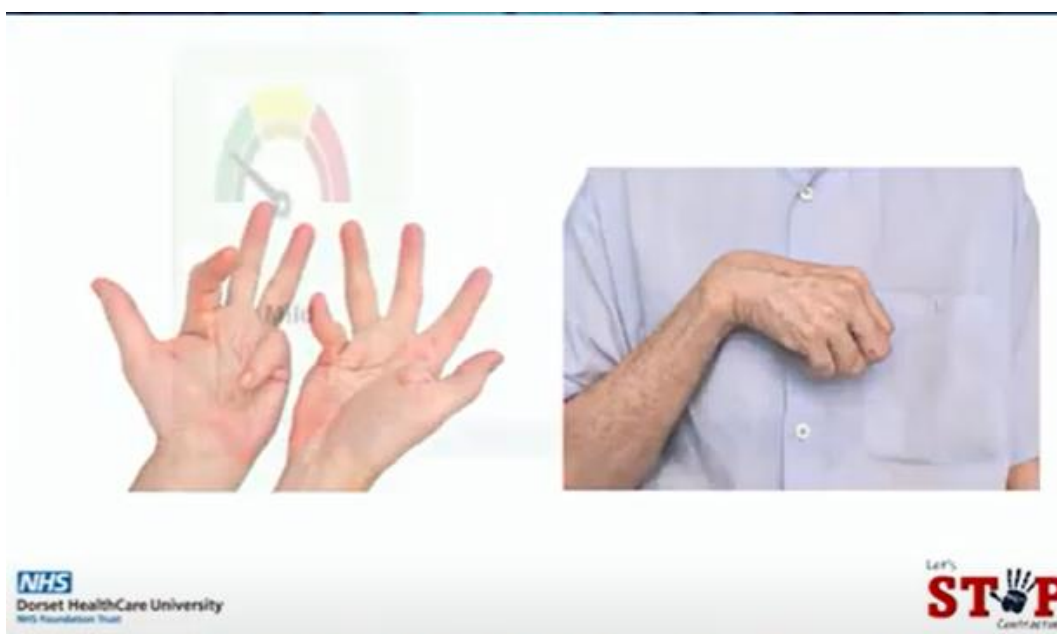
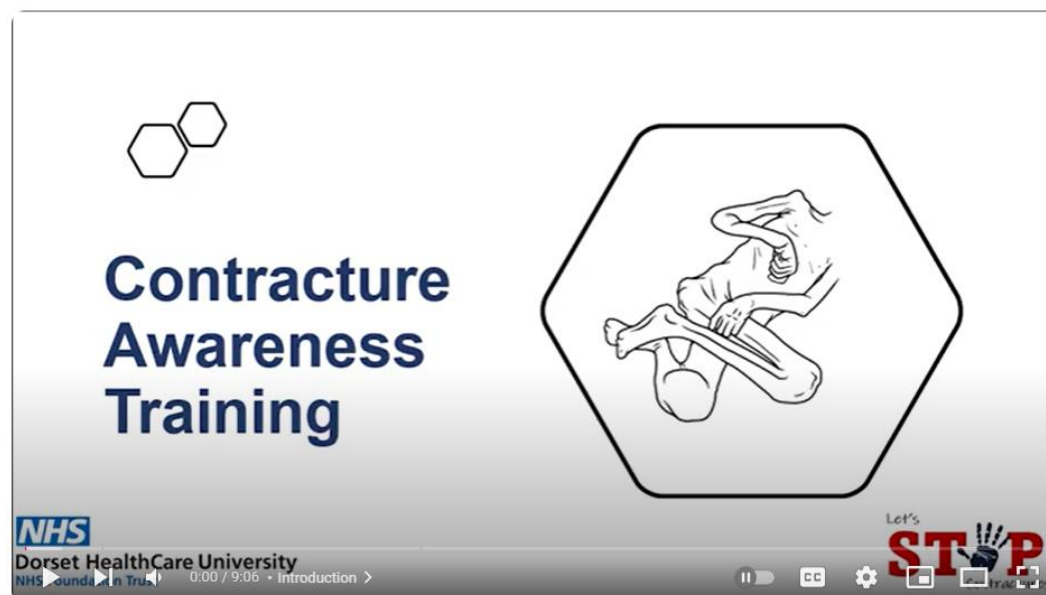
Please use key words to describe the impact of this training

[illegible]

Is there anything you would change about this training?

[illegible]

C. Educational video snapshots



For the Individual



Pain and discomfort

Pressure sores and skin breakdown

Difficulty eating, dressing & washing

Difficulty in getting out of bed and moving around

Increased risk of falls

For Care Home & Staff

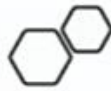


Increased burden of care

Increased need for equipment

Difficulty in moving and handling tasks

Increased physical demands



**Reduced physical
mobility**



Dorset HealthCare University
NHS Foundation Trust



Strength



Treatment



Opportunity to engage



Positioning

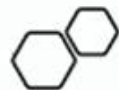


Dorset HealthCare University
NHS Foundation Trust





- Structured and regular risk assessments.
- **ORACLE:** Observational Risk Assessment for Contractures (Longitudinal Evaluation)



Appendix V

- A. Barthel Index
- B. Screening document and demographics
- C. Participant Information Sheet for residents
- D. Easy-read summary of study
- E. Participant Information Sheet for personal consultees
- F. Participant Information Sheet for nominated consultees
- G. ICF- Conceptual overlap between ORACLE and Barthel Index

A. Barthel Index

BARTHEL INDEX

To be completed by a Registered Nurse

Please encircle the correct scores and indicate the total score and level of risk below this form.

Resident Unique ID: _____

1. BOWELS Incontinent or needs enemas Occasional accident (1x/wk) Continent	0 1 2	6. TRANSFER (bed to chair and back) Unable, no sitting balance Major help (1 or 2 people), can sit Minor help (verbal or physical) Independent	0 1 2 3
2. BLADDER Incontinent or needs enemas Occasional accident (1x/wk) Continent	0 1 2	7. MOBILITY Immobile Wheelchair independent (including corners) Walks with the help of 1 person (physical or verbal help) Independent (may use aid)	0 1 2 3
3. GROOMING Needs help with personal care Independent (including face, hair, teeth, shaving)	0 1	8. DRESSING Dependent Needs help – can do ~ ½ unaided Independent (including buttons, zips, laces, etc.)	0 1 2
4. TOILET USE Dependent Needs some help Independent	0 1 2	9. STAIRS Unable Needs help (verbal or physical) Independent	0 1 2
5. FEEDING Unable Needs help, e.g., cutting Independent	0 1 2	10. BATHING Dependent Independent (bath or shower)	0 1

Total score _____

Completed by: _____

Completion Date: _____

B. Screening and demographics



Screening Document (To be filled by the registered nurse)

1. ID: (example 001)
2. Is the resident receiving **end-of-life care**?
☐Yes ☐No

If you have selected yes, then please do not proceed with the next section.

Demographics

1. Age:
2. Gender: ☐ Female ☐ Male ☐ Other
3. Does the resident have any joint contractures?
☐Yes ☐No
4. If you ticked yes above, please specify the area(s) below:
5. **Past Medical History: (check all that apply)**
 - ☐ Asthma or lung disease
 - ☐ Chronic Obstructive Pulmonary Disease (COPD)
 - ☐ Alzheimer's disease
 - ☐ Blood disorder (e.g., anaemia)
 - ☐ Cancer
 - ☐ Dementia
 - ☐ Depression/Mental illness
 - ☐ Diabetes
 - ☐ Heart disease
 - ☐ Myocardial Infarction
 - ☐ Hypertension
 - ☐ Multiple Sclerosis
 - ☐ Osteoarthritis
 - ☐ Parkinson's disease
 - ☐ Rheumatoid Arthritis
 - ☐ Stroke
 - ☐ High cholesterol (hyperlipidaemia)
 - ☐ **Other (please specify):**
6. Does the resident have any informal carers, family, or friends who attend?
☐Yes, they visit regularly
☐Yes, they visit occasionally
☐No

C. Participant Information Sheet for residents



Participant Information Sheet (Care Home Residents)

IRAS ID: 318311

Version: 2.0

Date: 20/03/2023

Study title

Development, validation, and evaluation of a risk assessment tool for contractures: the ORACLE study

You are being invited to take part in a research study. This study is being carried out as part of a PhD project undertaken by the researcher, Hina Tariq. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. You can ask a friend, family or a staff member to help you with this.

Who is funding the research?

This research project is funded by Bournemouth University and Dorset Healthcare University NHS Foundation Trust (DHUFT)

Who has reviewed the study?

This research study has been reviewed by a panel of experts and granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC.

What is the purpose of the study?

Contractures can be defined as loss of joint movement due to permanent shortening of the muscles or other tissues surrounding the joint. This study aims to test a newly developed observational tool, **Observational Risk Assessment for Contractures- Longitudinal Evaluation (ORACLE)** to identify the risk of restricted joint movement (contractures) following reduced mobility, muscle weakness, and non-use of the limbs in care home residents. This tool is not currently validated or used routinely.

Regular checks through the use of this tool to see if someone is at risk of developing a contracture could help specialists to have earlier interventions minimising its impact on the person. Furthermore, it may possibly reduce the risk of new contractures or worsening of existing contractures, help maintain or promote independence with daily activities, and improve your overall quality of life.

Before ORACLE can be used the research team need to assess if the tool tests what it should be testing, and, whether the staff gets the same outcome when the test is repeated more than once.

Why you have been invited?

You are invited because you are living in a care home and can help to contribute towards the testing of this newly developed risk assessment tool for contractures.

Do I have to take part?

Taking part in this research study is entirely voluntary, and your decision to take part or not taking part will not impact on the care you receive. If you do decide to take part, you will be asked to sign a consent form before participating. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

The care home staff will care for you in the usual way and with your consent, will complete the observational forms related to the risk assessment tool and update you with the results on request. You will not be asked for your active participation apart from requesting your informed consent. These observations will be recorded by different staff members more than once and should not take more than a day to be completed. By taking part, you will not be identifiable by any of the data collected as part of the research project.

What are the possible advantages and disadvantages of taking part?

Whilst there are no immediate benefits for those participating in this study, it is hoped that this tool will be used widely to help in early identification if someone is at risk of developing a contracture. Earlier identification and management may help to improve people's quality of life. There are no anticipated disadvantages to taking part in the study.

How will my information be managed?

Participation in this study is based on consent, and you can change your mind at any point in the study. Once we complete the data collection, your personal information is processed in compliance with the data protection legislation. We will use your data on the basis that it is necessary for the conduct of research, which is an activity in the public interest.

Bournemouth University (BU) is a Data Controller of your information which means that we are responsible for looking after your information and using it appropriately. Undertaking this research study involves collecting and/or generating anonymised information about you. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws.

[BU's Research Participant Privacy Notice](#) sets out more information about how we fulfil our responsibilities as data controller and about your rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis on which we will process your information. Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this information sheet.

Publication

You will not be identified in any external reports or publications about the research. Your information will only be included in these materials in an anonymous form (i.e., we will not use your name or any other information that might lead to you being identified). Research results will be published in a reputable journal or a conference presentation.

Security and access controls

Bournemouth University will hold the anonymised information we collect about you electronically on a password-protected secure network. Contact information will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research, or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

Keeping your information if you withdraw from the study

You can stop being part of the study without giving a reason, but we will keep information about you that we already have. This is because once we anonymise the information, we will not be able to tell what information came from you. We need to manage your records in specific ways for the research to be reliable. This means that we will not be able to let you see or change the data we hold about you.

Retention of your data

We will keep the signed consent form for a period of 12 months after the study has ended. This is the only document that has your name and signature on it and is kept separate from the anonymised data. Your anonymised information and samples cannot be linked to your name on this form. Although published research outputs are anonymised, we need to retain underlying data collected for the study in a non-anonymised form for 10 years to enable the research to be audited and/or to enable the research findings to be verified.

Where can I find out more about how my information is used?

You can find out more about how we use your information by:

- Accessing this link at: <http://www.hra.nhs.uk/patientdataandresearch>
- Accessing BU's Research Participant Privacy notice at:
https://intranetsp.bournemouth.ac.uk/documentsrep/Research_Participant_Privacy_Notice.pdf
- Contacting one the research team members.
- Sending an email to: DPO@bournemouth.ac.uk

Finally

A copy of this information sheet will be given to you to keep at the start of the study. You will also be given the chance to read this again and ask questions before you then sign the consent form. Thank you for considering taking part in this research project.

Contact for further information

If you would like to talk to one of the researchers to help you decide whether or not you would like to take part, or would like answers to any questions you may have, then please contact:

PhD Student

Mrs Hina Tariq

Email: htariq@bournemouth.ac.uk

Tel: 07404564696

Chief Investigator

Professor Sam Porter

Email: porters@bournemouth.ac.uk

Clinical Supervisor:

Mr Joel Dunn

Email: joel.dunn1@nhs.net

In case of complaints

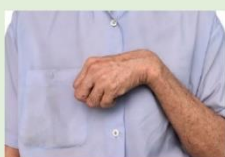
Any concerns about the study should be directed to Professor Vanora Hundley, Faculty of Health and Social Sciences (FHSS), Bournemouth University by emailing researchgovernance@bournemouth.ac.uk

D. Easy-read summary

Easy Read Summary of the Study (Residents lacking capacity)

IRAS ID: 318311
Version: 1.0
Date: 24/05/2023

What is this study about?



We would like you to take part in a study about contractures.

Joint contractures occur when our joints become stiff and tight, making it difficult to move them.

This can happen when a person stays in the same position for a long time. It can also be caused by certain medical conditions or muscle problems.

We have developed a tool to identify the risk of joints becoming stiffer, so that something can be done to try to prevent this.

Can I take part?



You can take part if:

- If you are an adult aged 18 or above.

What will happen?



Members of your care team will care for you in the usual way and record their observations based their daily interactions with you.



You will not be asked any questions or take part actively during the observations.



This will not take more than a day.

Who will be told about it?



If further action is required regarding your care, your local community therapy team will be sent a copy of your observation chart.



If you or your consultee (usually a family member who knows you well, or maybe a carer) would like to know the results of the study we will share this.



No other information with your personal details will be shared.



All the information we keep about you will be locked securely in a cabinet or stored in a secure computer record at Bournemouth University

Only people who are part of the study team can see it.

Are there any benefits?



By taking part in this study, you are helping identify the risk of a joint becoming stiffer and preventing this which may have a positive impact on daily function.



This might help us improve your care now or might be useful in the future.

This may also help other residents in the future.

Are there any disadvantages or risks?



There are no treatments involved, so there are no other disadvantages or risks to taking part.



If you have any further questions, please ask a member of your care team or contact the researcher using the following contact details:



Hina Tariq, Postgraduate Researcher,
Faculty of Health and Social Sciences,
Bournemouth University, BH8 8GP



Email: htariq@bournemouth.ac.uk



Telephone: 07404564696

E. Participant Information Sheet for personal consultees



PARTICIPANT INFORMATION SHEET (Personal Consultee)

IRAS ID: 318311

Version: 1.0

Date: 22/05/2023

Study title

Development, validation, and evaluation of a risk assessment tool for contractures: the ORACLE study

Your friend/relative has been invited to join our research study which is described below. Your friend or relative is not able to decide for themselves if they would like to participate. We invite you to read the information below.

To help decide if he/she should join the study, we'd like to ask your opinion whether or not they would want to be involved. We'd ask you to consider what you know of their wishes and feelings, and to consider their interests. Please let us know of any advance decisions they may have made about participating in research. These should take precedence.

If you decide your relative/friend would have no objection to taking part we will ask you to read and sign the consultee declaration on the last page of this information leaflet. We'll then give you a copy to keep. We will keep you fully informed during the study so you can let us know if you have any concerns or you think your relative/friend should be withdrawn.

If you decide that your friend/relative would not wish to take part it will not affect the standard of care they receive in any way.

If you are unsure about taking the role of consultee you may seek independent advice. We will understand if you do not want to take on this responsibility.

The following information is the same as would have been provided to your relative/friend:

This study is being carried out as part of a PhD project undertaken by the researcher, Hina Tariq. Before you decide on behalf of your relative/friend, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. You can ask a staff member to help you with this.

Who is funding the research?

This research project is funded by Bournemouth University and Dorset Healthcare University NHS Foundation Trust (DHUFT)

Who has reviewed the study?

This research study has been reviewed by a panel of experts and granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC.

What is the purpose of the study?

Contractures can be defined as loss of joint movement due to permanent shortening of the muscles or other tissues surrounding the joint. This study aims to test a newly developed observational tool, **Observational Risk Assessment for Contractures- Longitudinal**

Evaluation (ORACLE) which is designed to identify the risk of restricted joint movement (contractures). Contractures can develop following a decrease in mobility, muscle weakness, and not using of the limbs, this can happen in all people, especially in in care home residents. This tool is not currently validated or used routinely.

Regular checks through the use of this tool to see if someone is at risk of developing a contracture could help specialists to have earlier treatment which could minimising the impact of contractures on the person. Furthermore, it may reduce the development of new contractures or worsening of contractures people already have. The tool can also help to maintain or promote independence with daily activities, and improve your overall quality of life. Before ORACLE can be used the research team need to check if the tool tests what it should be testing, and , whether the staff gets the same outcome when the test is repeated more than once. These are key parts to developing a risk assessment tool.

Why your relative/friend has been invited?

Your relative/friend has been invited because he/she is living in a care home and can help to contribute towards the testing of this newly developed risk assessment tool for contractures.

Does your relative/friend has to take part?

Taking part in this research study is entirely voluntary, and your decision on behalf of your relative/friend to take part or not take part will not impact on the care he/she receives. If you do decide that your friend or relative would like to take part, you will be asked to sign a consultee declaration form. However, you are still free to withdraw for your friend/relative on their behalf at any time and without giving a reason.

What will happen to your relative/friend if he/she takes part?

The care home staff will care for your relative/friend in the usual way and will complete the observational forms related to the risk assessment tool and update you with the results on your request. He/she will not be asked for his/her active participation. These observations will be recorded by different staff members more than once at different times and the whole process should not take more than a day to be completed. By taking part, your relative/friend will not be identifiable by any of the data collected as part of the research project.

What are the possible advantages and disadvantages of taking part?

Whilst there might be no immediate benefits for those participating in this study, it is hoped that this tool will be used widely to help in early identification if someone is at risk of developing a contracture. Earlier identification and management may help to improve people's quality of life. There are no anticipated disadvantages to taking part in the study.

How will your relative/friend's information be managed?

Once we complete the data collection, the personal information is processed in compliance with the data protection legislation. We will use the data on the basis that it is necessary for the conduct of research, which is an activity in the public interest.

Bournemouth University (BU) is a Data Controller of your relative/friend's information which means that we are responsible for looking after their information and using it appropriately. Undertaking this research study involves collecting and/or generating anonymised information about them. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws.

[BU's Research Participant Privacy Notice](#) sets out more information about how we fulfil our responsibilities as data controller and about their rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis

on which we will process the information. Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this information sheet.

Publication

The participants (your relative/friend) will not be identified in any external reports or publications about the research. Their information will only be included in these materials in an anonymous form (i.e., we will not use their name or any other information that might lead them being identified). Research results will be published in a reputable journal or a conference presentation.

Security and access controls

Bournemouth University will hold the anonymised information we collect about the participants (your relative/friend) electronically on a password-protected secure network. Contact information will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research, or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

Keeping participants' information in case of withdrawal

If you decide to withdraw your relative or friend on their behalf, we will keep information about them we already have. This is because once we anonymise the information, we will not be able to tell what information came from them. We need to manage their records in specific ways for the research to be reliable. This means that we will not be able to let you see or change the data we hold about you.

Retention of your data

We will keep the signed consultee declaration form for a period of 12 months after the study has ended. This is the only document that has your name and signature on it and is kept separate from the anonymised data. Your anonymised information and samples cannot be linked to your relative/friend's name on this form. Although published research outputs are anonymised, we need to retain underlying data collected for the study in a non-anonymised form for 10 years to enable the research to be audited and/or to enable the research findings to be verified.

Where can you find out more about how participants' information is used?

You can find out more about how we use participants' information by:

- Accessing this link at: <http://www.hra.nhs.uk/patientdataandresearch>
- Accessing BU's Research Participant Privacy notice at: https://intranetsp.bournemouth.ac.uk/documentsrep/Research_Participant_Privacy_Notice.pdf
- Contacting one of the research team members.
- Sending an email to: DPO@bournemouth.ac.uk

Finally

A copy of this information sheet will be given to you to keep at the start of the study. You will also be given the chance to read this again and ask questions before you then sign the consultee declaration form. Thank you for considering to take the role of the consultee.

Contact for further information



If you would like to talk to one of the researchers to help you making a decision or would like answers to any questions you may have, then please contact:

PhD Student

Mrs Hina Tariq

Email: htariq@bournemouth.ac.uk

Tel: 07404564696

Chief Investigator

Professor Sam Porter

Email: porters@bournemouth.ac.uk

Clinical Supervisor:

Mr Joel Dunn

Email: joel.dunn1@nhs.net

In case of complaints

Any concerns about the study should be directed to Professor Vanora Hundley, Faculty of Health and Social Sciences (FHSS), Bournemouth University by emailing researchgovernance@bournemouth.ac.uk

F. Participant Information Sheet for nominated consultees



PARTICIPANT INFORMATION SHEET (Nominated Consultee)

IRAS ID: 318311

Version: 1.0

Date: 22/05/2023

Study title

Development, validation, and evaluation of a risk assessment tool for contractures: the ORACLE study

You have been nominated as a possible consultee for this resident. He/she is not able to decide for themselves if they would like to participate. We invite you to read the information below.

To help decide if he/she should join the study, we'd like to ask your opinion whether or not they would want to be involved. We'd ask you to consider what you know of their wishes and feelings, and to consider their interests. Please let us know of any advance decisions they may have made about participating in research. These should take precedence.

If you decide this resident would have no objection to taking part we will ask you to read and sign the consultee declaration on the last page of this information leaflet. We'll then give you a copy to keep. We will keep you fully informed during the study so you can let us know if you have any concerns or you think the resident should be withdrawn.

If you decide that this resident would not wish to take part it will not affect the standard of care they receive in any way.

If you are unsure about taking the role of consultee you may seek independent advice. We will understand if you do not want to take on this responsibility.

The following information is the same as would have been provided to this resident:

This study is being carried out as part of a PhD project undertaken by the researcher, Hina Tariq. Before you decide on behalf of the resident, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. You can ask a staff member to help you with this.

Who is funding the research?

This research project is funded by Bournemouth University and Dorset Healthcare University NHS Foundation Trust (DHUFT)

Who has reviewed the study?

This research study has been reviewed by a panel of experts and granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC.

What is the purpose of the study?

Contractures can be defined as loss of joint movement due to permanent shortening of the muscles or other tissues surrounding the joint. This study aims to test a newly developed observational tool, **Observational Risk Assessment for Contractures- Longitudinal**

Evaluation (ORACLE) which is designed to identify the risk of restricted joint movement (contractures). Contractures can develop following a decrease in mobility, muscle weakness, and not using of the limbs, this can happen in all people, especially in in care home residents. This tool is not currently validated or used routinely.

Regular checks through the use of this tool to see if someone is at risk of developing a contracture could help specialists to have earlier treatment which could minimising the impact of contractures on the person. Furthermore, it may reduce the development of new contractures or worsening of contractures people already have. The tool can also help to maintain or promote independence with daily activities, and improve your overall quality of life. Before ORACLE can be used the research team need to check if the tool tests what it should be testing, and , whether the staff gets the same outcome when the test is repeated more than once. These are key parts to developing a risk assessment tool.

Why this care home resident has been invited?

This resident under your care has been invited because he/she is living in a care home and can help to contribute towards the testing of this newly developed risk assessment tool for contractures.

Do they have to take part?

Taking part in this research study is entirely voluntary, and your decision on behalf of the resident to take part or not taking part will not impact on the care he/she receives. If you do decide that this resident under your care would like to take part, you will be asked to sign a consultee declaration form.. However, you are still free to withdraw on their behalf at any time and without giving a reason.

What will happen to the resident if he/she takes part?

The care home staff will care for this resident in the usual way and will complete the observational forms related to the risk assessment tool and update you with the results on your request. He/she will not be asked for his/her active participation. These observations will be recorded by different staff members more than once at different times and the whole process should not take more than a day to be completed. By taking part, they will not be identifiable by any of the data collected as part of the research project.

What are the possible advantages and disadvantages of taking part?

Whilst there might be no immediate benefits for those participating in this study, it is hoped that this tool will be used widely to help in early identification if someone is at risk of developing a contracture. Earlier identification and management may help to improve people's quality of life. There are no anticipated disadvantages to taking part in the study.

How will your resident's information be managed?

Once we complete the data collection, the personal information is processed in compliance with the data protection legislation. We will use the data on the basis that it is necessary for the conduct of research, which is an activity in the public interest.

Bournemouth University (BU) is a Data Controller of the participant's information which means that we are responsible for looking after their information and using it appropriately. Undertaking this research study involves collecting and/or generating anonymised information about them. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws.

[BU's Research Participant Privacy Notice](#) sets out more information about how we fulfil our responsibilities as data controller and about their rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis

on which we will process the information. Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this information sheet.

Publication

The participants (resident under your care) will not be identified in any external reports or publications about the research. Their information will only be included in these materials in an anonymous form (i.e., we will not use their name or any other information that might lead them being identified). Research results will be published in a reputable journal or a conference presentation.

Security and access controls

Bournemouth University will hold the anonymised information we collect about the participants (resident under your care) electronically on a password-protected secure network. Contact information will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research, or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

Keeping participants' information in case of withdrawal

If you decide to withdraw this resident on their behalf, we will keep information about them we already have. This is because once we anonymise the information, we will not be able to tell what information came from them. We need to manage their records in specific ways for the research to be reliable. This means that we will not be able to let you see or change the data we hold about you.

Retention of your data

We will keep the signed consultee declaration form for a period of 12 months after the study has ended. This is the only document that has your name and signature on it and is kept separate from the anonymised data. Your anonymised information and samples cannot be linked to you're the resident's name on this form. Although published research outputs are anonymised, we need to retain underlying data collected for the study in a non-anonymised form for 10 years to enable the research to be audited and/or to enable the research findings to be verified.

Where can you find out more about how participants' information is used?

You can find out more about how we use participants' information by:

- Accessing this link at: <http://www.hra.nhs.uk/patientdataandresearch>
- Accessing BU's Research Participant Privacy notice at: https://intranetsp.bournemouth.ac.uk/documentsrep/Research_Participant_Privacy_Notice.pdf
- Contacting one the research team members.
- Sending an email to: DPO@bournemouth.ac.uk

Finally

A copy of this information sheet will be given to you to keep at the start of the study. You will also be given the chance to read this again and ask questions before you then sign the consultee declaration form. Thank you for considering to take the role of the consultee.

Contact for further information



If you would like to talk to one of the researchers to help you making a decision or would like answers to any questions you may have, then please contact:

PhD Student

Mrs Hina Tariq

Email: htariq@bournemouth.ac.uk

Tel: 07404564696

Chief Investigator

Professor Sam Porter

Email: porters@bournemouth.ac.uk

Clinical Supervisor:

Mr Joel Dunn

Email: joel.dunn1@nhs.net

In case of complaints

Any concerns about the study should be directed to Professor Vanora Hundley, Faculty of Health and Social Sciences (FHSS), Bournemouth University by emailing researchgovernance@bournemouth.ac.uk

G. ICF- Conceptual overlap between ORACLE and Barthel Index

(Adapted from Kaambwa et al. 2021)

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
Body Functions	- Mental Functions - Sensory Functions and Pain - Voice and Speech Functions - Functions of the Cardiovascular, Haematological, Immunological and Respiratory Systems - Functions of the Digestive, Metabolic, Endocrine Systems - Genitourinary and Reproductive Functions - Neuromusculoskeletal and Movement-Related Functions - Functions of the Skin and Related Structures	<i>Chapter: Mental Functions</i> ○ b152 Emotional functions ○ b156 Perceptual functions ○ b160 Thought functions	Cognition Activity engagement	N/A
		<i>Chapter: Sensory Functions and Pain</i> ○ b280 Sensation of pain ○ b298 Sensory functions and pain, other specified ○ b299 Sensory functions and	Pain	N/A

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		pain, unspecified		
		<i>Chapter: Functions of the Digestive, Metabolic, Endocrine Systems</i> ○ b525 Defecation functions	N/A	Bowels
		<i>Chapter: Functions of the Digestive, Metabolic, Endocrine Systems</i> ○ b610 Urinary excretory functions ○ b6101 Collection of urine ○ b620 Urination functions	N/A	Bladder

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		○ b6200 Urination ○ b630 Sensations associated with urinary functions ○ e1151 Assistive products and technology for personal use in daily living ○ s570 Structure of gall bladder and ducts ○ s6102 Urinary bladder		
Body structure	• Structure of the Nervous System • The Eye, Ear and Related Structures	N/A		N/A

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
	- Structures Involved in Voice and Speech - Structure of the Cardiovascular, Immunological and - Respiratory Systems - Structures Related to the Digestive, Metabolic and - Endocrine Systems - Structure Related to Genitourinary and Reproductive - Systems - Structure Related to Movement - Skin and Related Structures		Muscle weakness Pressure sores	
Activities and Participation	- Learning and Applying Knowledge - General Tasks and Demands - Communication - Mobility - Self-Care - Domestic Life	<i>Chapter: Mobility</i> ○ d410–d429 Changing and maintaining body position ○ d450–d469 Walking and moving	Bed mobility Transfer ability Walking ability	Mobility Stairs Transfer

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
	- Interpersonal Interactions and Relationships - Major Life Areas - Community, Social and Civic Life	☐ d498 Mobility, other specified ☐ d499 Mobility, unspecified		
		<i>Chapter: Self-Care</i> ☐ d510 Washing oneself ☐ d520 Caring for body parts ☐ d530 Toileting ☐ d540 Dressing ☐ d550 Eating ☐ d560 Drinking ☐	Functional ability	Bathing Grooming Feeding Dressing Toilet use

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		d570 Looking after one's health ☐ d598 Self-care, other specified ☐ d599 Self-care, unspecified		
		<i>Chapter: Domestic</i> ☐ d610–d629 Acquisition of necessities ☐ d630–d649 Household tasks ☐ d630–d649 Household tasks ☐ d650–d669 Caring for household objects and		

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		assisting others ☐ d650–d669 Caring for household objects and assisting others ☐ d698 Domestic life, other specified ☐ d699 Domestic life, unspecified		
		Chapter: <i>Interpersonal Interactions and Relationships</i> ☐ d710–d729 General interpersonal interactions ☐	Activity engagement	

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		d710 Basic interpersonal interactions ○ d720 Complex interpersonal interactions ○ d729 General interpersonal interactions, other specified and unspecified ○ d730–d779 Particular interpersonal relationships ○ d798 Interpersonal interactions and relationships, other specified ○ d799 Interpersonal interactions		

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		and relationships, unspecified		
		<i>Chapter:</i> <i>Major Life Areas</i> ○ d810–d839 Education ○ d840–d859 Work and employment ○ d860–d879 Economic life ○ d898 Major life areas, other specified ○ d899 Major life areas, unspecified		
		<i>Chapter:</i> <i>Community, Social and Civic Life</i>		

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		○ - d910 Community life ○ - d920 Recreation and leisure ○ - d930 Religion and spirituality ○ - d940 Human rights ○ - d950 Political life and citizenship ○ - d998 Community, social and civic life, other specified ○ - d999 Community, social and	Activity engagement	

International Classification of Functioning, Disability and Health (ICF) Classifications			Instrument Dimensions	
Domains	ICF Chapter	Specific ICF Chapters and Categories	ORACLE	Barthel Index
		civic life, unspecified		
Environmental Factors	• Products and Technology • Natural Environment and Human-Made Changes to Environment • Support and Relationships • Attitudes • Services, Systems and Policies	N/A	N/A	N/A

Appendix VI

- A. Interview guides
- B. Participant Information Sheet for senior staff members
- C. Participant Information Sheet for healthcare assistants

A. Interview guides



IRAS ID: 318311
Version: 1.0
Date: 11/10/2022

Study title

Development, validation, and evaluation of a risk assessment tool for contractures: the ORACLE study

Topic Guide for Interviews (Care Home Managers/Registered Nurses)

- a) **Introduction, welcome and demographics (age, gender, experience, speciality etc)**
 - Tell me about your experience using the tool?
 - Did anything work well in the tool?
 - Is there anything that did not work well in the tool?
 - Tell me about how you found the wording and questions in the tool?
 - Tell me about your experience of the recommendations based on level of risk in the tool?
 - Tell me about your experience of the training session? Is there anything you would change or want more information about?
- b) **Feedback about the layout, and language of the tool?**
 - How did you find the wording of the tool?
 - Ease of use – scoring, time taken to complete the observation etc.
 - Overall layout of the tool (font, font size etc).
 - Prompts
 - Can you tell me more about that?
- c) **Practical implementation of ORACLE**
 - Do you have the responsibility for organising the day today routine of the residents?
 - If you do, how easy or difficult it was to incorporate the tool into their routine?
 - How are the in-reaching services (e.g. PTs and OTs, GP, spasticity management services etc.) supporting you in response to the referrals made through this tool?
 - Does the care home have the appropriate resources (time, staff & skills) to regularly perform assessments?
 - Education and training needs of the staff to use the tool effectively.
 - Service user education and involvement to optimise tool fidelity.
 - Prompts
 - Can you tell me more about that?
- c) **Contextual factors that need to be considered to optimise the usability of the tool within a care home**
 - Nutrition/Diet
 - Medications

- Opportunity to engage socially with friends, family, and other community members
- Support from family, healthcare professionals and /or healthcare assistants.
- Prompts
 - i. Can you tell me more about that...?

d) Ending

- Is there anything else you would like to add or talk about anything we have not discussed?
- Thank you so much for your valuable time.

Topic Guide for Interviews (Healthcare Assistants)**a) Introduction, welcome and demographics (age, gender, experience, speciality etc)**

- Tell me about your experience using the tool?
- Did anything work well in the tool?
- Is there anything that did not work well in the tool?
- Tell me about how you found the wording and questions in the tool?
- Tell me about your experience of the recommendations based on level of risk in the tool?
- Tell me about your experience of the training session? Is there anything you would change or want more information about?

b) Feedback about the layout and language of the tool?

- How did you find the wording of the tool?
- Ease of use – scoring, time taken to complete the observation etc.
- Overall layout of the tool (font, font size etc).
- Prompts
 - o Can you tell me more about that?

c) Completing the tool

- When did you find the best time to complete it?
- How easy or difficult it was to incorporate the tool into your work routine?
- Discussion around training needs
- Prompts
 - o Can you tell me more about that...?

d) Ending

- Is there anything else you would like to add or talk about anything we have not discussed?
- Thank you so much for your valuable time.

B. Participant Information Sheet for senior staff members



Participant Information Sheet (Senior Staff member/ Registered Nurses)

IRAS ID: 318311
Version: 5.0
Date: 14/03/2024

Study title

Development, validation, and evaluation of a risk assessment tool for contractures: the ORACLE study

You are being invited to take part in a research study. This study is being carried out as part of a PhD project undertaken by the researcher, Hina Tariq. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Who is funding the research?

This research project is being funded by Bournemouth University and Dorset Healthcare University NHS Foundation Trust (DHUFT).

Who has reviewed the study?

This research study has been reviewed by a panel of experts and granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC.

What is the purpose of the study?

Contractures can be defined as loss of joint movement due to permanent shortening of the muscles or other tissues surrounding the joint. This study aims to test a newly developed observational tool, **Observational Risk Assessment for Contractures- Longitudinal Evaluation (ORACLE)** to identify the risk of restricted joint movement (contractures) following reduced mobility, muscle weakness, and non-use of the limbs in care home residents. This tool is not currently validated or used routinely.

Regular checks through the use of this tool to see if someone is at risk of developing a contracture could help specialists to have earlier interventions minimising its impact on the person. Furthermore, it may reduce the risk of new contractures or worsening existing contractures, potentially reducing the burden on the carers and improving the quality of life for the person.

Before ORACLE can be used, the research team need to assess if the tool is valid – tests what it should be testing, and reliable- gets the same outcome when the test is done more than once. We are also interested in learning about your experience and acceptability of using the tool. The information we learn from looking at the validity and reliability and speaking with you will help the team further develop the tool and how we might improve it to make it more acceptable to use in practice.

Why have you been invited?

You are invited because you are a senior staff member/registered nurse responsible for organising and incorporating the newly developed risk assessment tool in the care home.

Do I have to take part?

Taking part in this research study is entirely voluntary, and your decision to take part or not take part will have no impact on you or your job. If you decide to participate, you will be asked

to sign a consent form before participating. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

If you decide to take part, the researcher will contact you to arrange a convenient time to be a part of a focus group discussion with other registered nurses and/or senior staff members or undertake a face-to-face/remote individual interview. This discussion aims to find out your opinions on the tool, the language/wording used, and the feasibility and practical implementation of ORACLE in care homes. The interview or discussion will last for a maximum of 60 minutes. The discussion will be audio recorded with your permission, and your responses will be transcribed onto a document.

What are the possible disadvantages and risks of taking part?

Taking part will require approximately 60 minutes of your time to arrange and conduct the interview. During the interview, some questions will be asked about the organisational challenges you encountered while incorporating the tool as part of the clinical assessment of the care home residents. We will ensure that these discussions are handled sensitively, and any sharing of information is completely led by the participant.

What are the possible benefits of taking part?

By participating, you will contribute to improving and developing the ORACLE tool. As the ORACLE tool is further developed it is hoped it will be used widely to help early identification if someone is at risk of developing a contracture. Earlier identification and management may help to improve people's quality of life and decrease care needs.

For your time, you will receive an Amazon voucher of £20 for participation in this research.

How will my information be managed?

Participation in this study is based on consent, and you can change your mind at any point in the study. Once we complete the interview, your personal information is processed in compliance with the data protection legislation. We will use your data on the basis that it is necessary for the conduct of research, which is an activity in the public interest.

Bournemouth University (BU) is a Data Controller of your information which means that we are responsible for looking after your information and using it appropriately. Undertaking this research study involves collecting and/or generating anonymised information about you. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws.

[BU's Research Participant Privacy Notice](#) sets out more information about how we fulfil our responsibilities as data controller and about your rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis on which we will process your information. Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this information sheet.

Publication

You will not be able to be identified in any external reports or publications about the research. Your information will only be included in these materials in an anonymous form (i.e., you will not use your name or any other information that might lead to you being identified). Direct quotes of what you said may be used in our publications, but they will be kept anonymised. Research results will be published in a reputable journal or a conference presentation and will be stored by the university in anonymised form for other researchers to use. In order to contact you with the study results, your contact information will only be kept by the researcher (Hina

Tariq). Your data will be held in a password protected Bournemouth University account. After contacting you, the researcher will destroy your personal information by deleting it from the Bournemouth University account in which it is saved.

Security and access controls

Bournemouth University will hold the anonymised information we collect about you electronically on a password-protected secure network. Contact information will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research, or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

Keeping your information if you withdraw from the study

You can stop being part of the study during the interviews or afterwards, without giving a reason, but we will keep information about you that we already have. This is because once we anonymise the information, we will not be able to tell what information came from you.

We need to manage your records in specific ways for the research to be reliable. This means that we will not be able to let you see or change the data we hold about you.

Retention of your data

We will keep the signed consent form for a period of 12 months after the study has ended. This is the only document that has your name and signature on it and is kept separate from the anonymised data. Your anonymised information and samples cannot be linked to your name on this form. Although published research outputs are anonymised, we need to retain underlying data collected for the study in a non-anonymised form for 10 years to enable the research to be audited and/or to enable the research findings to be verified.

Where can I find out more about how my information is used?

You can find out more about how we use your information by:

- Accessing this link at: <http://www.hra.nhs.uk/patientdataandresearch>
- Accessing BU's Research Participant Privacy notice at: https://intranetsp.bournemouth.ac.uk/documentsrep/Research_Participant_Privacy_Notice.pdf
- Contacting one the research team members.
- Sending an email to: DPO@bournemouth.ac.uk

How will the results/findings of the study be fed back to you?

If you are interested in receiving the results of the study, we will send you a summary of the results via the email you provided us in the consent form.

Finally

A copy of this information sheet will be given to you to keep at the start of the study. You will also be given a chance to read this again and ask questions before signing the consent form to participate in the interview. Thank you for considering taking part in this research project.

Contact for further information

If you would like to talk to one of the researchers to help you decide whether or not you would like to take part, or would like answers to any questions you may have, then please contact the research team:



PhD Student

Mrs Hina Tariq

Email htariq@bournemouth.ac.uk

Tel: 07404564696

Chief Investigator

Professor Sam Porter

Email: porters@bournemouth.ac.uk

Clinical Supervisor:

Mr Joel Dunn

Email: joel.dunn1@nhs.net

In case of complaints

Any concerns about the study should be directed to Professor Jane Murphy, Deputy Dean for Health & Social Sciences, Faculty of Health and Social Sciences (FHSS), Bournemouth University, by emailing researchgovernance@bournemouth.ac.uk



C. Participant Information Sheet for healthcare assistants.



Participant Information Sheet (Healthcare Assistants)

IRAS ID: 318311
Version: 4.0
Date: 14/03/2024

Study title

Development, validation, and evaluation of a risk assessment tool for contractures: the ORACLE study

You are being invited to take part in a research study. This study is being carried out as part of a PhD project undertaken by the researcher, Hina Tariq. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Who is funding the research?

This research project is being funded by Bournemouth University and Dorset Healthcare University NHS Foundation Trust (DHUFT).

Who has reviewed the study?

This research study has been reviewed by a panel of experts and granted a favourable opinion by an independent NHS research ethics committee, Camberwell St Giles REC.

What is the purpose of the study?

Contractures can be defined as loss of joint movement due to permanent shortening of the muscles or other tissues surrounding the joint. This study aims to test a newly developed observational tool, **Observational Risk Assessment for Contractures- Longitudinal Evaluation (ORACLE)** to identify the risk of restricted joint movement (contractures) following reduced mobility, muscle weakness, and non-use of the limbs in care home residents. This tool is not currently validated or used routinely.

Regular checks through the use of this tool to see if someone is at risk of developing a contracture could help specialists to have earlier interventions minimising its impact on the person. Furthermore, it may reduce the risk of new contractures or worsening existing contractures, potentially reducing the burden on the carers and improving the quality of life for the person.

Before ORACLE can be used, the research team need to assess if the tool is valid – tests what it should be testing, and reliable – gets the same outcome when the test is done more than once. We are also interested in learning about your experience and acceptability of using the tool. The information we learn from looking at the validity and reliability and speaking with you will help the team further develop the tool and how we might improve it to make it more acceptable to use in practice.

Why you have been invited?

You are invited because you are a Healthcare Assistant (HCA) working in a care home, and involved in using the newly developed ORACLE tool to test it.

Do I have to take part?

Taking part in this research study is entirely voluntary, and your decision to take part or not take part will have no impact on you or your job. If you decide to take part, you will be asked to sign a consent form before participation. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

If you decide to take part the researcher will contact you to arrange a convenient time to be a part of a focus group discussion with other HCAs or undertake a face-to-face/remote individual interview. The purpose of this discussion is to find out more about your experience of using the tool, the language/wording we used in the tool, and layout of the tool etc. The interview or discussion will last for a maximum of 60 minutes. The discussion will be audio recorded with your permission, and your responses will be transcribed onto a document.

What are the possible disadvantages and risks of taking part?

Taking part will require up to 60 minutes of your time to arrange and conduct the interview. During the interview, some questions will be asked about the challenges and opportunities you encountered using the ORACLE tool. We will ensure that these discussions are handled sensitively, and any sharing of information is completely led by the participant.

What are the possible benefits of taking part?

By participating, you will contribute to improving and developing the ORACLE tool. As the ORACLE tool is further developed it is hoped it will be used widely to help early identification if someone is at risk of developing a contracture. Earlier identification and management may help to improve people's quality of life and decrease care needs. You will receive an Amazon voucher of £20 for participation in this research.

How will my information be managed?

Participation in this study is based on consent and you can change your mind at any point of the study. Once we complete the interview, your personal information is processed in compliance with the data protection legislation. We will use your data on the basis that it is necessary for the conduct of research, which is an activity in the public interest. Bournemouth University (BU) is a Data Controller of your information which means that we are responsible for looking after your information and using it appropriately. Undertaking this research study involves collecting and/or generating anonymised information about you. We manage research data strictly in accordance with:

- Ethical requirements; and
- Current data protection laws.

[BU's Research Participant Privacy Notice](#) sets out more information about how we fulfil our responsibilities as a data controller and about your rights as an individual under the data protection legislation. We ask you to read this Notice so that you can fully understand the basis on which we will process your information. Research data will be used only for the purposes of the study or related uses identified in the Privacy Notice or this information sheet.

Publication

You will not be able to be identified in any external reports or publications about the research. Your information will only be included in these materials in an anonymous form (i.e., you will not use your name or any other information that might lead to you being identified). Direct quotes of what you said may be used in our publications, but they will be kept anonymised. Research results will be published in academic journals or a conference presentation and will be stored by the university in anonymised form for other researchers to use. In order to contact you with the study results, your contact information will only be kept by the lead researcher (Hina Tariq). Your data will be held in a password protected Bournemouth University account that only the research team have access to. After contacting you, the researcher will destroy your personal information by deleting them from the Bournemouth University account it is saved in.

Security and access controls

Bournemouth University will hold the anonymised information we collect about you electronically on a password-protected secure network. Contact information will be accessed and used only by appropriate, authorised individuals and when this is necessary for the purposes of the research, or another purpose identified in the Privacy Notice. This may include giving access to BU staff or others responsible for monitoring and/or audit of the study, who need to ensure that the research is complying with applicable regulations.

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PhD Student

Mrs Hina Tariq

Email: htariq@bournemouth.ac.uk

Tel: 07404564696

Chief Investigator

Professor Sam Porter

Email: porters@bournemouth.ac.uk

Clinical Supervisor:

Mr Joel Dunn



Email: joel.dunn1@nhs.net



In case of complaints

Any concerns about the study should be directed to Professor Jane Murphy, Deputy Dean for Research & Professional Practice, Faculty of Health and Social Sciences (FHSS), Bournemouth University by emailing researchgovernance@bournemouth.ac.uk

Appendix VII

A. ORACLE final version

B. Guidelines for care homes

A. ORACLE final revision

OBSERVATIONAL RISK ASSESSMENT FOR CONTRACTURES-LONGITUDINAL EVALUATION (ORACLE)



Contractures can be described as a loss of joint motion due to permanent shortening of the muscles or other connective tissues such as tendons, ligaments, joint capsules, and skin spanning one or more joints.

1. AGE <i>Please select the age category for the person</i>		6. MUSCLE WEAKNESS <i>Does the person have difficulty moving any of their limbs?</i>		
Less than 65	0	No difficulty: can move limbs independently	0	Q1
Between 65 and 84	1	Some difficulty: can move with assistance	1	Q2
85 or more	2	Great difficulty: cannot move themselves	2	Q3
Score		Score		
2. BED MOBILITY <i>Is the person able to move and roll in bed?</i>		7. PAIN <i>Is the person experiencing any pain?</i>		
Able to move and roll independently	0	No pain at all	0	Q4
Able to move and roll with some assistance	1	Yes, but controlled by medication	1	Q5
Unable to move at all without assistance	2	Yes, despite medication	2	Q6
Score		Score		Q7
3. TRANSFER ABILITY <i>Is the person able to move from bed to chair?</i>		8. PRESSURE SORES <i>Are there any changes to the person's skin?</i>		
Able to move independently	0	No, not at all	0	Q8
Able to move with some assistance	1	Change in colour (red, blue, purple, or black)	1	Q9
Unable to move at all without assistance	2	Damaged or broken skin	2	Q10
Score		Score		Total score
4. WALKING <i>Is the person able to walk?</i>		9. COGNITION <i>Does the person have difficulty following instructions?</i>		
Able to walk independently	0	No, not at all	0	
Able to walk with some assistance	1	Yes, sometimes	1	
Unable to walk at all without assistance	2	Yes, all the time	2	
Score		Score		
5. FUNCTIONAL ABILITY <i>Is the person able to carry out activities of daily living (e.g., eating, dressing, bathing, toileting, grooming)?</i>		10. ACTIVITY ENGAGEMENT <i>Is the person motivated to engage in activities?</i>		
Able to carry out ADLs independently	0	Engages without encouragement	0	
Able to carry out ADLs with some assistance	1	Needs encouragement in activities	1	
Not at all without assistance	2	Does not engage at all	2	
Score		Score		

SCORE	RISK
0-10	Low risk
≥11	High risk

RESPONSE ACTIONS			
SCORE	RISK	ACTIONS IF RISK IS DIFFERENT FROM LAST REVIEW (OR NEWLY ASSESSED)	ACTIONS IF RISK IS UNCHANGED SINCE THE LAST REVIEW
0-10	Low risk	- Encourage the person to move at regular intervals with support or independently. - Encourage the person to engage in their own care routines, such as dressing, grooming and feeding with support or independently. - Effective use of pillows to support proper positioning - Ensure adequate fluid and food intake - Engage in meaningful conversations and encourage social participation, e.g. games, group activities with peers - Inspect and review vulnerable skin areas. - Review pain control - Review medications - Review assistive devices - Engage family and friends in care plans	- Continue to follow existing care plan - Review in one month
≥11	High risk	- Make URGENT referral to occupational therapist/physiotherapist for detailed assessment - Encourage the person to move at regular intervals with support or independently. - Encourage the person to engage in their own care routines, such as dressing, grooming and feeding with support or independently. - Effective use of pillows to support proper positioning - Ensure adequate fluid and food intake - Engage in meaningful conversations and encourage social participation, e.g. games, group activities with peers - Inspect and review vulnerable skin areas. - Review pain control - Review medications - Review assistive devices - Engage family and friends in care plans	- Continue to follow existing care plan devised by OT/PT - Review in one month

B. Guidelines for care homes

The Observational Risk Assessment of Contractures: Longitudinal Evaluation (ORACLE)

Guidelines for Care Homes

The following guidelines, developed based on the research findings, provide care homes with best practices to ensure accurate and consistent use of ORACLE.

1. Purpose of ORACLE

- To identify care home residents at risk of developing joint contractures early.
- To provide a structured and systematic assessment to guide preventive actions in response to the risk identified.
- Trigger timely referrals to specialists if needed, particularly for high-risk individuals.

2. Aimed users of the tool

The tool has been designed for use by all care staff, including healthcare assistants.

3. Training

- Before integrating into regular care routines, all staff should receive initial training on contracture awareness and the purpose and use of ORACLE.
This should include:
 - How to interpret each subscale (e.g., functional ability, pain, mobility).
 - How to assign ranks based on observed behaviours and conditions.
 - A review of the scoring system, including when and how to trigger referrals
- Ongoing refresher sessions for maintaining consistency and accuracy in assessments.
- Care homes should ensure that the new staff, including agency staff, receive introductory training on ORACLE before completing assessments.
- Offer specialised training programs for staff to improve their skills in assessing residents with dementia or communication challenges e.g pain assessment.
- Offer education and awareness programs for care home residents and informal carers, including relatives, to highlight the importance of physical activity to prevent contractures.
- Offer training sessions or workshops for relatives on engaging residents in physical activities during their visits.

4. Integration of ORACLE into care routines

- It is recommended to carry out risk assessment on ORACLE every month for all residents. However, the risk assessment should be repeated if there is a sudden or significant change in the resident's health status, such as following a fall, accident, or a period of bed confinement.

- The tool typically takes between 2-5 minutes to complete. However, care managers should ensure that the staff is allocated enough time to complete the assessment accurately, particularly when first learning the tool.

5. Documentation

Ensure that each ORACLE assessment is documented thoroughly and stored according to care home policy.

Document:

- The individual scores on subscales and the overall risk score.
- Any areas of concern or uncertainty (e.g., difficulty categorising functional ability).
- Any changes from previous assessments that indicate worsening of risk.

6. Referrals

If a resident scores 11 or higher on ORACLE, make urgent referrals to appropriate healthcare professionals (e.g., physiotherapists or occupational therapists). Keep a record of the referral and follow up as necessary.

7. Ongoing feedback

Encourage feedback from care staff about any difficulties with the tool and regularly discuss solutions during team meetings. Implementing these feedback loops can improve both the consistency and reliability of assessments.