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Frailty and Sarcopenia in the Colorectal Patient

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Intellectual Property and Publication

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To my patient mentors, I wish to convey my most sincere gratitude. Dr Simon Howell, a true 'English Gentleman', has been a considerate, patient mentor. I sincerely wish to thank Simon for his perseverance with my education, both academically and culturally, and hope that this work has done him proud. I wish to also convey my deepest gratitude towards Mr Dermot Burke. Dermot has pushed myself and my work towards excellence, whilst maintaining a flexibility to allow the work to have my own personal slant. Dermot has provided motivation, compassion, enthusiasm, care and overall tremendous support throughout the past 4 years.

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Abstract

Frailty and sarcopenia are geriatric conditions, becoming more prevalent with the United Kingdom's (UK) ageing population. More older patients are presenting for colorectal surgery, who may be frail or sarcopenic. Current literature suggests assessments for these conditions may have a predictive validity for adverse post-operative outcomes. There is confusion as to which measures are of true clinical value.

Qualitative methodologies were employed to determine that whilst surgeons wish for frailty to be routinely identified at St James' hospital, Leeds, UK, pre-assessment staff would require an intervention to also be available before identification is implemented. Initial pilot studies investigate prevalence of frailty and sarcopenia, identifying that there is a substantial variance between prevalence rates of either condition, depending on the assessment methodology. Initial analyses indicate these measures may not be predictive of post-operative outcomes.

Development of Frailty and Sarcopenia Trial (FAST) identified that whilst prevalence of frailty by different measures varied, predictive validity was poor. FAST also determined that sarcopenia, as measured by the European Working Group of Sarcopenia in Older People criteria, identifies patients who are more likely to require increased care in-hospital, post-operatively. This may support the identification of patients who may fare worse as a result of their operation, and interventions put into place to optimise patient's clinical conditions pre-operatively.

An eccentric exercise program, lasting 4 weeks, can improve strength in older adults. It is hoped that developments from this study can inform physiotherapy interventions for frail or sarcopenic in-patients in the peri-operative window.

This work highlights the possibility that there may be publication bias regarding frailty and sarcopenia, and that whilst these conditions may be prevalent in a clinical setting, caution is required when considering which assessment should be adopted to be clinically informative in a colorectal surgical pathway.

Public works as a result of this Doctorate

Some of the works over the previous four years have been presented in scientific programmes. Here, a list has been provided of these publications:

Posters

Incorporating frailty scoring in pre-assessment

Graham, L 2, Keshwala, V 2, Dale MacLaine, T 1, Kotze, A 2, Howell, A 2

(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Frailty: is an eyeball assessment sufficient?

Dale MacLaine T 1, Howell S 1,2, Burke D 1,2,
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Frailty: Are you fit for surgery?

Dale MacLaine T 1, Burke D 1,2, Howell S 1,2
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Fragile concordance between frailty measures

Thomas Dale MacLaine 1, Oliver Baker 2, Laura Graham 1, Rebecca Anthony 3, Alwyn Kotze 3, Dermot Burke 1, 3, Simon J Howell 1, 3.

(1) Leeds Institute of Biological and Clinical Sciences, University of Leeds, Leeds, UK
(2) University of Leeds Medical School, Leeds, UK
(3) Leeds Teaching Hospital Trust, Leeds, UK

Presentations

Can we identify patients who are going to have a poor outcomes post operatively using a large primary care dataset?

D. Narganes 1, D. J. Drayton 2,3, L. McMenamin 2,3, T. Dale MacLaine 2, D. Wong 1 , C. Bates 4, A. Kotze 3 and S. J. Howell 2,3

(1) Leeds Institute for Data Analytics, University of Leeds, Leeds, UK
(2) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(3) Department of Anaesthesia, Leeds Teaching Hospitals NHS Trust, Leeds, UK,
(4) The Phoenix Partnership (TPP), Leeds, UK

A quality improvement project into peri-operative medicine for the older surgical patient at Leeds Teaching Hospitals NHS Trust

T. Dale MacLaine 1, R. Anthony 2, D. Burke 1,2

(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Radiological assessment of sarcopenia in surgical patients and the influence on surgical outcomes

Dale MacLaine T 1, Howell S 1,2, Burke D 1,2,
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Can a shortcut to measure sarcopenia pre-operatively be as accurate as a full radiological assessment?

Dale MacLaine T 1, Howell S 1,2, Burke D 1,2,
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Comparison of frailty identification tools in the pre-assessment clinic

Dale MacLaine T 1, Burke D 1,2, Howell S 1,2
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Frailty: so you think you know what it is?

Dale MacLaine T 1, Burke D 1,2, Howell S 1,2
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Frailty phenotype indicates pre-operative difficulty walking and post-operative readmission in colorectal surgery

Dale MacLaine T 1, Baker, O 1, Burke D 1,2, Howell S 1,2
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

FAST (Frailty and sarcopenia trials): Poor agreement between commonly-used frailty assessments in elective colorectal surgical patients

Dale MacLaine T 1, Graham, L 2, Kotze, A 2, Clegg, A 1, Burke D 1,2, Howell S 1,2
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

FAST (Frailty and sarcopenia trials): A qualitative investigation into frailty identification implementation into the general surgical pathway, in the UK

Dale MacLaine T 1, Graham, L 2, Bunce, D 2, Lawton, R 1, Burke D 1,2, Howell S 1,2
(1) Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, Leeds, UK,
(2) Leeds Teaching Hospitals NHS Trust, Leeds, UK,

Works in this thesis

Chapter 2:

This qualitative study was designed by TDM, with external design support from Professor Rebecca Lawton and Dr Rebecca Hawkins. Dr Laura Graham supported the development of the pre-assessment clinic focus group. TDM performed all surgeon interviews, and all general practitioner interviews. TDM and Laura Graham performed the pre-assessment focus group. TDM and Dr William Bolton conducted the patient focus groups. Julie Clarke performed the transcription of all recordings. TDM checked the transcriptions, performed the analysis and write up of this work.

Chapter 3:

TDM designed the study, received ethical support, and provided training to Oliver Baker (OB). TDM and OB recruited 100 patients each, and assessed for pre-operative data. Post-operative data were collected by TDM. TDM analysed and interpreted the results of this study.

Chapter 4:

TDM designed the research, with permission from the Radiology Department to conduct this work. TDM completed the initial investigations into sarcopenia. OB, Miyuki Omura, Dr Christopher Clarke, and TDM performed the inter-rater variability work. TDM completed the intra-rater variability of this work. TDM completed the analyses for this work.

Chapter 5:

TDM designed the study, received ethical support, and provided training to the research nursing staff. Research nursing staff collected pre-operative and post-operative data excluding the computed tomography sarcopenia assessments, which was done by TDM. TDM analysed and interpreted the results of this study.

Chapter 6:

This study was evenly split in terms of design, ethical support approval, recruitment and training of participants, and collecting and analysing data. TDM analysed and interpreted the results of this study in this thesis.

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Chapter 1: Introduction

This introduction explores key literature relevant to the works involved in this thesis. This is a general narrative literature review, provided to outline and give scope to the different concepts involved in the overall thesis. Key words (outlined at the start of each section) and synonyms were used to identify relevant literature in each of the different sections, and MeSH terms and relevant references in each publication was reviewed for its relevance to this work. A formal systematic review was not undertaken.

1.1: The perceptions surrounding frailty

Key words: 'perceptions', 'frailty', 'surgical', 'colorectal', 'patients'

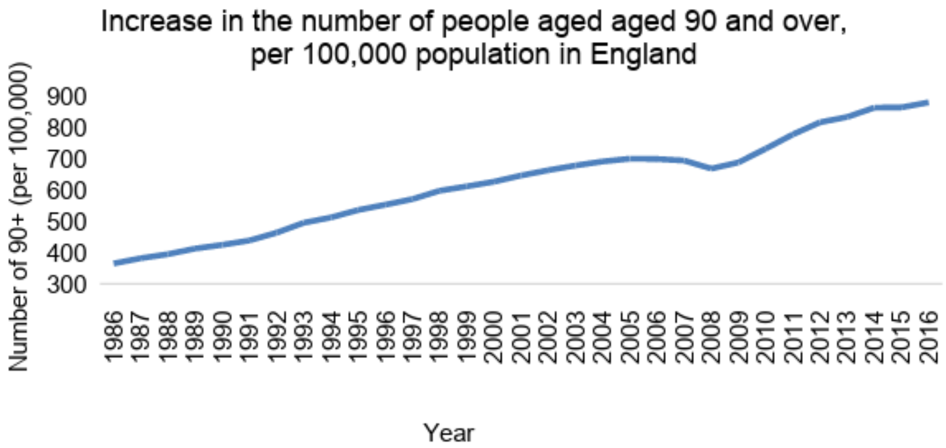
Frailty is the inability to recover following a stressor event. Frailty is described as 'the most problematic aspect of population ageing' and to be the reduction of physiological reserves due to biological ageing (Clegg *et al*. 2013; Partridge *et al*. 2012). A report by the British Geriatric Society and Age UK (BritainThinks *et al*. 2015) is a source of reliable information reporting qualitative research on perceptions of frailty. This work reports that the public have an incomplete understanding of frailty and elderly people rarely consider themselves as frail. They may accept that they are 'living with frailty'. A group of frail elderly people were asked about their perceptions of the word 'frail'. The perceptions were that frailty is an irreversible state inclusive of malnourishment and a lack of independence, indicating an end-of-life state. There are some similarities in this and in what is scientifically known, such as the increased level of dependency (Puts *et al*. 2009; Nicholson *et al*. 2012). This research identified that there were variations in general practitioners' (GPs) perceptions of frailty. GPs were reported to relate frailty to end of life care. One GP discussed weight loss being a factor of frailty in patients with terminal malignancies, regardless of age (BritainThinks *et al*. 2015).

There is little qualitative research on the perceptions and experiences of frailty in surgery. We could not identify any systematic reviews investigating the qualitative perceptions of frailty in a surgical patient. Qualitative investigations of frailty predominantly study nursing home residents, those with cancer or those who are receiving palliative care (Bailey *et al*. 2014; Warmoth *et al*. 2016; Schoenborn *et al*. 2018). There are limited data on the expectations of recovery of frail patients undergoing major surgery. Frail surgical patients may need additional information about their current health-baseline in order to make a more informed decision, as to whether or not to have surgery.

1.2: Frailty: definition and background

Key words: 'frailty', 'ageing', 'elderly', 'identification'

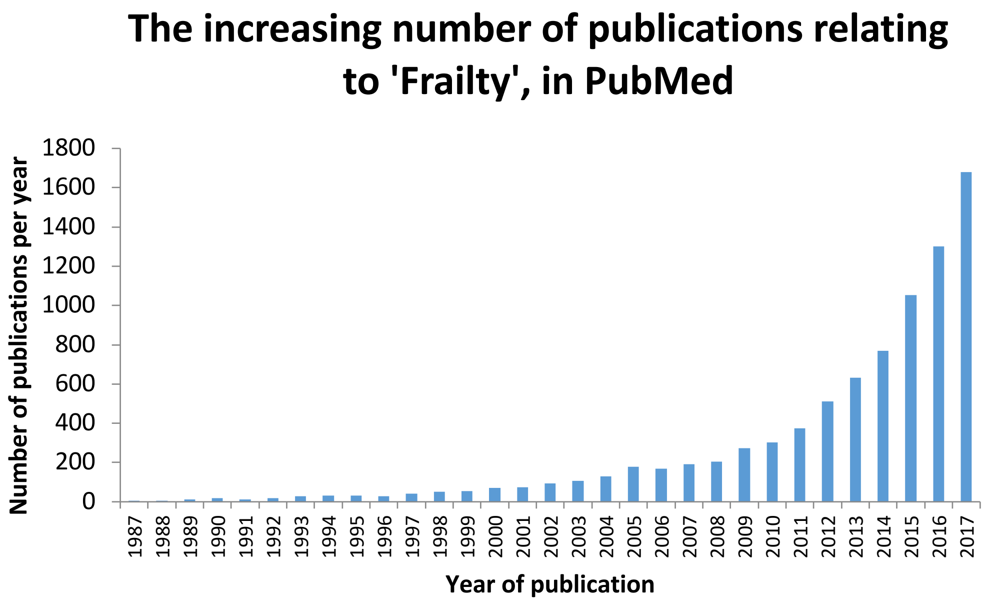
Media coverage has highlighted that an increase in life expectancy in the UK is well known (Rahman 2017; Span 2017; Anon 2017; Davis & Guardian 2017; Taylor 2014). Currently, there are almost 900,000 people in England over the age of 90 (Office for National Statistics 2017). This has more than doubled in 20 years (Graph 1). With stretched healthcare and social care systems, we are at risk of providing suboptimal care for a population with intricate and complex care requirements (Patterson 2014; Oliver *et al*. 2014). Tailoring care has been described as "paramount in the elderly population" (Dodds *et al*. 2014).



Graph 1: A graphical representation of the change in the population of those aged 90 and over in England, since 1986 until 2016 (Office for National Statistics, 2017).

It is possible to make a distinction between chronological and biological ageing. Whilst chronological ageing is recognised as the adding of years, biological ageing does not have a single agreed definition. Biological ageing relates functional capacity, cognitive function and independence (Mitnitski *et al*. 2015). The effects of biological ageing may have a significant impact on clinical care (Chen *et al*. 2014). Frailty is now described as a syndrome (Fried *et al*. 2001). An accurate measure of how biologically old, or ‘frail’ someone is may enable us to provide tailored health and social care.

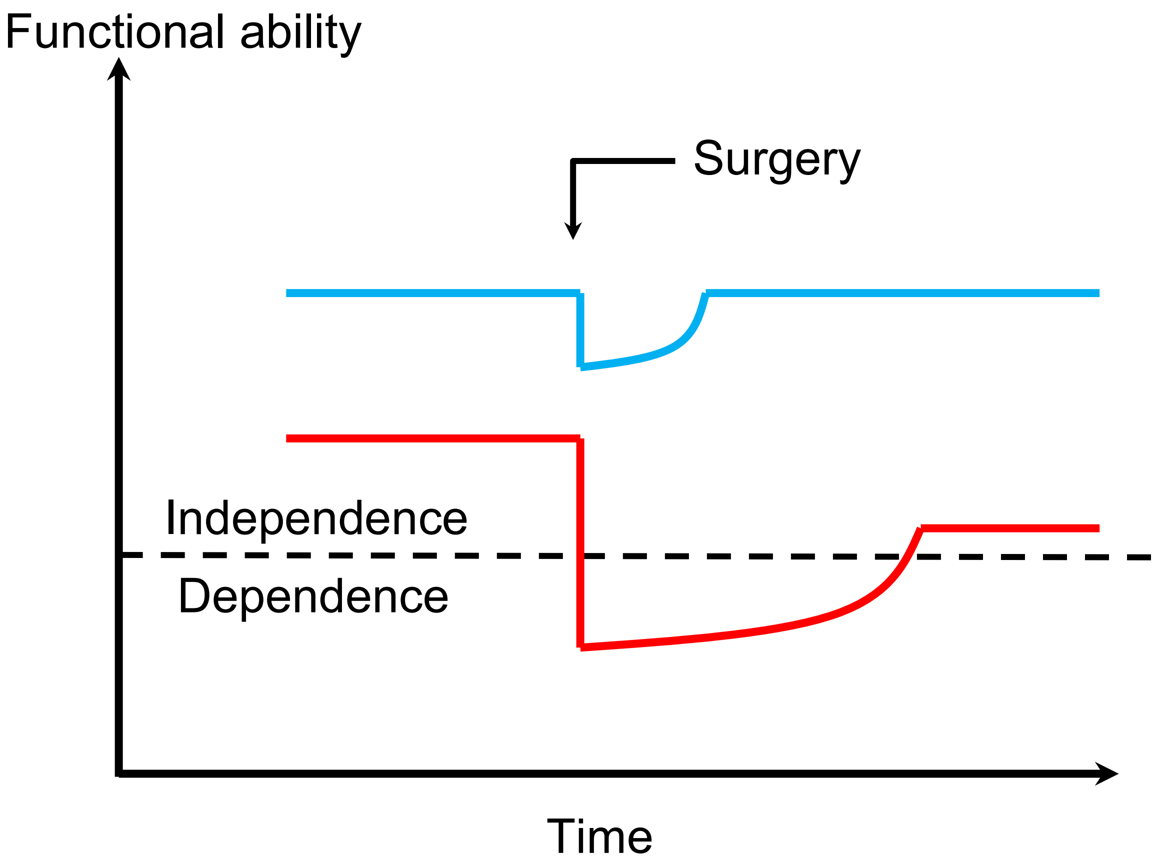
Research into frailty is steadily increasing. In all but two years over the last 30, there has been an increase in the number of publications released (Graph 2). Despite the additional scientific and clinical interest in the area, there are many aspects of frailty that are not fully understood. This may be due in part to a lack of consensus on how to define and diagnose frailty.



Graph 2: The number of publications found from searching the keyword "Frailty" in PubMed, released from 1987 until 2017 - collected in 2018.

Frailty may perhaps be best described as the inability to return to baseline following a stressor event (Clegg *et al*. 2013). Frail patients tend to present with a reduced functional capacity; a stressor such as surgery impacts a frail person more than a robust person. Recovery typically takes longer for a frail patient. Rather than making a complete recovery, these individuals establish a new baseline that is closer towards the line of dependency (Graph 3). There is currently no International Statistical Classification of Diseases and Related

Health Problems (ICD-10) code for frailty supported by the World Health Organization. This is may be due to the lack of clarity as to the precise definition of frailty, its impact and the variation of measures available.



Graph 3: Representation of a robust (blue) and frail (red) older adult when faced with a stressor (surgery) over time (amended from (Clegg et al., 2013)).

A systematic review of frailty screening tools in primary care identified 10 different assessment tools in 11 publications (Pialoux *et al*. 2012). A systematic review on the relationship frailty has with pre-operative risk evaluations identified that some studies use either modified versions of validated assessment tools. This may reduce the validity of these assessments. Some studies have used more than one frailty assessment (Buigues *et al*. 2015). This adds to the uncertainty as to how best identify frailty in a population.

1.3: Clinical presentation of frailty

Key words: 'frailty', 'ageing', 'elderly', 'identification'

The first image that typically comes to mind when confronted with the word 'frail' is physical weakness. Frailty is accompanied with a reduction in activity levels, dietary intake, and the patient may appear to have rapidly lost weight (Fried *et al*. 2001; Song *et al*. 2010; Malnutrition Task Force 2017; Morley *et al*. 2012). Due to the reduction in physical activity, the patient may also exhibit muscle mass loss and reduction in muscle strength (Rennie *et al*. 2010). This may lead to a damaging spiral (Figure 1) whereby over time, further physical involution occurs.

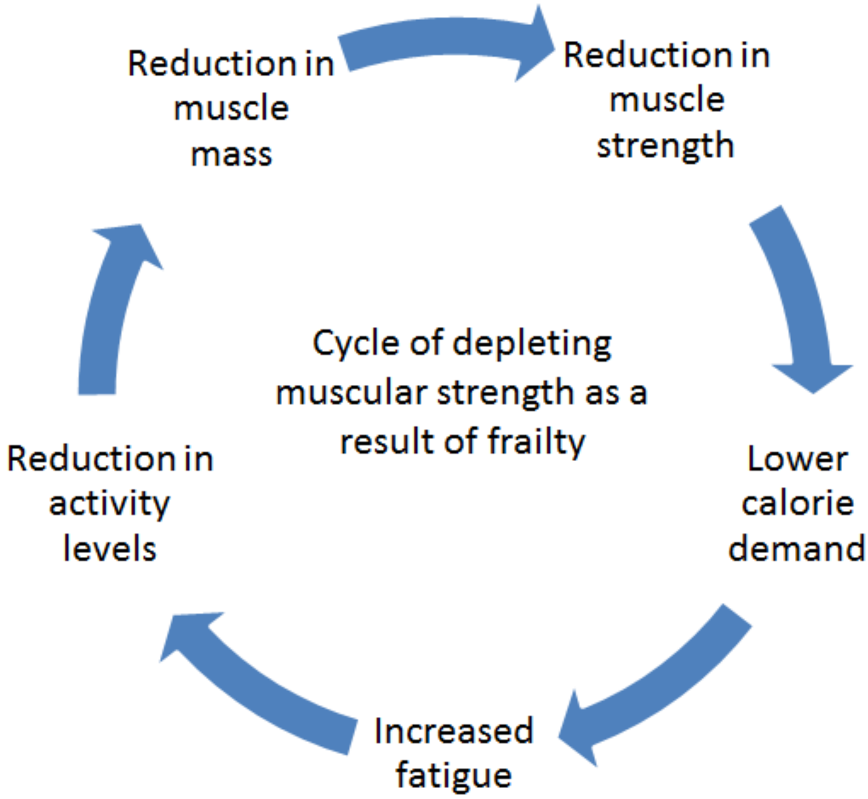


Figure 1: The cycle of muscular degradation in a frail person, occurring simultaneously throughout the ageing process.

Muscular wasting impacts directly on behaviour and confidence performing daily tasks. Frail people can be limited in many aspects of their life. A frail older adult living in a nursing home may require substantial assistance with personal hygiene and food preparation, but may be cognitively robust (Puts *et al*. 2009; Op het Veld *et al*. 2015). Alternatively, a frail patient living independently may be socially isolated and at risk of cognitive impairment, malnutrition and additional physical decline (The British Geriatrics Society

2014). A recent report stated that in the UK 3.64 million people aged 65 or over live alone (Age UK 2017). The authors report that 33% of women, and 22% of men, aged over 65 years need help with at least one Instrumental Activity of Daily Living (IADL), with 15% and 12% respectively having at least one IADL need unmet. These unmet needs may potentially lead to further deterioration of health in a patient.

The ability to mobilise independently is a key aspect of wellbeing. Those who are frail are likely to walk less than a robust person and are less confident in their ability to do so (Fried *et al*. 2001). Frail people are more likely to fear falling (Wolf *et al*. 1997; Province *et al*. 1995), are at risk of falling and may require walking aids to prevent falling (Ignasiak *et al*. 2015). Falls in the frail can result in broken bones (Ensrud *et al*. 2007), increased fears of further falling (Esbrí-Víctor *et al*. 2017; Brothers *et al*. 2014) and potentially may remove some of the person’s independence, should they feel they require additional support or care (Collard *et al*. 2012).

1.3.1: Surgical presentation

Key words: 'frailty', 'ageing', 'elderly', 'surgery'

Co-morbidities and complexities in a surgical patient's condition can impact on the success of the procedure and recovery (Limpert *et al*. 2003). The decision to offer surgery to a frail patient can be complex, require careful consideration of the risks and benefits and involve many parties including the surgeon, the anaesthetist, the general practitioner, surgical pre-assessment staff and of course the patient and their family (Appendix 1).

Patients with a low energy-expenditure often have a low-calorie-intake. Almost one in ten people over the age of 65 are either at risk of malnutrition or malnourished (Malnutrition Task Force 2017). A frail person with malnutrition is likely to have more hospital admissions, longer hospital stays, an increased number of co-morbidities and are twice as likely to visit their GPs (Malnutrition Task Force 2017; Guest *et al*. 2011). Calorie intake is critical to the recovery of patients following their surgical procedure, both in the immediate and in the long-term period (Weimann *et al*. 2017). It is well understood that patients with poor pre-operative diet are more likely to suffer poor outcomes, including the exacerbation of malnutrition (Studley 1936; Pikul *et al*. 1994; De Luis *et al*. 2007; Weimann *et al*. 2017).

IADLs involve managing finances, cleaning the home, shopping, preparing meals and taking medication. Surgical pre-assessment includes components of IADLs. IADLs are impacted by surgical interventions. The frail elderly are likely to have an extended post-operative recovery and require additional support with these activities (Lawrence *et al*. 2004). The frail surgical patient is more likely to have a marked reduction in their activity levels pre-operatively (Ensrud *et al*. 2007; Labra *et al*. 2015; Broderick *et al*. 2015).

1.3.2: Surgery in a frail patient population

Key words: ‘frailty’, ‘ageing’, ‘elderly’, ‘surgery’, ‘perioperative’, ‘post-operative’

During in-hospital postoperative recovery, the ideal is that the patient’s dependency on external support diminishes steadily and once the patient is medically fit for discharge, they return to their usual place of residence. Patients may have a protracted recovery due to general debility or post-operative complications, leading to an extended in-hospital stay, discharge to a nursing home, or re-admission to hospital.

A meta-analysis of frailty and surgical outcomes was published in 2015 (Oakland *et al*. 2016). The post-operative mortality of frail patients was greater than those who were robust for both in-hospital outcome (pooled odds ratio (OR) 2.77, 95% confidence interval (CI) 1.62-4.73) and within one-year after surgery (pooled OR 1.99, 95% CI 1.49-2.66). Frail patients had greater odds of requiring additional rehabilitation (pooled OR 5.71, 95% CI 3.41-9.55). Frail patients were also more likely to have a longer length of in-hospital stay (pooled OR 1.05, 95% CI 0.02-2.07). This meta-analysis was unable to provide a measure of association between post-operative complications and frailty status; the prevalence of post-operative complications was too few to provide a pooled OR. There are limitations to this meta-analysis:

- This work states that five of the twelve frailty publications indicate frail patients may fare better than those who are healthy. This work includes data from studies using frailty and sarcopenia measures, which may account for the heterogeneity identified in the review. It may be that the involvement of sarcopenia is the cause of some heterogeneity, though the review concludes that the effect of frailty and outcomes were consistent.
- The frailty assessments used varied across the studies and included the Edmonton Frailty Scale, the Frailty Phenotype, reduction of IADLS and using gait speed.
- The meta-analysis includes work from several surgical specialities. It should not be assumed that the impact of frailty on outcome is similar across all specialties.

Length of hospital stay is often used as a measure of outcome. The more invasive a surgical procedure, the more likely that patient will experience problems in their recovery (Delaney *et al*. 2003; BUPA 2005). However, discharge may be delayed for non-medical reasons such as the time taken to put in place a social care package (Victor *et al*. 2008). A better measure may be time between admission and medical fitness for discharge.

Post-operatively, patients may require a change in the level of care. A change in discharge location has implications for the cost of healthcare and social care and for patient quality of life and satisfaction (Robinson *et al*. 2011).

Postoperative mortality in colorectal patients is improving. However patients with cancer, or elderly patients with multiple co-morbidities, have a significant risk of post-operatively mortality (Fagard *et al*. 2016). The systematic review published by Fagard and colleagues reports the impact of frailty on colorectal surgical outcomes. The prevalence of frailty ranged from 25%-46% of the colorectal surgical population. Papers in the review highlight post-operative mortality, in the first year after surgery, is comparable in patients with frailty and those who not frail (Kristjansson, Nesbakken, *et al*. 2010; Ommundsen, Torgeir B Wyller, *et al*. 2014). A statistically significant difference was identified in post-operative mortality over a 5-year follow up (Ommundsen, Torgeir B Wyller, *et al*. 2014). Those who were frail had a longer in-hospital stay to recover than those who were non-frail (Robinson *et al*. 2013). The Fagard review also investigated post-operative complications: three studies identified that frail patients had more complications than those who were robust (Kristjansson, Nesbakken, *et al*. 2010; Tan *et al*. 2012; Robinson *et al*. 2013), and a fourth study identified that more frail patients suffered post-operative sepsis than those who are not frail (p=0.003) (Fagard *et al*. 2016; Reisinger *et al*. 2015). The systematic review is limited by the small number of heterogenous studies included.

Elderly patients tend to be prescribed more medications (Kennedy *et al*. 2000). Polypharmacy has been reported to be an indicator of frailty, but also of patients who are high-risk for medical deterioration (Clegg *et al*. 2015;

Kristjansson, Jordhøy, *et al*. 2010; Pal *et al*. 2010). Major procedures are accompanied by an inflammatory response (Arias *et al*. 2009). Patients may require analgesia (Garimella & Cellini 2013), antibiotics (National Institute for Health and Care Excellence (NICE) 2008) and other medications prescribed in the peri-operative period. These may interact with pre-existing medications or incur disorientation in the patient (Dagli & Sharma 2014). Medicine-compliance is a difficult aspect of the patient's management (Yap *et al*. 2016; Dagli & Sharma 2014); if a patient is not compliant with their medications or experience confusion as a result of their medical management, it may delay discharge from hospital. The effective management of medications in the early postoperative period may reduce morbidity and mortality (Kennedy *et al*. 2000).

One component of frailty is cognitive frailty, or cognitive impairment. Elderly surgical patients may exhibit cognitive impairment (Brigola *et al*. 2015). Cognitive impairment is the deterioration of a person's ability to process information, produce or recall memories, to concentrate or to make decisions. Cognitive impairment can fluctuate over short periods of time, altering a person's capacity to make informed decisions at certain times and making diagnosis difficult (Petersen *et al*. 2001; Gauthier *et al*. 2006). Pre-operative cognitive impairment is reported to be a strong indicator for post-operative delirium (Zietlow *et al*. 2018; S. Deiner & Silverstein 2009), which in turn can substantially limit post-operative recovery (Rundshagen 2014).

1.4: Screening and diagnosis of frailty

Key words: 'frailty', 'ageing', 'elderly', 'surgery', 'identification'

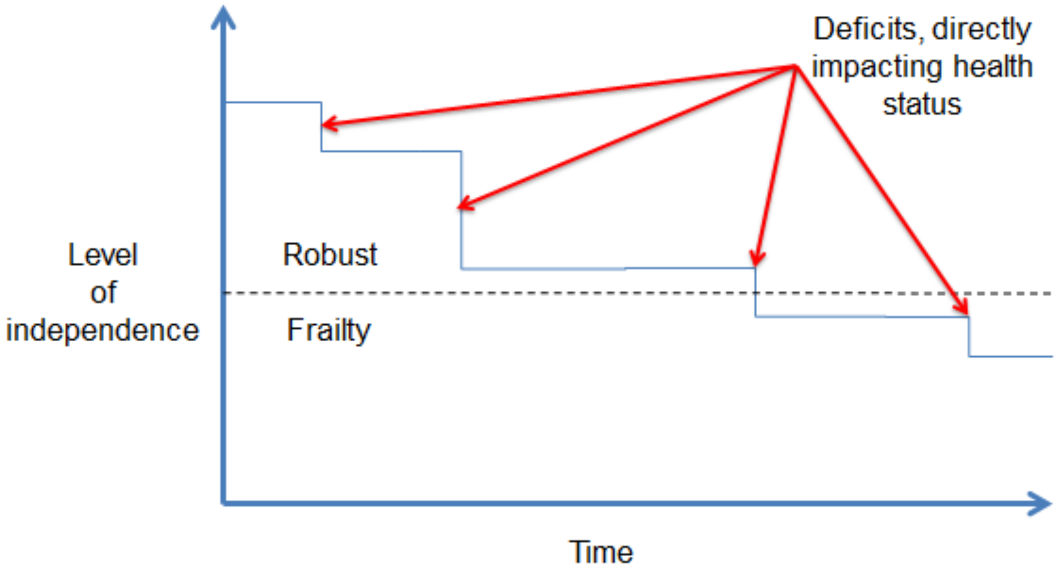
Frailty can be recognised through different assessments. Some assessments aim to identify and diagnose frailty, whilst others are screening tools for patients at risk of being frail (Bouillon, Kivimaki, *et al*. 2013). It is important to understand the intended use of individual frailty assessments to assess their use in research and clinical settings.

Most diagnostic tools for frailty use one of two different approaches or constructs are used in most :

- *The accumulation deficit (AD) model:* frailty is derived from the accumulation of health 'deficits' and each co-morbidity a person has reduces their functional ability further, declining step-wise to a point of becoming frail (Song *et al*. 2010);
- *The phenotypic model:* frailty is a reduction in functional ability, comprising of physical, mental and social factors. (Fried *et al*. 2001).

There are many derivatives, using one or other concept as their basis.

The AD is thought of as a step-wise gradient decline into a state of ill-health and frailty. The more co-morbidities a person has, the more likely they are to be frail (Graph 4). As these deficits accrue, the patient is considered to be increasingly frail (Rockwood & Mitnitski 2011).



Graph 4: Impact on health deficits on independence levels for patients at risk of becoming frail

The AD model has been extensively used in clinical research, in various forms. Rockwood and Song give a list of co-morbidities that may contribute to frailty (Rockwood & Song 2005). The AD concept was refined to measure frailty against a reduced number of co-morbidities. The most widely used measure of frailty utilising the AD concept currently is the 32-point AD method. The AD relies on translating the number of deficits into a percentage of the total number of deficits explored. Identification of frailty is whether the patient reported they have 25% or over the number of deficits. If a patient has 8-25% of co-morbidities outlined, the patient is in an intermediate state of 'pre-frailty', where the patient is likely to become frail if they do not receive further intervention or support. A score below 8% indicates a patient to be robust (Song *et al*. 2010).

Fried and colleagues, described the frailty phenotype (FP) assessment (Fried *et al*. 2001). The assessment is made across five domains: mood, activity levels, weight loss, grip strength and self-reported exhaustion. Each of the five domains has a specific cut-off, which may take into consideration weight, body mass index, height or sex. If a patient does not fall below the cut-off in any domain they considered to be robust. If the patient fall below the cut-off threshold in one or two domains, they are considered as pre-frail; fall below the cut-off threshold in three or more domains they are classified as frail.

The comprehensive geriatric assessment (CGA) has been described as the ‘gold-standard assessment’ of frailty (Clegg *et al*. 2013). However, the CGA, does not quantify frailty (or robustness) on a scale. It is a holistic review of a patient’s clinical presentation, including social, mental and physical factors and aims to co-ordinate specialists support the patient (Stuck *et al*. 1993). This requires specialist training and a multi-disciplinary team.

The lack of consensus on the diagnosis of frailty is illustrated by the proliferation of measurement tools available. A review in 2017 identified at least 67 frailty assessment tools (Buta *et al*. 2017). The results of one assessment may not translate to another. If a person is measured as frail by one method, it does not necessarily mean that the person will be frail by another (Cesari *et al*. 2014).

Consensus on which frailty assessment to use in a given setting would be helpful for both research and clinical care. This thesis includes studies intended to inform the choice of frail assessment tools for use in the surgical setting.

1.5: Introduction to Sarcopenia

Key words: 'Sarcopenia, 'ageing', 'elderly', 'identification', 'surgery'

An image of the frail older adult is of someone vulnerable, isolated with restricted mobility, and with little appetite (BritainThinks *et al*. 2015). The stereotypical image of frailty is of someone who is 'thin and sunken in'. This captures the sarcopenic aspects of frailty. The term sarcopenia was coined in the 1990's, from the Greek 'sarx' meaning flesh, and 'penial' meaning poverty (Cruz-Jentoft *et al*. 2010). Frailty and sarcopenia are inextricably linked (Figure 2) (Beggs *et al*. 2015).

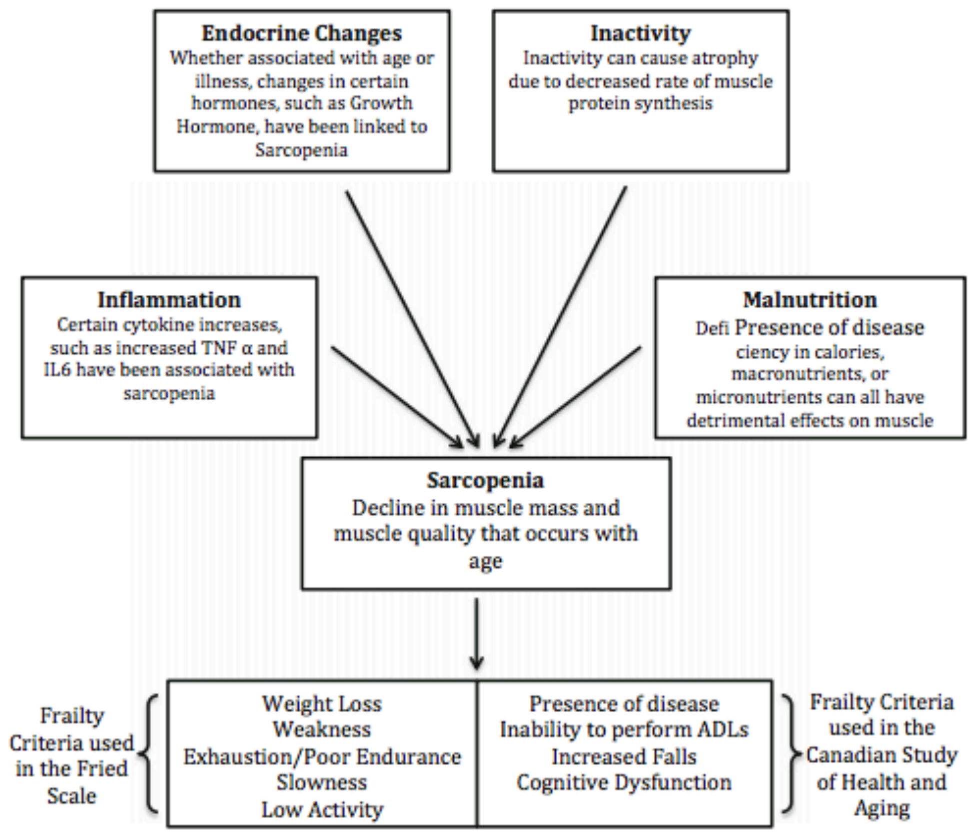


Figure 2: Causation of sarcopenia by inflammation, endocrine changes, inactivity and malnutrition, which progresses to induce a state of frailty (Beggs et al. 2015)

Sarcopenia is most frequently caused by degradation of muscle due to the ageing processes resulting in a decrease in muscle mass, quality and strength (Dodds *et al*. 2015). Muscle mass can be measured by radiological imaging. Muscle quality is assessed by measuring the muscle during activity. Muscle strength is the total contractile power (Figure 3) (Cruz-Jentoft & Landi 2014). The exaggeration of muscle loss seen in sarcopenia is due to the person's reduced ability to manufacture muscle (Rennie *et al*. 2010; Cuthbertson *et al*. 2005; Breen & Phillips 2011). This increased muscle loss combined with reduced muscle synthesis presents patients who are sarcopenic as 'sunken in' or what people perceive as frail (Schoenborn *et al*. 2018).

There is an expanding body of research into sarcopenia (Graph 5) and it is recognised as a distinct entity which has an ICD-10 code (M62.84). The Journal of Cachexia, Sarcopenia and Muscle published a welcome to the ICD-10 code, stating that 'this should lead to an increase in availability of diagnostic tools' (Anker *et al*. 2016). As with frailty, many diagnostic tools are available for sarcopenia, leading to uncertainty as to which assessment is best for use in surgical patients (Cruz-Jentoft *et al*. 2014; Studenski *et al*. 2014; International working group on sarcopenia 2012).

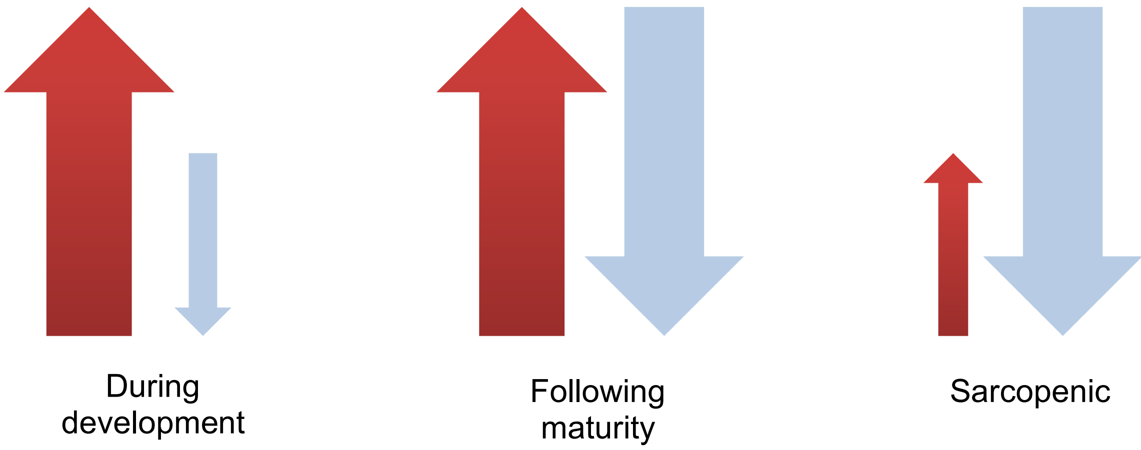
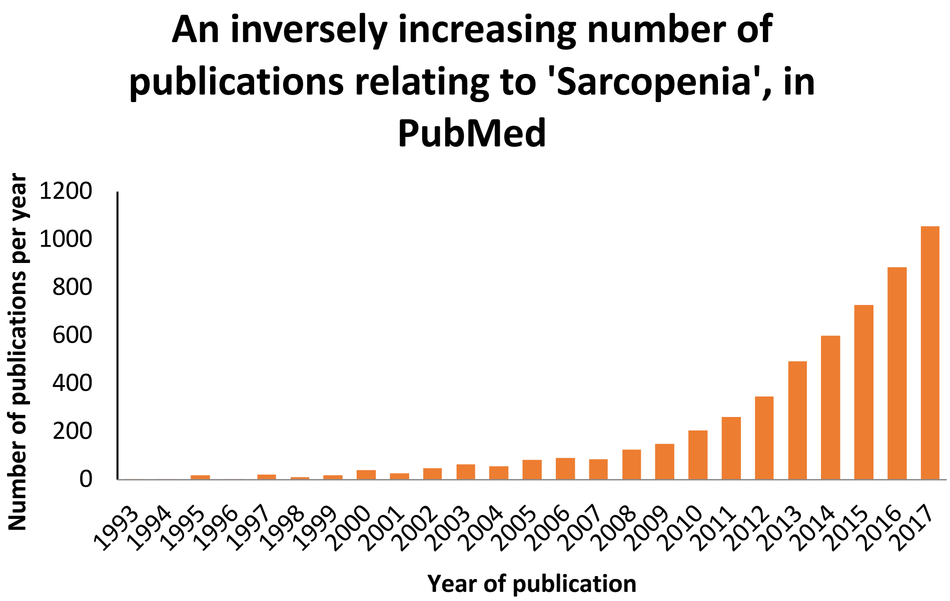


Figure 3: Muscle protein synthesis (red arrows) and muscle protein degradation (blue arrows) change during the ageing process. In the sarcopenic elderly, muscles tend to decrease in size due to the imbalance between muscle protein degradation and synthesis.



Graph 5: The number of publications found from searching the keyword "Sarcopenia" in PubMed, released from 1993 until 2017 - collected in 2018

The most widely used operational definition of sarcopenia is that of the European Working Group of Sarcopenia in Older People (EWGSOP) (Cruz-Jentoft *et al*. 2010). The EWGSOP criteria for the diagnosis of sarcopenia, are the presence of low muscle mass plus at least one of either low muscle strength or low physical performance. These criteria lead to a superficially-clear algorithm as to how to diagnose sarcopenia (Figure 4). The correct measures of muscle mass, strength and physical performance for this algorithm are still unknown (Cruz-Jentoft *et al*. 2014).

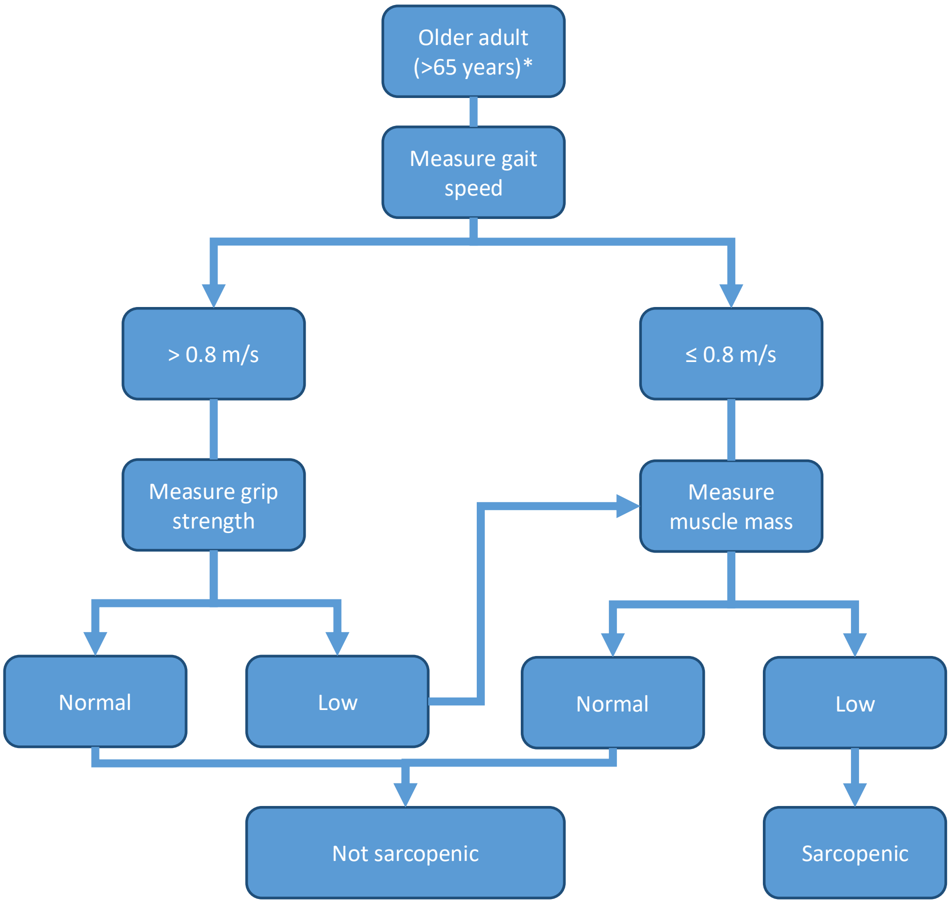


*Figure 4: European Working Group of Sarcopenia in Older People (EWGSOP) criteria. * Younger adults at risk can also be screened using this algorithm* (Cruz-Jentoft *et al*. 2014).

Approaches to diagnosing and quantifying sarcopenia are given in in Table 1. Computerised tomography (CT) and magnetic resonance imaging (MRI) are described as the gold standard measures for muscle mass (Cruz-Jentoft *et al*. 2010), meaning it would be ideal to use these measures to assess for sarcopenia when already part of standard care.

Handgrip strength has been reported to be indicative of post-operative recovery and mortality, in a variety of settings (Daphnee *et al*. 2017; Huang *et al*. 2015; Savino *et al*. 2013; Norman *et al*. 2011). Sarcopenia (defined by the EWGSOP diagnosis criteria) is related to post-operative outcomes in colorectal surgery (Huang *et al*. 2015).

Table 1: Measures available in research and clinical practice, as described by European Working Group of Sarcopenia in Older People

Component of sarcopenia	Research	Clinical practice
Muscle mass	CT scans	BIA
	MRI scans	DXA
	DXA	Anthropometry
	BIA	
	Total or partial body potassium per fat-free soft tissue	
Muscle strength	Handgrip strength	Hand grip strength
	Knee flexion/ extension	
	Peak expiratory flow	
Physical performance	SPPB	SPPB
	Gait speed	Gait speed
	TUG	TUG
	Stair climb power test	

BIA: bioimpedence analysis. CT: computed tomography. MRI: Magnetic resonance imaging. DXA: Dual energy X-ray absorptiometry. SPPB: short physical performance battery. TUG: Timed up-and-go.

Physical performance, in the EWGSOP definition, relates to the quality of the muscle. Methods to measure performance, such as the short physical performance battery (S Deiner & Silverstein 2009; Guralnik *et al*. 1994; Perera *et al*. 2006; Kwon *et al*. 2009), gait speed (Buchner *et al*. 1996; Guralnik *et al*. 2000; Cesari & Kritchevsky 2009; S Deiner & Silverstein 2009) and the timed up-and-go (Wall *et al*. 2000; Mathias *et al*. 1986) measures are well validated in clinical populations (Cruz-Jentoft *et al*. 2010).

An association between pre-operative sarcopenia in colorectal surgery patients has been reported. One study investigating the EWGSOP criteria of assessing sarcopenia reports (Huang *et al*. 2015):

- sarcopenia is associated with age (p<0.001)
- sarcopenic patients typically have a lower body mass index (p=0.01)
- sarcopenic patients have worse odds for developing post-operative complications following colorectal surgery (OR 4.5, 95% CI 1.6-12.9, P=0.007). This was the case for infectious complications (OR 3.3, 95% CI 1.1-9.6, P=0.052) though not significant for non-infectious complications (OR 3.1, 95% CI 0.7–13.2, P=0.3).

A systematic review identified significant differences between sarcopenic and non-sarcopenic colorectal surgical patient outcomes (Hasselager & Gögenur

2014). There is a statistically significant increased risk of complication (Lieffers *et al*. 2012; Englesbe *et al*. 2012; Sheetz *et al*. 2013), prolonged hospitalisation (Lieffers *et al*. 2012; Sheetz *et al*. 2013), and short-term (Lee *et al*. 2011), 1-year (Englesbe *et al*. 2012; Lee *et al*. 2011; Michael J. Englesbe *et al*. 2010; Van Vledder *et al*. 2012) and long-term mortality (Peng *et al*. 2012; Englesbe *et al*. 2012; Sheetz *et al*. 2013; Lee *et al*. 2011; Michael J. Englesbe *et al*. 2010; Van Vledder *et al*. 2012).

1.5.1: Radiological identification of sarcopenia

Key words: 'Sarcopenia, 'ageing', 'elderly', 'identification', 'surgery', 'computed tomography'

Some authorities contend that sarcopenia can be identified solely on muscle mass measures alone (Michael J. Englesbe *et al*. 2010; Van Vledder *et al*. 2012; Jones *et al*. 2015). To do so, muscle measurements in the abdominal transverse cross-sections are summed, stratified by the patient's height, and compared to sex-specific cut-offs (Du *et al*. 2014). This provides the dichotomy of whether a patient is sarcopenic or robust. The methods to identify sarcopenia through CT muscle mass measurements are not consistent in their approach or findings.

There is a substantial body of literature which relies upon identifying sarcopenia through muscle mass measures alone, predominantly through CT measurements. Further to this, there are a number of different methods to identify muscle mass from a CT scan such as; using different vertebral levels in the abdomen to measure within a transverse plane (Du *et al*. 2014; M J Englesbe *et al*. 2010), using a collection of different abdominal muscles to measure from (Huang *et al*. 2015; Jones *et al*. 2015); or using alternative dimensions of muscle measure (Jones *et al*. 2015). There is a sparse evidence base to work from when deciding which would be the best method of identifying muscle mass through a CT scan.

There are studies to indicate that a diagnosis of sarcopenia is clinically informative. A systematic review and meta-analysis (Shen *et al*. 2017) identified sarcopenia to be related to postoperative outcomes in gastrectomy patients. The seven studies included in this review differed in how they assessed for sarcopenia, as well as using different cut-offs for the same population, same muscle groups and same vertebral level analysed (Table 2). There is disparity between studies on what cut-offs to use in the same population, which brings substantial confusion as to what methodology should be used in a surgical population.

Table 2: Adaptation of sarcopenia criteria and cut-off points (Shen et al. 2017)

Study	Sarcopenia criteria		Cut-off points
(Sato *et al*. 2016)	HGS	High HGS ≥ GSL 20%	<27.5 kg in men
		Low HGS < GSL 20%	<16.2 kg in women
(Fukuda *et al*. 2016)	EWGSOP	4m gait speed	≤0.8 m/s
		Hand grip strength	<30 kg for men
			<20 kg for women
		Whole-body skeletal muscle mass (BIA)	<8.87 kg/m^2 for men <6.42 kg/m^2 for women
(Wang *et al*. 2016)	EWGSOP and AWGS	L3 SMM (cross-sectional CT image)	<36.0 cm^2/m^2 in men <29.0 cm^2/m^2 in women
		HGS	<26 kg for men
			<18 kg for women
		6m gait speed	≤0.8 m/s
(Tegels *et al*. 2015)	EWGSOP	L3 SMM (cross-sectional CT image)	43.0 cm^2/m^2 for males with BMI < 25.0 cm^2/m^2
			53.0 cm^2/m^2 for males with BMI ≥25.0 cm^2 /m^2
			41 cm^2 /m^2 for females
(Zhuang *et al*. 2016)	Skeletal muscle mass	L3 SMM (cross-sectional CT image)	40.8 cm^2/m^2 for men 34.9 cm^2/m^2 for women
(Chen *et al*. 2016)	EWGSOP and AWGS	L3 SMM (cross-sectional CT image)	<34.9 cm^2/m^2 for women <40.8 cm^2/m^2 for men
			<26 kg for men
		HGS	<18 kg for women
		6m gait speed	<0.8 m/s
(Nishigori *et al*. 2016)	Skeletal muscle mass	L3 SMM (cross-sectional CT image)	≤52.4cm^2/m^2 for men ≤38.5cm^2/m^2 for women

CT: computed tomography. EWGSOP: European Working Group on Sarcopenia in Older People. AWGS: Asian Working Group for Sarcopenia. BIA: Bio-impedance Analysis. HGS: Hand grip strength. GSL 20%: Gender-Specific Lowest 20th percentile. SMI: Skeletal Muscle Mass.

1.6: Supporting patients throughout peri-operative journey

Key words: 'Frailty', 'sarcopenia, 'ageing', 'elderly', 'identification', 'surgery', 'peri-operative', 'recovery', 'intervention'

1.6.1: Targeted interventions following surgery

Supporting patients throughout the peri-operative journey often rests on the Enhanced Recovery After Surgery (ERAS) program (Greco *et al*. 2014). ERAS is now standard care for all surgical patients in most UK hospitals. ERAS is a multimodal, multidisciplinary approach to supporting surgical patients to recover, with the intention of reducing hospital length of stay whilst also preventing readmission to hospital (Ljungqvist *et al*. 2017). The process involves pre-operative carbohydrate loading, early postoperative mobilisation and advanced nursing specialists facilitating the recovery of each individual patient (Ren *et al*. 2012). The ERAS system may subtly change between different hospitals nationally, yet the concept is similar regarding pre- and post-operative diet and mobility. A meta-analysis of ERAS in colorectal surgery identified that patients who underwent ERAS interventions were at a lower risk of mortality (relative risk ratio (RR) 0.6, 95% CI 0.5-0.8) and non-surgical complications (RR 0.4, 95% CI 0.3-0.6) than those who did not have the intervention. There was no evidence of a reduction for surgery-related complications (RR 0.76, 95% CI 0.5-1.08) (Greco *et al*. 2014). ERAS is not directly related with frailty, yet both frailty and sarcopenia are associated with surgery-related complications. It may be that some frail patients are not suited to the standard ERAS pathway as a result of difficulties with early mobilisation, with poor nutritional status or due to health-specific issues.

1.6.2: Targeted interventions prior to surgery

Diet and exercise can theoretically be used to intervene on frailty or sarcopenia (Talegawkar *et al*. 2012; Labra *et al*. 2015). However, there is currently a large gap in the literature base supporting exercise interventions (Labra *et al*. 2015; Villareal *et al*. 2006). Exercise interventions have previously been done to explore the impact exercise has on the non-surgical older adult (Durham *et al*. 2010). Work translating this into a colorectal surgical field is currently underway nationally, in a research study called PREPARE-ABC (Cancer Research UK 2017). The study aims to identify when an exercise intervention for colorectal surgical patients should be, and what form that may take. The majority of exercise interventions, similar to PREPARE-ABC, involve using a cycle ergometer - an indoor bike used in exercise laboratories. Cycle ergometers are used in these studies to measure the performance and train individuals as part of an intervention. There are many areas of exercise intervention modalities not currently being investigated, and it may be that cycle ergometers are not appropriate for health, disability and logistical reasons.

There are specific considerations when prescribing exercise programmes for the frail patient. Exercise is generally classified as being cardiovascular exercise or resistance exercise (Stewart *et al*. 2005). There are numerous reasons as to why an older adult may decide they personally prefer one or the other modality - an intervention could be tailored to an individual in order for it to have the best chance of success. This may be:

- Tailor the exercise to provide the most benefit to the patients' health, though the patient may be reluctant to perform the exercise
- Provide a range of somewhat beneficial exercises a patient can choose from, in order to find a program they can adhere to
- Compromise to find an exercise program that may not be optimal, but still successful, where the patient may not be too reluctant to complete

Cardiovascular exercise increases the heart rate to a level which may be considered uncomfortable by an older adult population or risky to perform (Carvalho *et al*. 2003). Resistance training is also not without its limitations. Patients who are physically weaker may struggle to increase their muscle mass due to anabolic resistance (Durham *et al*. 2010) - that is to say, they are likely to not be able to substantially increase the rate of muscle protein synthesis through exercise. It may be that exercise interventions in the frail could adopt a resistance-training effect on muscles, and have little cardiovascular demands on the body, whilst also being safe for the individuals.

Eccentric exercise is becoming increasingly recognised as an intervention for reduced physical fitness in the frail (Lastayo *et al*. 2014; Gault *et al*. 2013).

Eccentric exercise is a training modality where muscles lengthen as they contract (for example lowering a weight), as opposed to concentric exercise (for example, riding a bicycle) where muscles shorten as they contract (Power *et al*. 2016). This provides an opportunity to exert larger forces without taxing a person's cardiovascular system. There is limited research on the benefits of eccentric exercise in the frail elderly (Figure 5) (Gault *et al*. 2013).

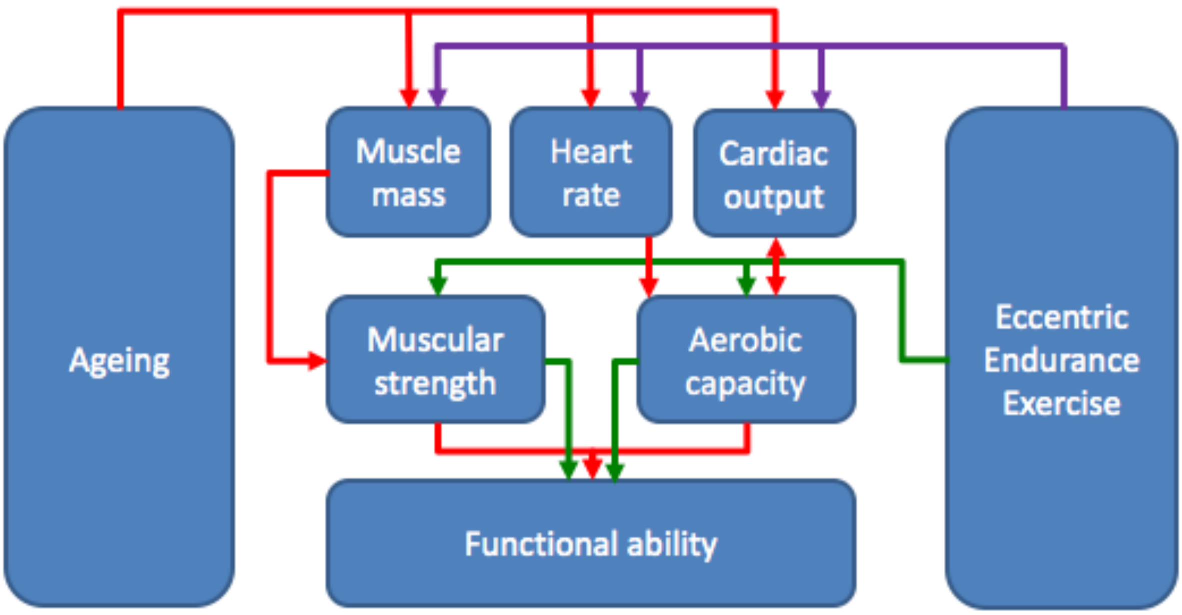


Figure 5: Diagram showing the positive effects (green arrows), negative effects (red arrows) and what is currently unknown effects (purple arrows) in the eccentric exercise - ageing relationship (adapted by Gault et al, 2013)). There is evidence to suggest that there is a positive effect of eccentric exercise endurance on aerobic capacity and muscular strength, which in turn supports functional ability. What is currently unclear in literature, as reported by Gault and colleagues, is the effect eccentric exercise has on muscle mass, heart rate and cardiac output.

1.7: Summary

This thesis includes a body of work on identification of frailty in surgical patients, the prevalence of frailty and sarcopenia in the colorectal patients, perceptions of patients, relatives and clinical staff regarding frailty, and a pilot study of an exercise intervention in elderly volunteers. It is unclear as to how colorectal surgical staff and colorectal patients perceive frailty. Chapter 1 explains the perceptions of healthcare staff and patients regarding how frailty impacts colorectal patients on the surgical pathway. The prevalence of frailty in the local hospital is currently unknown, with frailty identification not performed routinely. Chapter 2 compares the diagnosis of frailty using three widely accepted tools. The prevalence of sarcopenia in the colorectal surgical population is also unknown. Chapter 3 assesses the prevalence, and validity, of sarcopenia as defined by abdominal computed tomography scans and the relationship these sarcopenia measures has with post-operative outcomes. There is contention in literature as to how frailty and sarcopenia are associated with surgical outcomes. Chapter 4 investigates the use of rapid screening tools for frailty, as well as the relationship between frailty, with sarcopenia, and post-operative outcomes. Finally, little work has been done looking into the use of eccentric exercise to build up strength in the elderly. Chapter 5 describes a pilot study of a short-term eccentric exercise programme in elderly subjects.

Chapter 2: Perceptions regarding frailty

The work in this chapter aims to explore the perceptions surrounding frailty, held by both patients and healthcare staff involved in a patient's surgical journey.

2.1: Introduction

Frailty is considered a geriatric syndrome, which leaves surgical patients with a weakened constitution following a procedure, in comparison to their more robust non-frail counterparts (Clegg *et al*. 2013). Being labelled as 'frail' has negative connotations (Schoenborn *et al*. 2018; Warmoth *et al*. 2016; BritainThinks *et al*. 2015). Patients often are either opposed to being referred to as 'frail' or do not identify as being frail (Schoenborn *et al*. 2018). Elderly people see frailty as an inevitable aspect of ageing. There are psychological aspects to frailty; if someone believes they are frail, they will likely in turn become frail (Schoenborn *et al*. 2018). This American study may not reflect a UK perspective, and was not performed in a surgical population, but rather a geriatric clinic. It may be that surgical patients have a different perspective of frailty and may believe their surgical condition is the cause of their reduced capacity. Patients in a geriatric clinic may have a different perspective to surgical patients, who are typically community-dwelling and are unlikely to see a geriatric specialist. The elective pathway (Figure 6) generally involves the patient attending their general practitioner (GP) after recognition of symptoms, being referred to the surgeon, and following pre-assessment with the nursing and other healthcare staff, undergoing surgery. They then recover in hospital and continue to do so following discharge. A more detailed summary of the process can be found in Appendix 2.

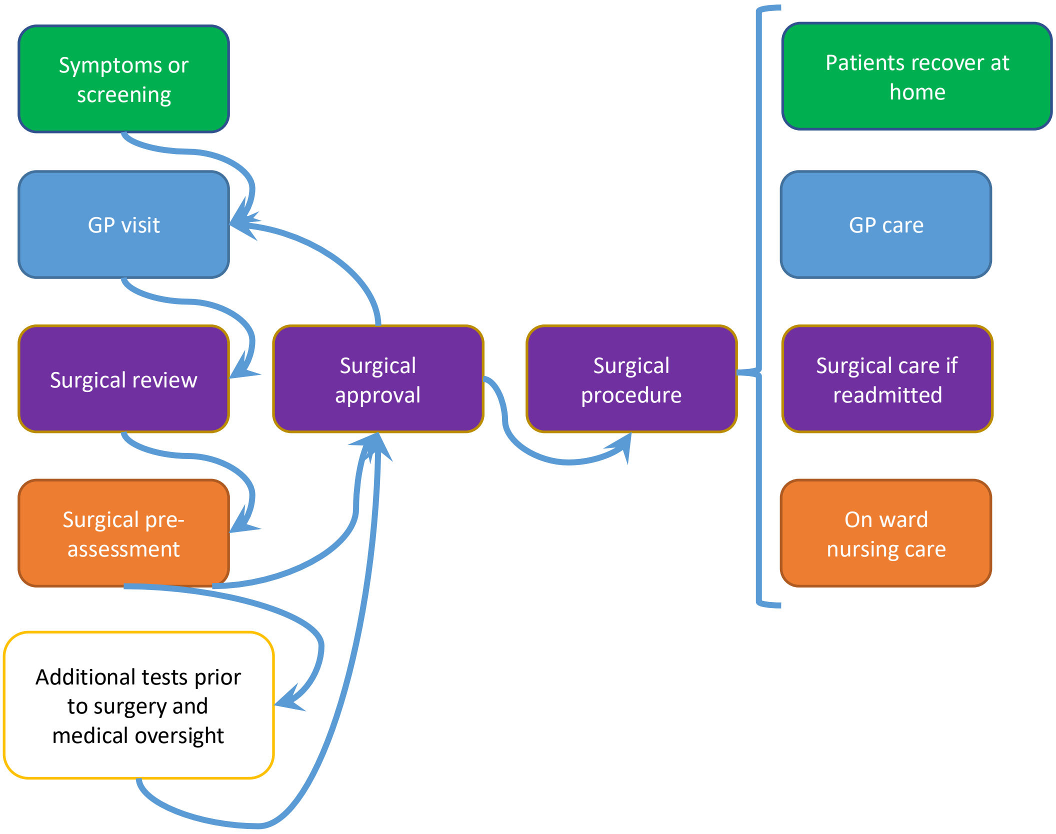


Figure 6: Flow diagram of elective care pathway. Green boxes represents patients, blue represents general practitioners (GP), purple represents surgical staff and orange represents pre-assessment clinic staff. Additional tests in the clear box is not explored within this study

Frail patients, whilst not liking being referred to as frail, may still suffer the consequences of being frail. There is an association between pre-operative frailty status and post-operative complications (Lin *et al*. 2016). Eamer and colleagues explain that frailty assessments are not part of surgical teaching, for either surgeons or surgical nurses. Interdisciplinary perceptions surgeons and nursing staff have regarding frailty are under-researched (Eamer *et al*. 2017a). Understanding the experiences and perceptions these healthcare providers have about the identification and support of frail patients is pivotal to learning more about how frailty impacts on surgical care.

Some work has been done to investigate the barriers to frailty assessment implementation the pre-operative pathway (Eamer *et al*. 2017b), though frailty assessments are not generally part of the routine surgical pathway in the UK (Partridge *et al.*, 2014). This work was performed in the Canadian health systems. It is currently unclear as to what the UK nursing, surgical and allied healthcare professional perspectives are.

This chapter describes and analyses perceptions of frailty, and its identification, from the perspective of healthcare staff involved in the colorectal surgical pathway at St James' Hospital, Leeds. This work also investigates the qualitatively-reported differences between frail and non-frail patient perspectives of their time as colorectal surgical patients. This qualitative work was produced as part of a mixed-methodology study design, with funding provided from the British Journal of Anaesthesia / Royal College of Anaesthetists grant, awarded by the National Institute of Academic Anaesthesia (WKR0-2015-0043).

2.2: Methods

2.2.1: Key considerations of qualitative methodological approaches

Qualitative methods are diverse. A glossary is provided below with reference to the qualitative studies described in this chapter:

- Codes/ coding

  Codes are labels assigned to extracts from the transcript, to demarcate an area of interest. These codes are clustered to produce loose themes.

- Data/ dataset

  Dataset and transcript are used interchangeably in this chapter, where a dataset is the overall transcript recorded for the individual interview/focus group. Data refers to extracts from the transcripts. 'Rich data' refers to the quality and complexity of the data.

- Epistemology

  Epistemology is one of the two key concepts underpinning to qualitative research, with the other (ontology) being the investigation into what is true. Epistemology is the theory of knowledge based from belief and opinion. It is the exploration of perceptions and experiences using belief and opinions of individuals or within a population.

- Essence

  Essence refers to the key value of a theme. It is presented by a coded extract of data. This extract aims to provide insight into the true meaning of the theme. The essence is given in a text box at the start of each section in the results in this thesis.

- Phenomenology

  Phenomenology is one of the many approaches within qualitative research. Phenomenological approaches investigate the understanding of a person's experiences and perceptions of the construct of interest.

- Saturation

  Saturation is the point at which the data recorded from new investigations or new participants does not provide new pertinent information. This is often used as a concluding point of a qualitative research study.
- Scope

  Scope within qualitative research refers to how broad a theme or subtheme is, and what content would fit within that part of the analyses.
- Thematic analysis

  Thematic analysis is one method of approaching the analysis and interpretation of the data. This method is detailed in a well-cited paper by Braun and Clarke, where coded data extracts are clustered into themes. These themes may have subthemes, and aim to provide a balanced scope of the interpretation of the data.
- Thematic map

  A thematic map is a diagram that provides an overview of the structure of the analyses. This diagram highlights what subthemes can be found under different themes in the investigation of a particular population.
- Thematic summary table

  In this thesis, thematic summary tables are provided at the beginning of the sections. These tables highlight the themes, subthemes, scope and essence for each thematic map.

For qualitative research, the focus is less on ‘statistical power’, and instead more directed towards ‘data saturation’ (Malterud *et al*. 2015). Saturation can be difficult to achieve in a short time-scale. Often qualitative research forms part of the initial scoping work for a quantitative project.

2.2.2: Methods of this chapter

This work takes an epistemological phenomenological approach - identifying the perspectives and experiences of the participants as they are lived and explores how frailty as a concept is experienced by four different populations:

- Patients
- Surgeons
- General practitioners
- Pre-assessment staff

A phenomenological approach is the most appropriate for recording qualitative data on perceptions of frailty within the four populations. For the pre-assessment staff, I explored how staff experiences differed when relating to a frail person; for the surgical staff, how frailty impacts on surgical planning; for patients, the differences in the experience of the perioperative process between a non-frail and a frail population; for GPs, their experience of frailty identification and managing frail patients in their care who undergo surgery
The interviewees are regarded as 'experts in their field', which is an important aspect of phenomenological approaches. First hand interviews allow participants to give a direct account of their experiences.

Ethical approval for this study was provided by the York and Humber Research Ethics Committee (15/YH/0513). This work took part of the FAST (frailty and sarcopenia trials) research project (Chapter 5:). Open-ended semi-structured topic guides were developed for the different groups (Appendix 3) and discussed with the research team to ensure the key questions were clear and concise, and that the questions used as prompts were supportive enough to help explore the essence of the subjects' perspectives accurately. The semi-structured interview/ focus group topic guides allowed flexibility so that the researchers could continue threads of conversation that were pertinent to the research questions, which had not been identified in the topic guide. Therefore, it was aimed to recruit 5 participants in the following groups recruited in the qualitative research:

- Patients
    - Non-frail female

    - Frail female
    - Non-frail male
    - Frail male
- Surgeons
- GPs

Pre-assessment clinic staff members were not recruited individually, but as an individual clinic. There was no minimum or maximum set on how many could participate from the clinic, in order to facilitate the varying views within one service. The number of participants in each group, other than the pre-assessment clinic, was decided pragmatically after reviewing key literature in qualitative research regarding sample sizes (Baker & Edwards 2012; Malterud *et al*. 2015). This work aims to investigate breadth of perceptions in different groups, allowing for developments of quantitative research projects. Scientific rigour was taken into account in the methodology, to ensure the results of this work was reliable. The steps included to ensure rigour aimed to negate the possibility of not reaching data saturation within the timeframe available for this study (Seale & Slverman 1997; Baker & Edwards 2012).

2.2.3: Patient focus group

Patients aged 65 or older, attending St James' Hospital for colorectal surgery, who were enrolled in the FAST study (Chapter 4:), were consented to be later approached for focus groups. The same topic guide was used for all groups. The focus groups were held at St James' Hospital in a comfortable meeting area, to allow participants to feel more comfortable. Patients were invited into sex- and frailty-specific focus groups, though they were blinded as to whether they were frail or non-frail. Frailty, in this study, was determined by the 32-point accumulation deficit model, collected in the FAST study.

2.2.4: Surgeon interviews

It was deemed unfeasible to conduct a surgeon focus group, due to constricted logistics. Interviews were therefore considered a more appropriate approach to collect data on their perspective of frailty. Consultant colorectal surgeons were approached, provided with information, and offered the opportunity to ask any questions, and consented if willing and able to participate. Interviews were scheduled depending on the availability of the surgeon. The location was chosen by the surgeon based on their preference. The interview topic guide was used as a reference for questions and there was flexibility to explore issues that arose during discussions.

2.2.5: Pre-assessment focus group

The pre-assessment clinic is comprised of staff nurses, charge nurses and healthcare assistants, with medical oversight. The staff work flexibly and the working of the clinic depends on the skill mix of available staff. Broadly, staff nurses determine what assessments are required on the basis of the planned surgical procedure. Healthcare assistants review the patient, take samples of blood and urine, complete electrocardiograms and swab for methicillin-resistant *Staphylococcus aureus*. The charge nurses assess the more complex patients, refer patients for anaesthetic assessment and ensure that all staff have appropriate support. The three groups staff are all involved in patient care and their perceptions of frailty are salient to deciding if frailty identification could be incorporated into the pre-assessment clinic.

One focus group was held at a pre-assessment clinic audit meeting, at St James' Hospital in the pre-assessment waiting room. The location was chosen for convenience of the staff members and to provide comfort to the participants, with the aim of capturing richer data. Participants were approached prior to the focus group and provided information sheets and consent forms. The participants were approached by the research team the following week to discuss any questions about the focus group. Consent was taken immediately prior to the focus group taking place, after all participants were able to ask questions before proceeding with the research. There was no seating arrangement planned, though the focus group was held as a large circle, to ensure everyone had the chance to see each other. This seating allowed the two facilitators to view all participants, to follow up on visual cues and body language. There were two dictaphones used, placed in the centre, to ensure that all conversation from either side of the room were captured for transcription. Both recordings began and ended simultaneously, to ensure the lapsed times of the two recordings were matched to allow the tapes to be cross-referenced for transcription.

At the beginning of the discussion, members of the focus group were provided with examples of the locally used pre-assessment proforma modified to include frailty assessments. This was done to support discussion of the practicality and resource requirements needed to incorporate a frailty assessment into the existing pre-assessment pathway. The three different proformas provided as examples including a frailty assessment were:

- the clinical frailty scale (Rockwood 2009) incorporated at the end of the proforma, with the thumbnail image guide adjacent for reference
- the 36-point accumulation deficit assessment (Song *et al*. 2010) incorporated at the end of the proforma, with the scoring system at the end, to support classification of frailty
- the 36-point accumulation deficit assessment incorporated throughout the proforma in the relevant sections (e.g. ‘memory problems’ aspect of the frailty assessment was incorporated with pre-existing questions on cognition), with the scoring system at the end, to support classification of frailty

2.2.6: General practitioner interviews

The research team is based in a secondary healthcare setting. This means that the opportunities to approach GPs for research purposes are fewer than surgeons. Individual interviews were deemed more appropriate than GP focus groups due to the likelihood of time constraints. Patients who were recruited as part of the FAST study had letters sent to their GP, informing them of the study. GPs were sent a letter of invitation to interviews and those who responded were followed up by the researcher. The date and location were suggested by the GP and after the researcher answered any questions the GP had, the GP would be consented. The interviews were recorded and the researcher used the topic guide as a foundation for all GP interviews.

2.2.7: Analytical approach

Transcription was out-sourced, to an independent transcriber used by the University of Leeds and Leeds Teaching Hospitals. The analyses were performed by the primary investigator of this work. The transcripts were checked for accuracy against the recordings by the author. The data were then analysed using thematic analysis methodology (Braun & Clarke 2006). The transcripts were reviewed several times, with the audio-recordings to check for mistakes and to become familiar with the context of the interviews. After familiarisation with the recordings, they were initially coded. The codes from all transcripts were clustered, and themes were drawn from all initial codes. Transcripts were then re-read and the data were investigated for missing codes, or additional data that had yet been coded. The codes within the themes were then checked, to ensure they were appropriate within the theme. At this point, the analysis then reverted to analysing the transcripts independently of each other, to gain clarity specific for the participant, for cleaner and richer data.

Once the codes were firmed in their themes and after clarity was checked for individual transcripts, the themes were investigated for the 'essence', as described by (Braun & Clarke 2006; Braun & Clarke 2013). The themes were also investigated for subthemes, categorising the data into appropriate groups. Themes were checked for balance, and the subthemes explained and explored for essence and scope. Essences in this chapter are presented in a textbox at the start of each subtheme section in the results. Data in this chapter are presented with 1-point line spacing, and italicised.

For the analysis regarding the pre-assessment staff, the secondary facilitator of this work performed an independent analysis, using the same thematic approach to the work, and meetings were held to discuss the similarities and differences in the results.

2.2.8: Main research questions

This work sought to address different questions for each of the four study populations:

Patients - What is the difference between a frail and non-frail colorectal surgical population in terms of their expectations over their surgical journey?

Surgeons - How do the expectations of both colorectal patients and colorectal surgeons differ with the surgical treatment of a frail patient, in comparison to a non-frail patient?

Pre-assessment clinic staff - Is pre-assessment the correct place to identify pre-operative frailty and if so, how should this be done?

GPs - How does frailty, especially in a colorectal surgical patient, impact the general practitioner?

The topic guides for the above populations can be found in Appendix 3.

2.2.9: Structure of thematic interpretation for this chapter

The populations are presented in the order of patients, surgeons, pre-assessment staff and finally GPs. Each population is colour co-ordinated for consistency and clarity. A thematic map and thematic summary table is provided at the start of each population in this work. The thematic map and thematic summary table provide an overview as to the content of that particular section of the chapter. The scope and essence were included in the thematic summary table to provide a better understanding of the population's responses.

The essence of each subtheme is highlighted at the start of the interpretation of that subtheme. For scientific rigour, this chapter uses direct data extracts from the datasets to reinforce the interpretation within the subthemes.

2.3: Interpretation of results

2.3.1: Patients

Two patient focus groups were held - one for frail females and one for non-frail females. Non-frail males and frail males whom we approached declined to participate in a focus group. Two participants were present for the frail females' focus group and three participants were present for the non-frail females' focus group. Whilst small number of patients interviewed may have limited the breadth of views elicited, this is perhaps counter-balanced by the fact that these intimate focus groups allowed more in depth interviews. A thematic map (Figure 7) was drawn up following the analysis of the data from both focus groups and a thematic summary table produced (Table 3).

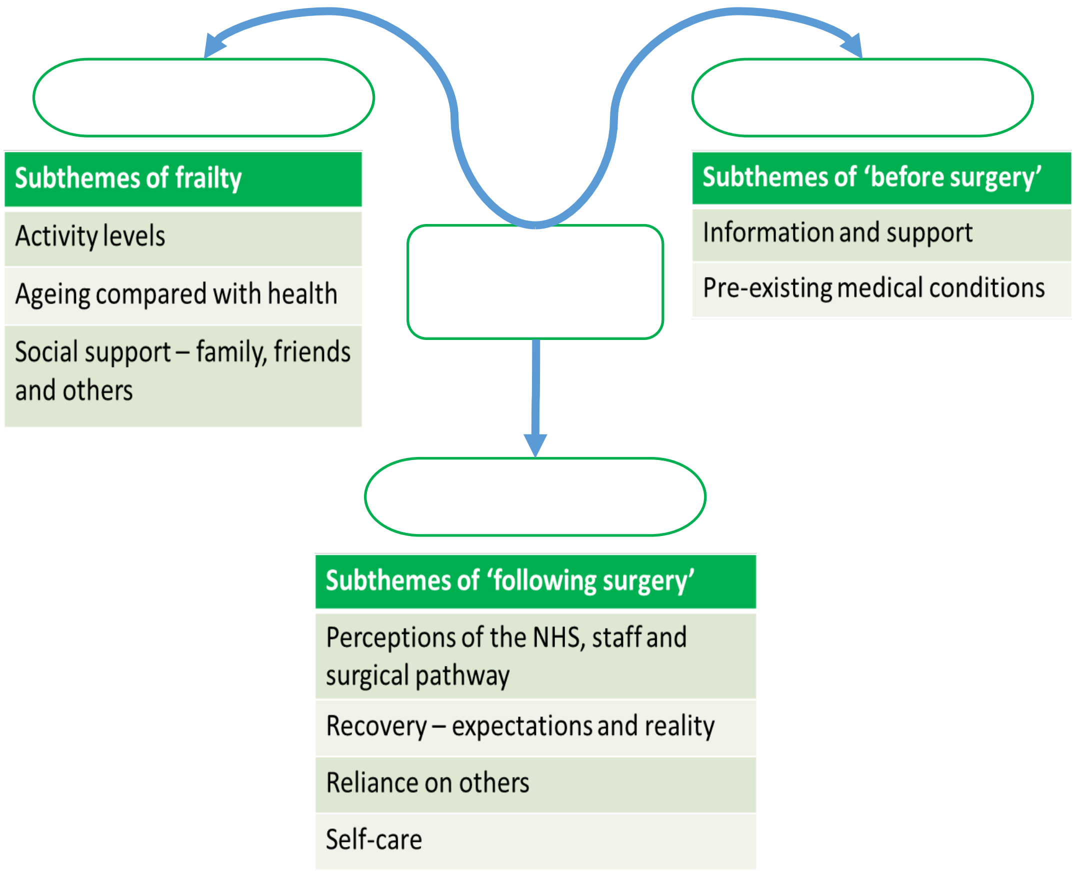


Figure 7: Thematic map produced following the analysis of the patient focus groups

Table 3: Thematic summary table drawn from patients, displaying themes, subthemes, scope and essence

Theme	Subtheme	Scope	Essence
Frailty	Activity levels	What patients felt able to do before surgery and how that has changed post-operative, following a period of recovery	"I'm not as active as I would like to be and I keep hoping that I will be able to return to something like my usual"
	Ageing compared with health	When discussing health, the connection with age-related conditions such as fatigue and taking medications	"It might have something to do with the fact that I'm 82, so I can expect to be a little less active. I'm very frustrated"
	Social support - family, friend and others	What external support patients had whilst on the surgical pathway, from non-healthcare professionals related to their treatment	"I rely heavily on my family and friends really. I live with one of my daughters and in a way she was absolutely indispensable"
Before surgery	Information and support	What information and support was provided before surgery, and how patients perceived this information and support.	"I was advised to build myself up; take iron, have these disgusting drinks, so I was conscious of the need, in fact, I got quite sort of worried in a way by the fact that I obviously had to be in much better condition really for the operation to take place"
	Pre-existing medical conditions	What conditions patients reported having pre-operatively	"I'm in pretty good – have always been in pretty good health" … "I was very reluctant. I'm always reluctant patient, if you like."
Following surgery	Perceptions of the NHS, staff and surgical pathway	What patients thought of the NHS staff they encountered and their surgical journey, whilst they were a colorectal surgical patient.	"I was a bit frustrated by was the fact that, quite rightly, I was being told get out of bed, walk up and down and so, which I absolutely appreciated, but the ward was very inadequate over in Lincoln wing. It was very small, packed. I just wish there'd been a little patio or something at the side of it to go and kind of walk around a bit. So I thought that was not good enough really for the aftermath of surgery and when, quite rightly, you're being told to get moving"
	Recovery - expectations and reality	What perceptions patients had of their post-operative recovery, and how these differ with actual events from their recovery	"I think I expected to be longer in hospital. I don't know why. Perhaps cause I'm thinking back to the old ways. So I was a bit surprised to be only in for just under a week. I had what in sixties we used to call a bad trip i.e. the morphine. The most awful hallucinations; very uncomfortable indeed and not pleasant at all"
	Reliance on others	How much did the support of others, both professionals and informal/ relatives, impact on patient recovery	"I think what I greatly appreciate, and I don't think it was like this in the past, was the honesty. You do want them to be honest with you. Explain the possibly outcomes which are not good. I think they're very good in terms of giving the information and not only the consultants, but also the specialist nurse that you get assigned to, although I think she was very busy and sometimes a little difficult to get hold of"
	Self-care	How do patients support themselves and perceive their own ability to recover and retain independence	"I do have a stick. I brought a folding one with me, but I don't really like using it very much even though it's a pretty one with a pattern on it. I'd rather not. I'd rather not really. I get teased about that"

2.3.1.1 Theme: Frailty

Patients were invited to focus groups blinded as to whether they were frail or non-frail. The aims of the focus group were to explore if there were subtle differences between the responses, perceptions and experiences of the two populations, without alluding to how they were being compared. Frailty was a theme throughout the focus groups, in a way the participants were directly unaware of. That is to say, the four subthemes that are found within the theme of frailty are not specifically ‘frailty’, but explore components that derive from frailty: activity levels, ageing in comparison with health, perceptions of health and resilience (not being frail), and having social support. These subthemes were drawn from the data provided by the focus groups, and arranged into themes.

2.3.1.1.1 Subtheme: Activity levels

<u>Essence</u>

“I’m not as active as I would like to be and I keep hoping that I will be able to return to something like my usual”

“I’m not as active as I would like to be”. The frail patients consider this to be as a direct result of the surgery and expect this to be resolved as part of their recovery: *“I keep hoping that I will be able to return to something like my usual or what has been my usual way of leading my life before that.”*

Those who are non-frail also said that as a result of their surgery, they were less active but reflected that this seemed to resolve during their recovery: *“for the first five weeks I felt as if I was in a bit of a bubble. I knew what was going on but I knew how I felt normally and then suddenly about five and a half weeks later, I just got up one morning and it was just as if that had lifted”.*

One of the robust patients reported that their recovery involved becoming strong enough to carry shopping:

“Interviewer (I): So do you find your ability to do these everyday tasks: washing up, changing the bedding, going out, going swimming, for example, has changed from pre-operatively to currently; has it changed at all?

Robust patient (RP)1: I, I found that it has taken a long time. I mean it, it's over a year since I had my operation (a year last July). I found that if I did up to a couple of months' ago, if I did a full day of, or tried to do a full day of house work and cleaning, the following two days I was just shattered. I just wanted to sit and do nothing
I: and it wasn't like that before surgery?
RP1: yeah, I mean obviously it's a case of I've done too much so therefore I'm suffering. I couldn't carry shopping like I used to be able to do and things like that; but that is coming back slowly"

Even though both groups identified a reduction in their activity levels post-operatively, those who were not frail mentioned ways of accommodating for their reduced function:

"RP2: I deliberately bought, you know the G-Tech Air Ram cleaners. I deliberately bought those cause they're lightweight so I'd got the heavy vacuum cleaner, which I used to go up and down stairs with but umm, I just think you've got to be sensible"
"RP1: So it would probably take me a couple of hours to do the dusting and then I'd get the vacuum out but because I have a corner unit like a chaise lounge. I would get the vacuum into the living room, switch it on, and sit on the end of the sofa."

Those who were frail did not identify tangible solutions to their weakness, and both participants instead agreed that it was a source of "*frustration*".

Another interesting point in the activity levels of these patients is that both frail participants were present with walking aids, whilst those who were considered healthy did not have any walking aids supporting them. An extract of data relating to the frail patients' walking capabilities supports this information:

"Frail patients (FP)1: I find I can't walk. I have a stick and that,
FP2; oh right, well I do have a stick. I brought a folding one with me, but I don't really like using it very much even though it's a pretty one with a pattern on it. I'd rather not. I'd rather not really. I get teased about that
FP1: I can't do without my stick, you know, I depend on my stick
FP2: well you've got a proper one as well
FP1: yeah, a hospital one
FP2: hospital one, yes"

2.3.1.1.2 Subtheme: Ageing compared with health

<u>Essence</u>

"It might have something to do with the fact that I'm 82, so I can expect to be a little less active. I'm very frustrated"

Neither group identified with the word 'frail', enough to discuss frailty directly in relation with themselves. However, there was a general awareness in both populations that age might factor into their current health . The essence of this subtheme embodies this. Frail participant 2 had significant frustrations due to feeling fatigue following surgery, which was the initial symptom that encouraged her to go see her GP.

Whilst the focus group did not discuss frailty as a key topic, when asked *"So would you say that any of the side effects we've just discussed could be attributed, in your mind anyway, to frailty in general"*, the frail patients responded:

"FP1: I think a lot has to do with your age, definitely. I'm sure it has
FP2: I don't really know. I kind of put everything down to the fact that I'd got this tumour, which is why I expected when the tumour was gone, I'll be back to normal"

The frail participants did not react negatively to the word 'frail', though they also did not identify themselves as being frail. Instead, the participants related their condition back to their age or to their cancer. The data suggest that patients do not necessarily see themselves as being frail but as having limitations and restrictions. These restrictions are either as a result of their surgery, diagnosis or age, yet not to do with their impaired functional capabilities:

"I: have you noticed any changes in terms of your physical strengths or your levels of activity now?
FP1: my physical strength is good
FP2: well I have but I don't know how much of it is down to simply growing older. I think the cancer had something to do with it, so I'm a bit frustrated. I'm custom'd to go for long country walks but I can't really do that anymore and now if we go away to the dales, we have to make arrangements that I do half

the walk and that I'm parked up at some pub or something and they carry on. I don't like that."

Both frail and non-frail participants believed they were not as unwell as others they encountered whilst being a patient on the surgical pathway.

Healthy patients:

"HP2: I know you were saying when you are on the ward and when you're with people, you know, obviously you're thinking of yourself at the time but when you see how poorly some of the people are and like what you've gone through as well it makes you feel grateful that yours wasn't as bad
HP3: no
HP2; but there's some really poorly people when you're in hospital, isn't there
HP3: oh yeah, it's horrendous"

Frail patients:

"FP1: I could have my own medication and I could sort of take them myself, well they ask you, are you happy to take your own medication. I said oh yes. And I found that better than having the staff giving me it, my medication. I mean a lot of patients they can't get out to do their own medication."

There were no identifiable differences in perceptions of ageing in comparison with health, between the frail and non-frail patients. Whilst this could be due to the structure of the topic guides used to lead questioning, these were developed as semi-structured and flexible to identify differences between patient populations. Frailty is perceived – by the members of the focus groups in this study - to be a lack of independence, and whilst participants from the frail group were aware of needing help from others, they were clear about wishing to retain their independence. An example of this was medication management. Both frail patients discussed the hospital staff taking control of patients' medications, although these same patients were managing their own medications prior to admission. The lack of a difference does not mean there is no difference between perceptions of frail and non-frail surgical patients. It may be that this study did not recruit sufficient participants to understand the intricate, qualitative differences between the two groups. There may also be within group differences– for example, patients may accept or resent being identified as frail. We did not have sufficient data to interrogate such within-group differences.

2.3.1.1.3 Subtheme: Social support - family, friends and others

<u>Essence</u>

"I rely heavily on my family and friends really. I live with one of my daughters and in a way she was absolutely indispensable"

Both non-frail and frail patients discussed family throughout the focus groups, although there was a nuanced difference between the groups. Those who were frail discussed their social connections in terms of 'how these people are concerned with me', whereas those who were more robust talked about their social circle in terms of 'how am I impacting others'. Key extracts summarise this point:

Non-frail patients:

"HP2: it was a tumour and, the first thing I did, my son was sat next to me and I said, 'Sorry,' to him and he looked at me and he said, 'Oh,' you know, 'What?' I said, 'it was the first thing that came into my mind.' It wasn't particularly me it was the extra pressure it was going to put on with my Son having an illness as well. You tend to think of other people as well but it does happen."

Frail patients:

"FP2: I live with one of my daughters and in a way she was absolutely indispensable: getting me to drink these horrible drinks that I had to have! And generally looking after me. And she, she still does help me deal with any after effects. This weakness that I seem to have, yes. And there are other members of my family as well very, very helpful to me and I really wouldn't like to be without that support at all"

2.3.1.2 Theme: Before surgery

2.3.1.2.1 Subtheme: Information and support

Essence

"I was advised to build myself up; take iron, have these disgusting drinks, so I was conscious of the need, in fact, I got quite sort of worried in a way by the fact that I obviously had to be in much better condition really for the operation to take place"

Pre-operatively, patients receive information regarding their surgery from the point of the surgical outpatient appointment, when surgical intervention is considered a viable option. Sometimes, a surgeon may not be able to provide the patient with a clear idea as to what will happen during and after their surgical procedure:

"FP1: My consultant really prepared me and told me everything about it. They said we don't know what we're going to find because you're a baffle. I'd baffled him because he didn't know what was causing my colon to narrow like it was doing. So he said the only option is operate and just take the piece that's really causing you the problem out. But he said I don't know what I'm going to find. As I say, you might end up with a colostomy or you may not."

The surgical advice pre-operatively was commonly discussed by both groups, with one frail patient identifying their GP being a source of information, and both frail patients agreeing that nursing staff supported them preoperatively. The non-frail patients did not identify pre-operative support, other than from the surgeons, without prompting. A frail patient discussed the impact of having open conversations about the procedure, the care and expectations that the surgeon had of their recovery:

"FP2: my experience was much like yours in that I think what I greatly appreciate, and I don't think it was like this in the past, was the honesty. You do want them to be honest with you, explain the possibly outcomes which are not good and so I think they're very good in terms of giving the information."

A frail patient discussed their willingness to follow the advice from healthcare professionals, as they were a source of information that they believed they could trust:

"FP2: I did feel a necessity to follow the advice because I trusted the people who were giving the advice and I could see that it was important so, you know I did. I was quite keen to follow the advice, starting with the GP"

Frail patients discussed receiving information from assigned nurses about what they could expect pre-operatively and how they could better support themselves whilst waiting for their surgery:

"FP2: …the nurse that you get assigned to - very good indeed, excellent both before and after. Although I think she was very busy and sometimes a little difficult to get hold of…"

2.3.1.2.2 Subtheme: Pre-existing medical conditions

> <u>Essence</u>
>
> *"I'm in pretty good – have always been in pretty good health" … "I was very reluctant. I'm always reluctant patient, if you like."*

The frail patients in this study were identified as frail using the accumulation deficit model (Song *et al*. 2010). This model of frailty is based on a checklist of comorbidities with patients being classified as prefrail or frail if they have more than the threshold number of co-morbidities. However, the frail patients did not identify that they had a significant medical history. Indeed, one patient said: "*I'm in pretty good – have always been in pretty good health" -* though later followed up with: *"I was very reluctant. I'm always reluctant patient, if you like."* This could mean that this patient either had not sought medical treatment or has chosen not to bring it up in conversation.

Amongst the non-frail patients who discussed pre-existing medical conditions, one patient had poor hearing, and another had previously had a frozen shoulder. These were the only two coded extracts that were taken from the transcripts, in comparison to the four codes frail patients provided, two of which were fairly in-depth:

"FP1: I'd had so many colonoscopies I was getting a bit fed up. I thought, 'Oh I just wish they'd operate and get it away whatever it was,' you know so I did prepare myself because I just wanted to get it over with and to be, as I say, free from pain when I went to the toilet. So I was really relieved when he decided; I know they have to go through all these tests and that and wanting to know, you know different things and that and he knew I'd had anaemia and he knew I'd had all these pints of blood and that and so I was relieved when he eventually said well I think we better operate and just find out what's causing the trouble so, mm
FP2: I really think the colonoscopy is, is absolutely the worst thing!

FP1: d'you know they're different now though cause me brother's just had one and he didn't go through-and I, I kept saying to him I says, 'Oh,' I says, the thing worse about it is taking the prep. Oh it's terrible
FP2: it is. I can tell you it's still awful

FP1: he didn’t have to take the prep or anything. I don’t know if they do it all digital or something on screen.”

“FP2: I’m quite a clumsy person. . . I do fall about. In fact, I injured one of my legs. I had to have treatment and bandaging and antibiotics even. Umm, but I don’t think that’s more than would’ve been the case, you know before . . .
FP1; no, I haven’t had any falls or anything . . . oh years ago I’d fall. I’d broken my wrist and me ankle and that. That’s when they found out I’d osteoporosis cause easily break things but not since me operation I haven’t had any falls
FP2: no I haven’t really, no
I2; Okay, so are you worried about falling now; is it something that plays on your mind at all or, maybe more so than before?
FP1: it plays on my mind; especially if it’s icy or there’s snow
FP2; you realise the need to be terribly careful in that situation
FP1: yeah
FP2: I’m afraid of falling but I don’t think I would’ve been less afraid if I hadn’t had the cancer or the surgery. I don’t think that’s really affected that side of things”

2.3.1.3 Theme: Following surgery

2.3.1.3.1 Subtheme: Perceptions of the NHS, staff and surgical pathway

<u>Essence</u>

"I was a bit frustrated by was the fact that, quite rightly, I was being told get out of bed, walk up and down and so, which I absolutely appreciated, but the ward was very inadequate over in Lincoln wing. It was very small, packed. I just wish there'd been a little patio or something at the side of it to go and kind of walk around a bit. So I thought that was not good enough really for the aftermath of surgery and when, quite rightly, you're being told to get moving"

The difference between frail and non-frail patients is most clearly identified in this subtheme. Those who were frail experienced a more challenging experience throughout their time on the surgical pathway in comparison to their more robust counterparts.

Regarding the nursing staff, there were mixed reviews between those who were frail and those who were non-frail.

Frail patient:

"FP2: I did have the feeling that staff were very harassed and didn't have a lot of time kind of spend with you, talk to you. Understandably. There were people much sicker than me on that ward, but it's not ideal. It's not what one would like to happen"

Non-frail patient:

"HP3: one thing I would like to say, I forgot at the time: when I was on the ward, the day that the nurse sat and said but it's not curable, she must have said something to one of the nurses that was looking after me on the ward and she came and sat with me later on. I said to her, 'You're due to go home.' And she said, 'But you're more important.' And that was wonderful and she just sat talking to me and explaining things and I must be honest, I felt so much better after she had but that was her own time. This is what people don't appreciate about the NHS, isn't it? They don't realise how much people in the NHS put into looking after patients"

"HP2: when you see how many people are running those wards, how many beds they're coping with; and that we've all had big operations, I'm just full of praise for you all. You earn every penny that you get, believe me!
HP1: I think the biggest thing is they look they're not busy
HP2: [laughs] they take it in their stride!
HP1: yeah
HP2: they do
HP1: you just look as if you're not busy and if you ask them a question it's, 'We've got all the time in the world to answer you,' you know but they haven't. You've got all these patients and it's…
HP2: I think that's a sign of a good nurse. It's part of your training, isn't it? You might be, you might be inside but outwardly no, and it does make you feel more at ease, doesn't it?"

Although the patient numbers are small, the difference in perspective is clear. The patients attended the same ward, though may have had different nursing staff care for them. Those who were frail identified that they did not have the time of the nursing staff, when the non-frail patients identified that nursing staff were staying later outside of their working hours to care for patients. The appreciation for staff from both the frail and non-frail participants also extended to the medical staff (though there is some misunderstanding in the role medical staff have):

Non-frail patients

"HP2: I'd had my bag reversed, and the young junior doctor who was on the two nights when it happened, he was absolutely brilliant. He even went off to the lab and did the blood tests himself and everything. And you just don't realise how much time and effort you all put it, honestly. I don't know if other areas are the same but I've got no complaints whatsoever"

Frail patients

"FP1: The pain relief was very good that they advised me to have: the anaesthetist, before the operation advised me to have an epidural so she put an epidural in and I was fine. All the staff was brilliant."

The frail patients felt that the nurses did not have enough time for the patients and their care, which brought about some frustration. Healthy patients commented on nursing staff who made additional time for patients and their care. The frail patients were not entirely unhappy with the nursing staff. One of the patients reported that a nurse had identified the patient as being in pain and remedied it using their experience and training:

“FP1: I know one of the nurses just said, ‘Are you in…’ I said, ‘I’m all right.’ So he just rolled a towel up and just put it on my tummy and eased it and that was really… just rolling a towel up . . .
I1: some of the nursing staff have a very good level of information about how to ease the pain to make it a bit more comfortable. It’s a shame that they were a bit harassed, that they didn’t have enough time
FP2: yes, I think they didn’t seem to have the time. I did have, having said that, you reminded really, it was quite soon after the surgery and I think I’d slipped down into what is probably very uncomfortable and someone did come and very efficiently sort of get me up, you know but not, not in a nasty way but made me more comfortable. I only think that happened once actually”

Patients attend pre-assessment after the initial surgical consultation at their out-patients appointment, either on the same day or shorty after. They then receive a date for surgery. Whilst cancer has a 6-week time-to-treat pathway, sometimes surgery has to rescheduled due to staffing issues or bed-shortages. A frail patient reported being unhappy in the time they waited:

“FP2: I had longer than that. I’m not sure how long. Too long from my point of view. It was not nice waiting. I think it was referred tests that must have been kind of roundabout January/ February, and then I had to wait, and the worse thing was I suddenly telephoned to tell me that it was put off for a week and that really threw me because I got myself psyched up and everybody rung. I was expecting a week, which isn’t very long but it certainly kind of threw; I was quite upset by that”

“FP2: but it would’ve been much better for me, much better if I hadn’t had to wait. It almost seemed like longer than it actually was, but it was very worrying indeed. It wasn’t a good thing at all”

There was an awareness by both frail patients that the bed crisis and the pressures in the NHS was the cause for delays in treatment:

“FP1: I’d come to see my consultant in clinic and he sent me straight to the assessment place. So I’d all my assessment done and everything. Just waiting then, and then I got the letter to say with the date to come in – well you’d to ring up to see there were a bed. He could only do it if there were a bed on high dependency, because he wanted high dependency
“FP2: I thought it was too long really but with the huge pressures on the service…”

“FP2: it was quite an ordeal because I don’t know about him but I think he had had to run this clinic by himself because there’d been some sort of problem with his registrar. And I really felt that was unacceptable, in the sense that you shouldn’t have to wait nearly an hour for that clinic.”

The perception of waiting differed between those who are frail and those who are non-frail. The non-frail patients report being "*very, very impressed how quickly you're dealt with".* One of the patients received the date of surgery on the day of their out-patient appointment, which also included their pre-operative assessment. It may partly be due to a small sample size in this study, and their surgical procedures happening at different times. It may also be due to frail patients feeling as if they need more support from their surgical healthcare staff and to have their expectations managed in a way they are comfortable with. Frail patients, from the data collected in the focus groups, have reported wanting more information pre-operatively and their frustration at being fatigued, and are likely to have considered this surgical intervention to be the solution to their frailty-derived frustrations. The frail patients reported feeling frustration during the recovery period as well as immediately after surgery.

2.3.1.3.2 Subtheme: Recovery - expectations and reality

<u>Essence</u>

"I think I expected to be longer in hospital. I don't know why. Perhaps cause I'm thinking back to the old ways. So, I was a bit surprised to be only in for just under a week. I had what in sixties we used to call a bad trip i.e. the morphine. The most awful hallucinations; very uncomfortable indeed and not pleasant at all"

Both frail and non-frail patients report that they expected to recover to full health post-operatively, and both groups agreed that it may take a while for them to recover completely.

Non-frail patients:

"HP2: it wasn't as bad as I thought it would be. I was really fit and healthy before I went in as well and my consultant said it helps so much with your recovery because of how fit and healthy you were before"

Frail patients:

"FP2: well on the one hand, surprised and pleased at the way, you know you recover quite quickly; the way my system seemed to return to normal but, in my case, I've still got this fatigue, which I'm annoyed about and it'd be nice to know whether it was a permanent thing or not. It's hard to say, I suppose
FP1: my problem was I'm one of these that want to get in and do things and cause I haven't to do strenuous things, you know but, but I felt fine and that, yeah, my husband kept saying, 'No, I'll do it. you haven't to do it.' but I'm there, I want to get on and I had to sort of, you know, you mustn't undo all the good work they've done, you know. So, it's frustrating!"

A non-frail patient recounted their perception of their interaction with the surgeon. The patient explained that the surgeon believes that patients who are fit and healthy pre-operatively will return to a similar pre-operative state, and those who are less well are less likely to do so. This is supported by the second frail patient, who above discusses the return of her severe "*fatigue"* following her surgery. This patient then went on to say:

"FP2: I should've said actually that before when I had this anaemia and I was so run down and of course they wanted to bolster me up for the operation. And so that didn't work terribly well because first of all I had some revolting

thing, which was sort of a powder you had to mix and drink loads of it. I couldn't cope with that. I did ring up and my nurse got me something else, which was also not very nice. But I kind of relied on my daughters forcing me or at least helping me to drink gallons and gallons of this stuff to kind of make myself. I had iron as well. I was shocked at how run down I was"

It could be that those who are frail are not only less likely to recover to their original baseline, but may find it more difficult to comply with pre-operative nutritional interventions. The frail patients in this work discuss other people providing support to them during their recovery, contrasting the non-frail participant who did not. Coded data in this theme for non-frail participants indicate that social support was only discussed as part of their recovery whilst in-hospital. The need for support following discharge was not raised by non-frail patients.

2.3.1.3.3 Subtheme: Reliance on others

<u>Essence</u>

"I think what I greatly appreciate, and I don't think it was like this in the past, was the honesty. You do want them to be honest with you. Explain the possibly outcomes which are not good. I think they're very good in terms of giving the information and not only the consultants, but also the specialist nurse that you get assigned to, although I think she was very busy and sometimes a little difficult to get hold of"

Following surgery, it is recommended by healthcare staff that patients are discharged with family support in place, to ensure appropriate support is available. As part of the pre-assessment work up, patients are asked about their social support structure and who would likely support them at home following surgery or where they could stay if they live alone. Patients receive both formal support (from healthcare professionals) and informal support (from family and friends) throughout their time on the surgical journey. The frail patients did have some less-positive perceptions relating to the healthcare staff, in comparison to the non-frail patients. Both populations found a lot of support from their pre-existing informal support structures.

Frail patients:

""FP2: I did feel [the healthcare staff] were responsible for helping me to recover and certainly have to say that didn't have quite enough time to give me the attention which I should've had. Don't get me wrong, it's not serious, because I was recovering quite well. But this bit on exercising actually umm, you know surgeon saying got to walk around and, but really it was extremely difficult to do in a very confined space"

"FP2: I think what I greatly appreciate, and I don't think it was like this in the past, was the honesty. You do want them to be honest with you. Explain the possibly outcomes which are not good. I think they're very good in terms of giving the information and not only the consultants, but also the specialist nurse that you get assigned to, although I think she was very busy and sometimes a little difficult to get hold of"

"FP2: I relied a lot on my family and friends, and got as much information as I could about what's going to happen. It's a kind of emotional support; it's just sympathy, if you like. But also advice really about how to cope with things

“FP1: I’d been home about three days my sister took a sample down. I knew because there were blood in me urine so I knew; I knew I had, but we were such a while waiting for me results to come back and I was fatigued. I was sleeping and that and she rung the doctor and the doctor came out and they had me straight in hospital. I was only in hospital for nearly a week. My sister, she’s a nurse as well, and she kept saying, ‘Why don’t you give antibiotics intravenously instead of by mouth?’ they said, ‘Oh, I think we’ll clear it up by mouth.’ Well my temperature kept spiking and that so anyhow, they eventually gave me antibiotics through a drip and I was fine then”

“FP1: my younger sister, she’s had bowel cancer and that. She said, ‘When you come out of hospital I’m going to come up.’ She lives in down south, I have a daughter lives nearby but she said, ‘No, I’m going to come up and stay with you.’ So she came up and stayed. And she was a great help”

“FP1: I could have my own medication and I could sort of take them myself. Well they ask you, are you happy to take your own medication. I said oh yes. And I found that better than having the staff giving me it, my medication.”

Non-frail patients:

HP2: the first three days I was reliant [on the nurses] because I’d got the catheter in and a drain as well and I was on drip because I didn’t have any food for the first couple of days (they just had me on the drip). You are reliant on them but they were amazing. I mean when you see how few people were on the ward it’s just unbelievable. There’s only like six beds on each of those little wards but, and the night staff nurse, he’s just absolutely unbelievable. I mean first thing he used to do when you came in was when they’d just changed over he was there within 10 minutes with a trolley with a cup of tea extra for you all but they-they’re absolutely wonderful, you know and if you have the buzzes, it didn’t matter how few were on, they were really good. No, I just found I was in awe of them to be honest. The amount of hours that they spend working and then some of them don’t go home at the end of the shift because they’re doing other things. I don’t know how you cope with it all those hours, 12 / 13 hour shifts and then they’re still there afterwards. All the people on my ward definitely were all sorts of ages, and some of them were a lot poorly than I was and you didn’t hardly ever get left at all. They were just unbelievable”

“HP3: one thing I would like to say, I forgot at the time: when I was on the ward, the day that the nurse sat and said but it’s not curable, she must have said something to one of the nurses that was looking after me on the ward and she came and sat with me later on. I said to her, ‘You’re due to go home.’ And she said, ‘But you’re more important.’ And that was wonderful and she just sat talking to me and explaining things and I must be honest, I felt so much better after she had but that was her own time. This is what people don’t appreciate about the NHS, isn’t it. They don’t realise how much people in the NHS put into looking after patients”

“HP1: I had district nurses coming every day because I had to have injections blood clotting. So when we found that the wound had opened and it was leaking umm, the district nurse did it, you know dressed it on the Sunday and luckily my cousin, who’s here now, she’s a healthcare assistant and she came and stayed with me for ten days. So she, they just left the packs and she dressed it; it was that bad we had to dress it three times a day. But she was cleaning and dressing it for me, which was lucky and then when she went they took over.”

2.3.1.3.4 Subtheme: Self-care

Essence

"I do have a stick. I brought a folding one with me, but I don't really like using it very much even though it's a pretty one with a pattern on it. I'd rather not. I'd rather not really. I get teased about that"

Those who are frail, typically, are less resilient than their robust counterpart. The frail participants in this body of work discuss their independence in ways such as taking their own medication or through their frustrations of waiting longer than they would like for their surgical procedure to occur. Two main coded extracts were taken from the data:

Frail patients:

"FP2; well I haven't had any changes in my medication. It was a bit worrying though that while I was in hospital, that the arrangements for going on taking your medication, for instance, in my case statin and blood pressure lowering drug, they were very chaotic about that. One minute they were giving it to me, but I brought them all in too. So perhaps a little bit more care of that would've been good. And I also have eye drops and for staving off glaucoma basically; I was worried by the fact that I did remember myself and I got somebody to bring them in but there wasn't any kind of awareness that maybe it's important for you to go on taking these drops, you mustn't have a hiatus"

"FP1: I find I can't walk. I have a stick and that,
FP2; oh right, well I do have a stick. I brought a folding one with me, but I don't really like using it very much even though it's a pretty one with a pattern on it. I'd rather not. I'd rather not really. I get teased about that
FP1: I can't do without my stick, you know, I depend on my stick
FP2: well you've got a proper one as well
FP1: yeah, a hospital one "

The frail patients' perceptions of self-care relate to aspects of their frailty. For example, both patients use a walking stick and one of the patients reported being more aware of her medication-requirements than the hospital staff. The non-frail patients in this work, on the other hand, make a larger effort to look after themselves. One patient sought out a training programme in order to increase her functional ability and to lose weight. A second discussed her activities of daily living in a way to measure her gradual improvement in health over time, since the operation. The third patient discussed going on courses that would support her recovery and go to help her feel better after the surgery. It could be that frail patients are less inclined to look externally at how they can seek out opportunities to engage with activities that would be beneficial for their health, unlike those who are not-frail.

2.3.1.4 Key points

The patient focus groups provided valuable insights into patient expectations and perceptions. The key points from these are:

- Frail patients are less active than those who are not frail
- Both frail and non-frail patients had support from family and friends, though frail patients perceived support structures as mechanism whereby others could provide care for them, whereas those who were non-frail saw their personal networks in terms of mutual support.
- Frail patients considered the information available before surgery to be lacking whilst non-frail patients felt it to be adequate
- Both frail and non-frail were aware that additional activity pre-operatively could support post-operative recovery. Non-frail patients are were likely to adhere to pre-operative interventions than those who are frail
- Frail patients perceive NHS staff to be rushed and to not have as much time for the patients, yet are aware that the staff are trying to support patients as best they can
- Non-frail patients perceive NHS staff to have time enough for patients, and recognise that they are likely to go beyond what is expected of them to support patients
- Both frail and non-frail patients believe they will recover to their pre-operative state, or better, post-operatively
- Non-frail patients were more likely to engage with post-operative activities that support their recovery and retain independence than frail patients

2.3.2: Surgeons

5 consultant colorectal surgeons from St James' Hospital were recruited and interviewed. No participants withdrew at any point. Three key themes were identified (Figure 8): 'perceptions of frailty', 'surgical expectations' and 'treatment of frail patients'. The scope and essence of each subtheme was explored (Table 4).

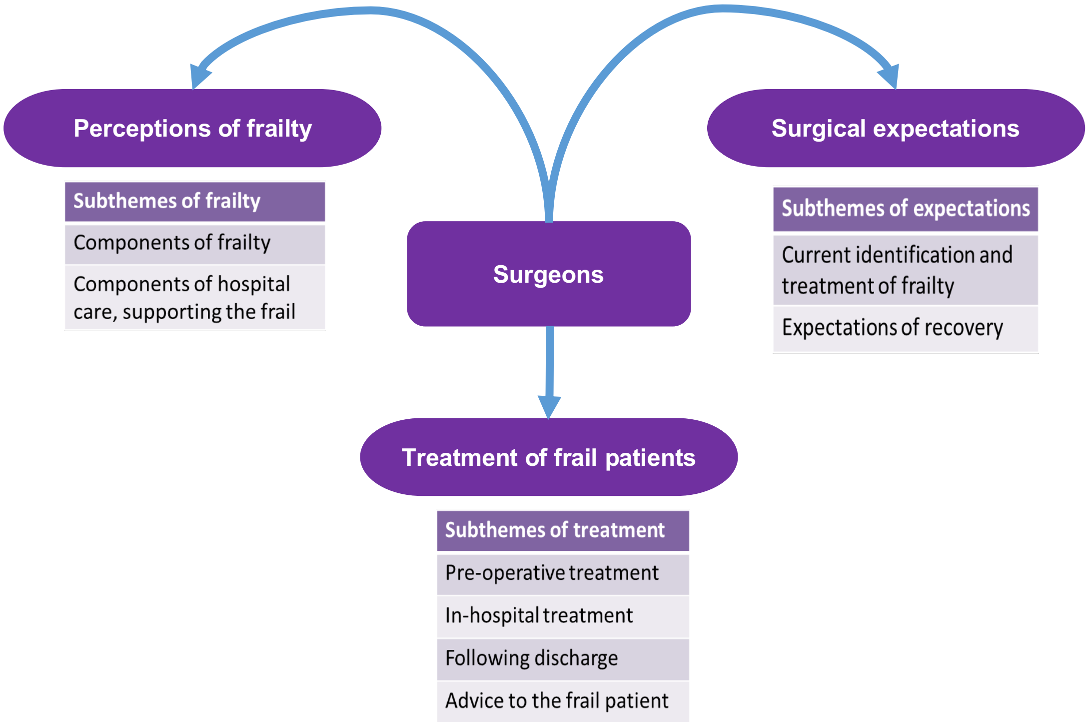


Figure 8: Thematic map representing the data collected from consultant colorectal surgeon interviews

Theme	Subtheme	Scope	Essence
Perceptions of frailty	Components of frailty	What components of frailty are surgeons aware of and how are these impacting planning?	The patient “thinks her shortness of breath is not because of cardiac issues or respiratory issues. She says in the morning at 11 o’clock she’s always struggled to breathe. And the question she asked me is can you do operation after 11 o’clock”
	Components of hospital care, supporting the frail	What resources in the hospital are/ are not available to provide support to frail patients?	“I think frailty is identified poorly” - patients need “help with eating, help with mobility, help with hygiene, are generally requested by nursing staff. So I just leave it to them to request or to do”
Surgical expectations	Current identification and treatment of frailty	What do surgeons expect when caring for frail patients?	“I think frailty is one of the key factors involved in [surgical] decision making. How are you going to manage this patient post-operatively: do I need HDU; do I need the care of elderly in ward? Can I optimise this patient?”
	Expectations of the recovery of frail patients	What are the expectations for a frail surgical patient to recover?	“A frail patient I would expect to get better more slowly than a healthy, fit and healthy non-frail more elderly patient”
Treatment of frail patients	Pre-operative	What is done pre-operatively to identify, support and optimize the frail patient?	“A lot of it is on intuition and ultimately it comes down to what measures you have the usual blood tests, their weight, BMI, the ASA, comorbidity scores umm, maybe the results of CPX testing, maybe, not always (we don’t use it routinely)”
	In-hospital	What do surgeons recommend in the hospital to identify and support the frail patient?	“None of us go round talking about, ‘Oh what frailty scores have you used? Or ‘What have you used?’ ‘Oh yeah, this patient scored so and so on the Edmonton (or something)’. You just kind of do. You just look and you do?”
	Following discharge	What do surgeons recommend following discharge to identify and support the frail patient?	“You’re already thinking of they’re not just going to bounce back after the operation, and they’ll need a prolonged period of support. They’re going to need a degree of rehabilitation“
	Advice for the frail patient	What advice would surgeons give to the frail patient?	“We’ll advise them that they’ll improve within the next four to six weeks. I’d expect a slow but steady improvement in terms of their appetite, their weight”

Table 4: Thematic summary table of surgeon interviews

2.3.2.1 Theme: Perceptions of frailty

When exploring the surgeons' perspectives of frailty, two key subthemes emerged components of frailty and components of hospital care that supports frail patients. Both theme, and subthemes, were drawn from the data collected in the interviews.

2.3.2.1.1 Subtheme: Components of frailty

> Essence
>
> *[The patient] "thinks her shortness of breath is not because of cardiac issues or respiratory issues. She says in the morning at 11 o'clock she's always struggled to breathe. And the question she asked me is can you do operation after 11 o'clock"*

The subtheme 'components of frailty' relates to which aspects of frailty surgeons routinely recognise and how are these impact on surgical planning.

Surgeons recognise that frailty is not identified routinely as part of local preassessment procedures. One surgeon [S2] discussed the use of pre-assessment picking up different aspects of frailty, and two surgeons [S1, S5] mentioned a specific pre-operative work up provided by pre-assessment, however the general consensus was that frailty in elective colorectal surgical patients is not identified routinely. Surgeons discussed frail surgical patients needing individualized pre-operative work ups, tailored in-hospital recovery care-plans and post-operative support following discharge. There was agreement across the surgeons that there currently is no specific frailty identification tool used and surgeons are instead using individual clinical judgments on a case-by-case basis.

Surgeons identified many clinical considerations of particular relevance in the frail patient. Pre-operatively, the patient's health should be optimized and attention should be given to cognitive function, mobility and diet. The surgeons identified that other factors that could be optimized are medical conditions - such as diabetes, low respiratory function etc. - and lifestyle choices, such as smoking or drinking alcohol. No surgeon identified that a geriatrician may be able to meet these needs or advise on these matters, though several mentioned their working relationship with an anaesthetist to ensure they're aware of a particular patient and their care requirements from a surgical perspective. S1 stated directly that frailty is more akin with physiological age, or 'biological age', than chronological age. This was supported by S2 and S3 who discussed their expectation of frail surgical patients having less physiological reserve at baseline. Several surgeons mentioned reduced ability to recover following a surgical procedure, and discussed that whilst the patient is in hospital, it may be that they will require increased support from allied healthcare professionals.

2.3.2.1.2 Subtheme: Components of hospital care

<u>Essence</u>

"I think frailty is identified poorly" - patients need "help with eating, help with mobility, help with hygiene, are generally requested by nursing staff. So I just leave it to them to request or to do"

The components of hospital care that currently support the frail patient subtheme considers what resources in the hospital are/ are not available to provide support to frail patients.

A surgeon's role in the surgical pathway [S1] "*primarily, is surgery. So if they don't have any surgery, then I might hand on that supportive role to somebody else*". According to the surgeons, [S1] "*we don't do anything special for the frail person verses a non-frail person*". This may be because [S3] "*frailty's identified poorly*", and that [S4] *"we don't measure. I know what you mean. We don't measure it. It's all intuition and end of the bed eyeball test"*. It could also be that [S4] *"It is a very high number* [of patients who are frail] *in the acute setting, which is a big problem. And they're the sickest patients, generally"*.

A frailty identification tool is currently not in place: [S5] "*do we identify [*frailty*]? Not in a formal manner"*. However, S5 did go on to say *"if there was a reliable reference score. Yes, it would be useful. Yeah"*. When asked further about how frailty identification would be useful, they continued:

[S5] *"within the concept of cancer surgery, then it really influences first of all whether we operate or not. So whether we go down a curative route or whether we're looking at a palliative route. And then, if we're looking at a curative route, it may influence the magnitude of the surgery, and what we do. So, for example, if you were doing a bowel resection, whether or not you do a primary anastomosis or not; so you may tailor your surgery accordingly"*

The provision of care in hospital is not determined based on the patient being considered frail, but more on the needs of the individual patients. This may incorporate the intuitive treatment of frail surgical patients:

[S1] *"…if you're 20-year old in for an abdominal operation they're going to be able to get themselves out of bed fairly quickly afterwards. They're not going to need assistance with that. A frail person might need 2 people to assist them; physiotherapy just to get themselves more mobile. So in that sense you would offer them more things. But those are not based around frailty as such. Those are things that already exist in the hospital because we recognise that there's a need for those things. And they're just much more likely to require it if they are frail. All those things exist. I don't necessarily, personally, request them because they are things that are generally requested… so help with eating, help with mobility, help with hygiene, are generally requested by nursing staff. So I just give, leave it to them to request or to do"*

There are ways to develop what is currently available to post-operative frail patients in secondary care, such as [S4] "*input from Care of the Elderly*" which could make a "*massive difference*". This is because "*they have knowledge I believe to deal with these patients on day-to-day basis to pick up things early, to coordinate their discharge and what happens after discharge"*. A service improvement project was performed at St James' hospital in the colorectal surgical department, where a geriatrician provided tailored care to post-operative frail patients. S4 identified that this physician made a "*big difference*" to their department in the few weeks that they were running the trial. Other than geriatric involvement, S1 identified that the allied healthcare professionals are also involved in the care provision of the frail patient recovering post-operatively:

[S1]: *if they're an out-patient, you'd hand it onto the GP. The alternative is they come in acutely unwell, in which case I'll have some responsibility; some role to play. But often the supportive work again is done by the nursing staff and the allied healthcare professionals. And my job then is if they're still in hospital, I'm still responsible, as the consultant. It wouldn't be for me to coordinate that problem, to be actively, too actively involved in that, because my primary focus is surgery"*

S1 identified that the nursing staff and allied healthcare professionals' involvement into care of the frail patient goes beyond awareness. They also identified a gap between those involved in the provision of care and that multi-disciplinary teamwork could be beneficial to supporting frail surgical patients. This gap may be partly why the other surgeons did not discuss the allied healthcare professionals as part of the care for frail patients unprompted.

[S1] *"the team needs to be more cohesive – particularly for frail patients. For fit and well people that come through for surgery, or they'll have surgery, then the very nature is they're going to get better no matter what the team does. You know you just do a straightforward operation. Things are going to get* *better because people are otherwise healthy. But for a frail people, the team needs to be more joined up, more cohesive for them to have a better ride through surgery. And in a lot of places, that isn't the case. And that's where I think we have a big chance to make things better. But whether that becomes better with things improved, by focusing, using frailty as an example of how to improve team working, and how to improve the patients' opportunities, or whether you would just go about improving team-working anyway by different mode, I don't know which would be more likely to be successful."*

2.3.2.2 Theme: Surgical expectations

'Current identification and treatment of frailty' and 'expectations of recovery' were the subthemes identified within the theme of surgical expectations. The theme incorporates surgical perspectives locally, how the colorectal surgical staff at the study hospital identifies and supports frail patients, and the surgeons' expectations of how frail patients recover following colorectal surgery.

2.3.2.2.1 Subtheme: Current identification and treatment of frailty

Essence

"I think frailty is one of the key factors involved in [surgical] decision making. How are you going to manage this patient post-operatively: do I need HDU; do I need the care of elderly in ward? Can I optimise this patient?"

The scope of the current identification and treatment of frailty is what do colorectal surgeons expect when caring for frail surgical patients?

Surgeons are aware that frailty is prevalent in their surgical patients. [S4] *"on [an] acute day, you'd probably admit 2 or 3 frail patients a day"; "I think frailty is one of the key factors involved in [surgical] decision making"*, for example *"how are you going to manage this patient post-operatively: do I need HDU; do I need the care of elderly in ward? Can I optimise this patient*?" or if there are *"any other alternative minor options like a stent"*. This gives insight into how frailty is considered by surgeons. There are many aspects of care provision that surgeons need to consider when tailoring the surgical plan of a patient. S1, for example, said *"does it actually change the actual surgery? Sometimes it does because most of the surgery I do would be laparoscopic, which takes longer than open surgery. If we wanted a quick operation, I might do it open rather than laparoscopic"* indicating that operative procedures may be influenced by frailty.

Whilst surgeons are aware of frailty it was suggested that knowledge and identification could be improved: [S3] *"I would say surgeons in general, and certainly me, are poor at identifying a frail patient",* though S1-4 agree that it is the surgeon who is ultimately responsible for the identification and management of the frail surgical patient. The responsibility of actively supporting the frail surgical patient is [S5] "*a multi-disciplinary"* concern, where *"you need a physiotherapist, you need the nutritionist, etcetera".* All surgeons agree that a multi-disciplinary approach is the most beneficial way to support the frail surgical patient when they are in hospital. S2 and S4 identified that input from a geriatrician would be supportive for these patients, following their procedure.

There is a consensus that frailty is treated intuitively in the surgical department: [S1] *"We don't do it formally. There will be some people, and you'll know some people, who take a different approach and identify it as a thing in itself, and go and set about trying to improve things. Yeah. In the surgical world, those people are few and far between. In the medical world, they'll be slightly more common";* [S2] *"none of us go round talking about, 'Oh what frailty scores have you used? Or 'What have you used?' 'Oh yeah, this patient scored so and so on the Edmonton (or something)'. You just kind of do. You just look and you do".*

There is a lack of confidence amongst surgeons supporting the frail patient:

[S2] *"'Am I the right person to be treating frailty?' No, I don't think so. But I need to know who that would be. I do, however, feel that we can all make a difference. We can all make a start";*
[S3] *"I think nursing staff are a lot better than medical staff at it";*
[S4] *"It is difficult… when you're not trained to look at their issues".*

2.3.2.2.2 Subtheme: Expectations of the recovery of frail patients

<u>Essence</u>

"A frail patient I would expect to get better more slowly than a healthy, fit and healthy non-frail more elderly patient"

There were two main topics that were discussed by the surgeons interviewed; what the surgeons perceive the patient expectations are of their surgery, and the surgeon's expectations of the patients recovery following surgery. There was a general consensus that patients expect to return to baseline following surgery, which if they are frail, is unlikely.

The surgical perspective of patient expectations is that patients are likely to have greater expectations than what may be realistic.

[S1] *"People want the problem to go away, essentially and the problem, in any 65-year old, can be a million and one things, can't it? If they've got an ingrowing toe nail they want it gone away; if they've got cancer they want it gone away. Those are two extremes. And then they want it to go away with as few side-effects as possible"*

In some cases, patients may have an informed discussion and opt to not have surgery, out of fear of losing their independence. Patient expectations are considered part of surgical planning and taken into account, though surgeons frequently believe that an operation is not the best course of treatment for the patient, when the patient believes it is.

[S3] *"there was a patient came under my take who had radiology signs consistent with a dead stomach. But she was wheelchair bound; a-communicative, with bad respiratory system. She'd no physiological reserve that I discussed with one of the other consultants. We reviewed the scans and we thought that an operation would have a bad outcome. And we discussed with her family who, who wanted us to try and so reluctantly we took her to theatre and she died two weeks later"*

The frail older patient is (according to S3) more likely to accept this loss of independence though and with a focused discussion with the surgeon, can often come to terms with the options they are given regarding their care. Some patients may choose to undergo surgery when it may not be considered the best treatment option by the surgeon. It may be that the patient's family advocates for the patient to undergo surgery, hoping for a full recovery. This can either result in the patient being required to identify a second opinion to get a surgeon who is willing to operate, or risking adverse surgical outcomes. One surgeon, S3, discussed an example where a patient's family pushed for the patient to undergo surgery, even though the surgeons were reluctant to operate, ultimately resulting in the patient's death shortly afterwards. The surgeon was reluctant as the patient was likely to die either with or without the surgery.

Surgeons have a more realistic perspective of the recovery a frail patient may experience.

[S1] "as people are more frail I would expect them to take longer to recover. Again, as we've talked about before, it doesn't necessarily mean that frailty and aging follow the same linear path. But a frail, younger patient I would expect to get better more slowly than a healthy, fit and healthy non-frail more elderly patient"

Surgeons consider the patient journey to include both in-hospital and post discharge care. In hospital, care planning incorporates a decision as to where provides the appropriate level of care for the patients' needs, such as the high dependency unit or intensive care. The surgeons also consider who else may be required to support the patient whilst in hospital, though may leave this to the nursing staff and allied healthcare professionals to co-ordinate. These departments include dieticians, occupational health, nursing, pharmacists and physiotherapists.

Following discharge, surgeons identified that the involvement of other services is vital to supporting the frail surgical patient. GPs, district nursing, and social care are all considered part of the support structure post-operatively during the at-home recovery, however a barrier for receiving this support is the lack of funding in the social care sector and the lack of district nurses to support these patients – points that were raised by the surgeons interviewed. This may be considered one reason that accounts for one of the surgeons [S2] reporting that during their training. During their surgical training, S2 recognised the same patients in their rehabilitation rotations that they had discharged during their surgical rotations. They explained it may be that whilst in hospital the patient seems fit for discharge, it may be that they are healthy enough not to require hospital care, but sometimes may still need care before returning to their original place of residence. The support that family and friends provide is valued as part of the surgical decision making, with this information being gathered both in the initial surgical consult and at pre-assessment.

2.3.2.3 Theme: Treatment of frail patients

There were four subthemes identified within the theme of treatment of frail patients: pre-operative, in-hospital, following discharge and general advice for frail patients. For pre-operative treatment and support of frail patients, the scope of the subtheme was ‘What is done pre-operatively to identify, support and optimise the frail patient currently?’ For in-hospital treatment and support of frail surgical patients, the scope of the subtheme was “What do surgeons recommend in the hospital to identify and support the frail patient?” For support of frail surgical patients following discharge, the scope of the subtheme was “What do surgeons recommend following discharge to identify and support the frail patient?” The final subtheme concerned the advice given to frail patients by colorectal surgeons. The scope of this subtheme is “What advice would surgeons give to the frail patient?”

2.3.2.3.1 Subtheme: Pre-operative treatment

Essence

“A lot of it is on intuition and ultimately it comes down to what measures you have the usual blood tests, their weight, BMI, the ASA, comorbidity scores umm, maybe the results of CPX testing, maybe, not always (we don’t use it routinely)”

When patients attend surgical out-patients for an initial consultation with the surgeon, the surgeon may consider how best they can optimise the health of the patient prior to their procedure.

[S2] *“I would want to think of any possible way that I could reverse any of those factors, if there was anything at all. Umm, and if there was anything I could optimise”*

“So if there was a patient who had co-existing, you know co-morbidities, could I improve their chest; could I improve their heart; could they be seen by a specialist in their field, you know a cardiologist or a respiratory physician. Can I arrange some baseline investigations just for an objective assessment is what I clinically feel”

[S3] *“I do think in some patient’s pre-condition will a big effect. I think the frail patients who you are choosing to operate on electively, can benefit from pre-*

condition. That might encompass various aspects; not just nutrition and physical but psychologically, I think, being mentally prepared for a big operation, and a decent length of stay in hospital, is important. And coping with what happens afterwards. So, yeah. No, I think pre-conditioning is and for our patients would be important"

The surgeons discussed that preparation for surgery is dependent on the frailty of the patient pre-operatively:

[S4] *"it'll certainly help, planning, you know if they need more tests to assess their fitness or on the other hand, more tests to know if there's underlying disease that can be connected. But yeah, it would help. And also the support mechanisms post-op. because a 65 year old fit patient and an 90-85 year old frail patient are not the same in terms of preparing for an operation. There's a massive difference between the two"*

[S5] *"A lot of it is on intuition and ultimately it comes down to a mixture of intuition and using what measures you have. And so the measures you have are the usual blood tests umm, their weight, BMI, the ASA, comorbidity scores umm, maybe the results of CPX testing, maybe, not always (we don't use it routinely)"*

There is no consensus on methods to effectively optimise all frail patients pre-operatively: When preparing the frail patient for an operation the surgeon may offer the patient lifestyle advice and consult with other members of the healthcare team, such as anaesthetists and care of the elderly physicians:

[S1] *"I think we don't know what we would change particularly, other than the things we've already mentioned. How we might change things. We don't know r-e-a-l-ly how b-e-s-t those things need to be changed. But, yeah, I think identification is the first step, and then understanding what we might change so that the person stood essentially more chance of getting through their surgery"*

[S1] *"the advice again is sort of the same: is while you're waiting for your operation, make sure you go out every day for a walk, cause most of them won't be working, or if you are working, keep working and go out at weekends for a walk. Get some exercise and fit yourself up. And then make sure you eat sufficient firstly, and second, try and eat more healthily"*

[S2] *"So if there was a patient who had co-existing, you know co-morbidities, could I improve their chest; could I improve their heart; could they be seen by a specialist in their field, you know a cardiologist or a respiratory physician. Can I arrange some baseline investigations just for an objective assessment is what I clinically feel"*

[S2] *"I got her seen by the anaesthetist, sort of tried to optimise and prepare the patient a lot more, I think, and a lot more discussion with family perhaps. You know, more surgery carries risks but I would definitely explain how their added risk of morbidity and mortality; and certainly make sure there was a definite awareness of that, you know… prepare them for a high-dependency bed post-operatively."*

2.3.2.3.2 Subtheme: In-hospital treatment

<u>Essence</u>

"None of us go around talking about, 'Oh what frailty scores have you used? Or 'What have you used?' 'Oh yeah, this patient scored so and so on the Edmonton (or something)'. You just kind of do. You just look and you do?"

S2 discussed measures that can be taken to support frail patients whilst they are in hospital. These included them being "*first on the list in theatre*", being allocated "*in a bay, as opposed to a side room". "I would want this patient to be in an open ward where they were easily accessible to the nursing staff. So they had clear visibility of them the whole time; these people are prone to falls, you know episodes of delirium."*

There are additional members of the team that the second surgeon identified that could support the frail surgical patient in hospital:

[S2] *"you'd have the input of the physios with regard to their chests and their mobility as well. The dietetic input would be so important um, I mean I think the occupational therapists would come in once we're sort of assessing patients and suitability for discharge but that, that would be later for me. But, yeah, sort of medical input has sort of been part of it um, you know people like the pharmacists that need to be there to, to make sure that the drugs that we're giving them, we all there right drugs, you know patients come and they're given half a diabetic regime or, you know we omit a drug that we didn't realise or, you know other such things so it's err, I suppose we do that for all patients; but with the frail patients I think they need that more sort of hands-on delivery"*

These interventions, as S1 reports, *"are things that already exist in the hospital because we recognise that there's a need for those things. And they're just much more likely to require it if they are frail. All those things exist. I don't necessarily, personally, request them because they are things that are generally requested, so help with eating, help with mobility, help with hygiene, are generally requested by nursing staff. So I just give, leave it to them to request or to do".* Whilst the team approach for this provision of patient care has been identified as supportive, [S1] "*the sad thing is, particularly here, in* *this hospital (I can't speak for everywhere), the team is quite fragmented. And the team doesn't really get together very frequently. And that makes life difficult. But it should really be the team that identifies the problem and then goes about managing the problem"*.

These current methods of supporting patients in-hospital include a nursing-led scheme called the Enhanced Recovery After Surgery (ERAS) regime, which incorporates physiotherapy, pharmacy, occupational health and others. Unfortunately this program, as one surgeon has reported, may not be entirely appropriate to frail surgical patients:
[S3] "I don't think ERAS necessarily. I know it can be applied to, to different populations but I do think that there are populations that ERAS doesn't necessarily work for and I don't think a frail population is necessarily ERAS appropriate."

2.3.2.3.3 Subtheme: Following discharge

<u>Essence</u>

"You're already thinking of they're not just going to bounce back after the operation, and they'll need a prolonged period of support. They're going to need a degree of rehabilitation"

The surgical insult leads to impaired function in the postoperative period. Those who are frail are likely to take longer to recover. One surgeon reports having encountered post-operatively frail patients who have not fully recovered from surgery:

[S1] "*my particular interest with surgery is operating on people who've been operated on before… so they end up fairly weak, if not frail.*"

A patient can be discharged to one of a number of locations, including their family home, a nursing home, hospice care or a care-in-the-community bed. This is dependent on whether the patient requires an increased level of post-operative care. This is described as being discharged to a usual place of residence or being discharged to a different location. A surgeon's role, as described by S1, is limited when a patient is being discharged to the community:

[S1] *"So they have all sorts of different descriptors to what happens to people once they leave hospital. So most people go home to their own environment and they're helped out by friends and relatives. Some people need to go to a different environment; there's a lot of talk these days about care in the community (or CIC-beds). Some people need to go to nursing homes. Some people have to be institutionalised and stay for ages in hospital. All those different things and they bundle it all up, don't they? Call it a 'package of care', if someone needs extra things to go home with. So a lot of that is sorted out, is thought about, is arranged by people who aren't doctors. So my involvement in that is really quite peripheral, as an individual person, yeah"*

This discharge location is not always the ultimate destination for the patient. It could be that this is temporary until the patient's constitution changes or until the patient's recovery trajectory becomes clear:

[S2] "*When I was a very junior doctor, and saw all these patients that I'd cared for, who had been operated on by my consultants and then moving over to medicine and doing a stint in rehab, and seeing all those same patients that I'd thought had gone home and they really hadn't gone anywhere. So you had this sort of real satisfaction that these patients had had an operation whether it was an emergency or an elective and you'd thought they'd got better. Then you saw so many of them, and that was really hard for a while and then you sort of grow up and learn to be strong as a doctor and carry on. Umm, so, yeah, so I don't know that. I think all of these issues definitely need to be addressed*"

Surgeons recognize that frail patients will [S3] "*need a prolonged period of support. They're going to need a degree of rehabilitation. Because often they agree to have the operation and chances are they'll then go straight back to the environment they came from, and so you need to be thinking of other agencies you can involve*". This is a shared opinion across the surgeons, with S5 providing realistic insight into a patient's recovery at home:

[S5] "I don't know if it's so much about recommendations to them as making sure that there is a package of care available for them; because they're goanna need help. You're not just gonna send these people home to a house on their own, expect them to get up the next day, do their shopping, cook a meal. This isn't just gonna happen, you know. So if you're discharged from hospital you're gonna need input for several weeks afterwards, you know. So you're gonna need people to, to come in, do your washing, ironing, housework, do your shopping, and you would encourage people to do as much as they felt they physically could. So it's about encouraging them to do as much as they physically can without expecting them, without having unrealistic expectations about what they can do; and therefore making the environment unsafe for them"

Whilst [S5] discussed post-operative support not necessarily being about making recommendations, but rather the package of care being available to them, the other surgeons considered that advice may be supportive to recovering surgical patients, including those who were frail.

2.3.2.3.4 Subtheme: Advice for frail patients

<u>Essence</u>

"We'll advise them that they'll improve within the next four to six weeks. I'd expect a slow but steady improvement in terms of their appetite, their weight"

Advice for frail patients can be split to pre-operative and post-operative advice, though these are relatively similar in their content. The main differences are that pre-operatively, recommendations are typically related to stopping, or reducing, bad habits. Post-operatively, recommendations are typically related to improving, or developing, good habits.

Pre-operative advice was similar between surgeons, though this advice is not formalised. The advice pre-operatively asks patients to be engaged with behaviour changes that reduce their risks, such as reducing the amount they smoke, for example:

[S2] "*some of these factors are irreversible. I would consider surgery if we could do A, B and C. If we could do lose, if we had a target weight or if we stop smoking or, you know other factors that I could; and then I would put the onus on the patient really, you know if I, if I'm here trying to do the very best for them, then they're in this with me and they need to sort of participate fully as well"*

[S5] "*various lifestyle things, they can, you know stop smoking; they could undertake some exercise, make sure they're compliant with their medication. Make sure that their blood pressure is actually stabilised, it's under control; that their blood sugars are okay. So it's about optimising their current condition, whatever that might be really"*

The comment made by S2, implies that the onus is on the patient in order to optimise their own health recommendations. Whilst the surgeon may be able to provide advice on how patients can reduce their perioperative risks, a balance needs to be appreciated between what would be most beneficial and what changes are realistic for patients to make:

[S2] "*that would be really disheartening umm, so, you know asking someone to… I don't know, 20 stone person to lose half their body weight. It's just not a realistic goal but to think that if we've made some efforts and targets that are achievable and then the patient feels more motivated to be able to. Whereas if you set something that's so far beyond… so my lady with the Hartmann's, I didn't say to her you have to abstain from smoking completely. I said 'why* *don't we cut it down and see; why don't we just cut it down a bit further'. It's the same thing with alcohol. Let's just try and break it; and they're just more receptive, I think because you're not dictating. These are adults; these are people that have lived far more interesting lives than I have. So they don't need to be told by me what and what not to do perhaps. So it's doing it in a non-sort of patronising way, as well"*

Post-operative advice differs slightly in that, initially, patients are advised that they are likely to have a relatively typical recovery, should there be no complications:

[S3] *"We'll advise them that they'll improve within the next four to six weeks. I'd expect a slow but steady improvement in terms of their appetite, their weight and um . . . and their strength, mobility. Any deviation from that, I'd want them to seek advice from their GP or to contact us. I would advise them to stay mobile; stay active. Not to, not to spend prolonged period in bed and would also advise them that, about their wound healing. And that they shouldn't really do any heavy lifting (that requires two hands to lift) for four weeks*."

Patients are advised, in their post-operative recovery, to [S1] "*exercise regularly and that they exercise essentially to the limit of their tolerance that particular day. And as each day goes by I would anticipate that their tolerance will increase. So they should do that; once they've exercised they should then rest because they'll be tired, and then they should wake up and they should eat. And then they should go and exercise again*." However, whilst the surgeons in this study agreed that exercise is a key aspect of recovery, there was an understanding that this could be challenging for the patient:

[S3] "*well, I want them to be mobile. I mean there, I guess there's always the tendency after operations umm, especially if they're at home alone after an operation, to just stay in bed. They're so, they're tired, they're lethargic. Um, if you're by yourself I imagine that oomph to get out of bed and get on with your life is reduced but I'm basing that on nothing*"

2.3.2.4 Key points

Whilst interviewed independently, the surgeons had very similar views throughout. The key messages from these interviews are:

- There is no formal frailty identification method used by the surgeons. Frailty is both identified and treated using surgical experience and intuition.
- Preoperative lifestyle changes may reduce perioperative risk. The surgeons interviewed highlighted the potential benefits of smoking cessation and reduced alcohol consumption. There was an implication from the participants that patients would ideally be making efforts to support their own health, as well as receiving support from the healthcare systems.
- Patients receive a lot of information prior to surgery, in order to manage expectations and to empower patients to make an informed decision, though this sometimes can have limited effect.
- Surgeons suggested that pre-conditioning, or prehabilitation may offer benefit though the content of what this would involve or how it would be structured and delivered by was not explored.
- Patients post-operatively are encouraged to further support their recovery by having a balanced diet, with regular exercise and other positive lifestyle choices.
- Post-operatively, in hospital, support for patients that currently exists (such as ERAS) may not be wholly beneficial or appropriate for frail elderly patients
- Patients are more likely to want surgery when surgeons do not believe it is appropriate than the reverse.
- Surgeons are not likely to be actively involved with supporting patients with the consequences of being frail, whilst in hospital. This is delegated to the nursing staff to co-ordinate, though the surgeons are ultimately responsible.
- St. James' Hospital has done a trial with a Care of the Elderly physician involved in surgical recovery, which was beneficial, but this is no longer running.

- Frail patients may be more likely to need a high dependency unit bed in the immediate post-operative period, and a ward bed near the nurses' station (not in a side room) to help nurses monitor these patients, as well as allied healthcare staff support on the ward.

2.3.3: Pre-assessment clinic staff

One focus group was held in the pre-assessment, where participants involved were members of the pre-assessment clinic staff. No staff withdrew from the focus group. This included staff nurses, charge nurses and healthcare assistants. A thematic map was drawn (Figure 9) from the results of this work, and the key themes, subthemes, essences and scopes were explored (Table 5).

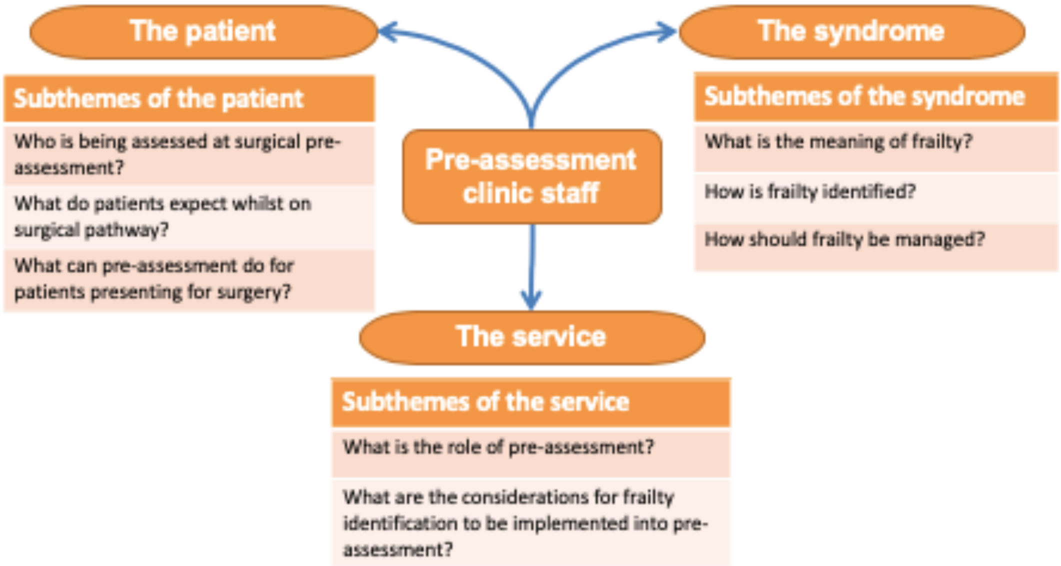


Figure 9: Thematic map of pre-assessment clinic staff focus group

Table 5: Thematic summary table of pre-assessment clinic focus group

Theme	Subtheme	Scope	Essence
The patient	Who is being assessed at surgical pre-assessment?	The variety of patients and their opinions during the surgical pathway	"Patients that wouldn't normally 10 or 15 years ago go for surgery are now going for surgery"
	What do patients expect whilst on the surgical pathway?	What are the expectations of the patient throughout their time on the surgical pathway, and what would pre-assessment expect for the patient?	"To go back to being independent after surgery; go back to their normal life as soon as they can; go back to their daily activities in life"
	What can pre-assessment do for patients presenting for surgery?	What support does the patient receive from pre-assessment?	"It's preparation for surgery through the discharge planning, or maybe should … there are some elements of discharge planning that we do already"
The syndrome	What is the meaning of frailty?	What is the meaning of frailty to pre-assessment staff and to patients themselves?	"Are they going to be isolated at home on their recovery? Have they got somebody that can go out and do their shopping or do some washing for them while they're recovering at home… that sort of thing"
	How is frailty identified?	Who should identify frailty and how should it be done?	"There isn't a specific tool that we use"
	How should frailty be managed?	What is pre-assessment's role in managing the frailty status of their patients?	"I don't think it's pre-assessment's role to do it"
The service	What is the role of pre-assessment?	The role pre-assessment plays in the surgical journey for patients and how the work is used throughout	"It's in a state of change at the moment; we're all changing a little bit at the moment, aren't we?"
	What are the considerations for frailty identification to be implemented into pre-assessment?	What barriers are there to implementation of frailty and what considerations need to be made before doing so?	"If we're going to be doing an assessment, we need to know how it's going to be used"

2.3.3.1 Theme: The patient

2.3.3.1.1 Subtheme: Who is being assessed at surgical pre-assessment?

Essence
"Patients that wouldn't normally 10 or 15 years ago go for surgery are now going for surgery"

Pre-assessment staff identified that they are now seeing *"more and more complex patients*". These patients are typically older with more co-morbidities and struggle with increased weight, a lack of appropriate diet and exercise. More elderly patients are now being seen in pre-assessment. *"Patients that wouldn't normally 10 or 15 years ago go for surgery are now going for surgery"* for example. The importance of functional status as well as age was noted. *"it's not just the elderly that are frail".* Patients may be *"in their 70s who's just retired from running marathons*" in comparison to a *"30-year-old that can't walk the length of the corridor".* Patients presenting for assessment vary considerably, from people who are living with dementia or have problems with their memory, to people who rely on carers or may be isolated at home, to patients who do not meet societal norms of hygiene standards yet are self-reporting functional independence - to use examples provided from the focus group. This may not always be the case, and some patients may be entirely well aside from their presenting surgical complaint.

2.3.3.1.2 Subtheme: What do patients expect whilst on the surgical pathway?

> Essence
>
> *"To go back to being independent after surgery; go back to their normal life as soon as they can; go back to their daily activities in life"*

Staff were not confident in reflecting the expectations patients may have about their time on the surgical pathway. One participant responded *"I don't think they expect anything"*, one responded "*to recover*" and another responded "*to go back to being independent, back to their daily activities in life"*. It was reported that there is little time in pre-assessment to explore patient expectations. It was also understood that there is limited time in surgical outpatients. *"It's a time factor. Consultants haven't the time to sit and explain every aspect"* and *"we haven't got the time to do that"* either,.

A recent POPs (Preoperative assessment and Optimisation of the older surgical Patient) trial of an anaesthetist and a geriatrician explored expectations should a patient have surgery, such as "*the percentage of muscle loss he could expect after his surgery, or [visiting the] intensive care unit*". The patient joined with a family member, and opted to not have surgery. "*Two or three patients changed their mind and there was no surgery involved"* as a result of the trial. The focus group discussed that there is a belief patients are told surgery is a treatment option, yet patients sometimes believe that they do not have a choice.

2.3.3.1.3 Subtheme: What can pre-assessment do for patients presenting for surgery?

Essence

"It's preparation for surgery through the discharge planning, or maybe should … there are some elements of discharge planning that we do already"

The first question from the participants at the beginning of the focus group was "*will it become clear about what sort of support you would give post-operatively?"* – indicating that the staff are very interested in learning what else can be done to support the frail elderly surgical population.

The documents completed in pre-assessment are used as [indicated by a participant in the focus group] "*an early trigger. The ward see the booklet, understand something needs to be done and will start the process on admission"* meaning that pre-assessment starts identifying additional care needs prior to admission. For example, the patient may need occupational therapy, social workers or additional support as part of their care. If the assessing nurse believes the patient is particularly vulnerable, they will complete a specific 'discharge form' for the patient – a form pre-assessment use to highlight areas of additional care a patient may require, to begin thinking about patient discharge before their admission. The staff also look at the patient's BMI, mental health, support structure, diet and mobility as well as their other co-morbidities: all of which will be used as triggers elsewhere in the hospital.

Nurses provide advice for patients in the build up to their surgery, with the aim to give both pre-operative and post-operative support. The advice given is not part of a formal protocol, and relies on the nurse's expertise in the area. One nurse, for example, recommends *"an iron-rich diet, proteins and light exercise if [the patients] feel up to it"* so that they can "*improve their physical ability after"* the surgery. An issue faced is that patients have a varying window of time between their pre-assessment appointment their operation. Some patients have *"two days before having the surgery*" meaning "*there's no time to act on the risks identified"* at pre-assessment, however the patient "*could be waiting six months before they get a date"* and some information from the assessment may no longer be accurate.

Another barrier to supporting the patient is their willingness to accept support post-operatively, or willingness to change behaviours before surgery. Patients may not want to have increased support and one pre-assessment nurse mentioned that if a patient is identified as frail, it may cause offence to the patient and make them less inclined to engage with an intervention, "*My gran's 93. If you try to call her frail she'd thump ya, you know*".

2.3.3.2 Theme: The service

2.3.3.2.1 Subtheme: What is the role of pre-assessment?

<u>Essence</u>

"It's in a state of change at the moment; we're all changing a little bit at the moment, aren't we?"

Pre-assessment staff see their function as highlighting surgical risks for healthcare teams to be aware of, with their assessment proforma serving as a source of triggers for care requirements. Assessment for anaesthesia is reported to be a key function of preassessment. The service also identifies patients who do not require an in-patient stay following their procedure. For more complex patients, pre-assessment staff may discuss patient care with other healthcare colleagues. This may include referrals to support services such as sleep medicine, discussion with the patient's general practice and with the pre-assessment anaesthetist or surgical colleagues. Some referrals that are not surgically or anaesthetically orientated can be infrequent due to the time constraints of the service, with a consensus of the service feeling "*rushed*". These referrals may also depend on the assessing nurse and their perception of the preassessment clinic's function. This focus group discussed that the clinic was in a state of change, and when asked about the function of the clinic, there were different responses from the healthcare staff. These changes may increase the workload and include additional referrals to new pathways, or the referrals may be to services previously rarely contacted by pre-assessment staff. The changes to the preassessment clinic may take further time for them to become common practice, in this setting.

There is an element of post-operative support planning at the stage of pre-assessment, however this is contradicted by one participant stating *"this is about fitness for the anaesthetic, not what happens when they go home. I think the system we've got at the moment with the discharge communication booklet, we've identified that patient is at risk. Let it go to people who are in charge of discharge".* When discussing how pre-assessment identifies those patients at risk, this rests on patients saying 'yes' to specific questions in the pre-assessment booklet. *“That’s where pre-assessment come in: if you say ‘yes’ we know what probing questions to ask. They’re not in the document”* but the nurses use their training and experience to investigate further. The service is reported to be “*in a state of change at the moment*” and that *“the questions don’t lend themselves to enough probing perhaps”.*

2.3.3.2.2 Subtheme: What are the considerations for frailty identification to be implemented into pre-assessment?

Essence

"If we're going to be doing an assessment, we need to know how it's going to be used"

The majority of participants agreed who has a duty of care to the patient has a responsibility to identify frailty. However, there are barriers to implementing frailty identification. With the nurses feeling "*rushed*" currently. Nursing preoperative assessment is currently timetabled to last forty minutes, and sometimes over-runs due to the complexity of the patients. Some staff believe that it is not "*something you can do in 2 or 3 minutes*" and that it would need to be "*a separate assessment*". It was suggested that a frailty assessment could be constructed from questions already included in the preassessment tool and that these could be combined to produce a score. Staff felt that the assessment should not be a bolted-on questionnaire, such as the accumulation deficit 36-point tool as this was considered cumbersome, involved duplication of pre-existing pre-assessment questions and would occlude a considerable percentage of time allotted per assessment. There was another assessment shown by the facilitators as part of this focus group that pre-assessment staff mentioned liking, called the Clinical Frailty Scale, which uses images as representations of the differing severities of frailty. This is because it would take little extra time to perform a simple observation i.e.an end of the bed test. There would also be a very short training period for its use "*'cause once you know what each one is, you'll be able to do that without thinking about it*". However, one participant had a strong belief that frailty identification as part of the pre-assessment process was not going to be beneficial:

"Interviewer (I): what benefits do you think would come with frailty identification occurring at pre-assessment?
Participant (P): none whatsoever
P; sorry, what did you say?
P: I mean extra work and a lot of guilt and moral responsibility to do something about it when we don't have time to bother."

Frailty identification may not identify all patients at risk of surgical complications, as some more robust patients will experience postoperative problems. However, a frailty assessment may identify patients who are unaware of the potential impact surgery may have on their fitness. The patient may require further assessments or consultations before making an informed decision as to whether to have surgery or not. To summarise, factoring frailty into preassessment has the potential to be beneficial to the patient.

2.3.3.3 Key points

This group offered varied views reflecting the complexities of pre-assessment. The key points were:

- An increasing number of complex patients are presenting for assessment for surgery, including a greater number of patients with frailty.
- The local pre-assessment is undergoing substantial changes at the moment, due to a high turnover in staffing, as well as growing infrastructure and Trust-wide changes such as trying to go paperless.
- Pre-assessment staff reported that many patients expect to fully recover post-operatively, returning back to baseline at home, regardless of how frail they may be.
- Pre-assessment staff reported that patients may believe surgery is their only option, when in fact it may be one of many available treatments.
- Staff in the surgical pre-assessment clinic were not aware of the formal definitions of frailty but did identify some of the generally accepted components that could make a person frail.
- If frailty assessment were to be undertaken in the preassessment clinic the information should have clinical application and lead to modifications in care.
- Frailty assessment in the preassessment clinic should either use pre-existing material from the current proforma and take very little time at all, or replace other content in the surgical assessment booklet.
- Most pre-assessment staff believe frailty should be identified as part of their surgical assessment, though this will potentially bring about a greater work load and emotional burden on the staff.
- Pre-assessment is not an appropriate setting for the active management of frailty but could be the point on the surgical pathway where frailty is identified and highlights recommended pathways for treatment.

- In this particular clinic, there is currently no formal guidance on what to advise for frail patients undergoing surgery. Some pre-assessment staff draw on their knowledge and experience to offer advice to patients on preoperative nutrition and exercise.

2.3.4: General practitioners

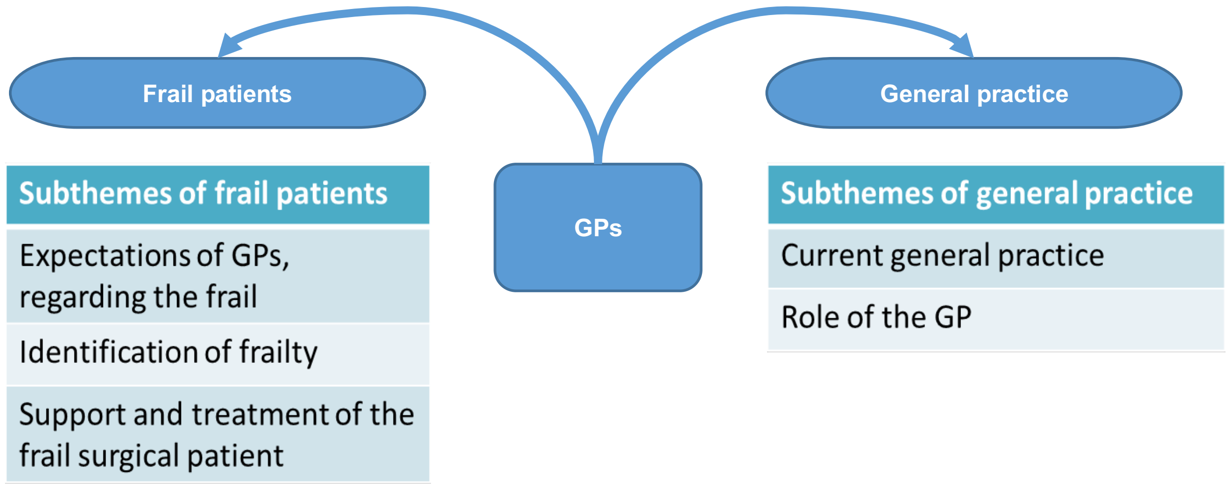


Figure 10: Thematic map of general practitioner interviews

Invitations were sent to sixty GPs and four GPs and four respondents participated in interviews. Fifty-seven GPs were sent letters for interview, though this method only recruited one participant. The remaining three GPs were recruited through personal contacts. The poor response rate to our initial invitations is likely due to the lack of time and lack of direct knowledge of the project, though there may be multiple reasons.

There were two main themes from the interviews with the four GPs (Figure 10), and the scope and essences were explored (Table 6). Frailty was a significant part of interviewees workload, though they commented that this may be due to the individual practices they were working in.

Table 6: Thematic summary table for general practitioners perceptions of frailty in a colorectal surgical patient

Theme	Subtheme	Scope	Essence
Frail patients	Expectations of GPs, regarding the frail	What are the assumptions and expectations GPs have relating to frail surgical patients?	“I think the frail patient is much greater at risk. Elderly patients always fear going into hospital, particularly if hospital acquired infection: chest infections; urine infections; wound infections and MRSA, this sort of thing. They’re always keen to come out as soon as they can, but they’re likely to be concerned about how they manage. A lot of frail patients will be living alone. They may have carers, so there maybe needs to liaise with the carers, make sure that they’re coming back once they’re discharged. They may be less able to do straightforward things: change a dressing; keeping a wound clean, whatever needs to be done”
	Identification of frailty	How do GPs perceive frailty in their patients, both formally and informally?	“One lady I see, she’s 103 now so until she was 102 she was living independently without carers, and while she had a few diagnoses she wasn’t frail. She’s had some setbacks recently. She’s now definitely frail so her mobility’s decreased. She’s lost weight. She’s become anxious. She’s calling us more frequently. She’s needed to get in carers to help with personal hygiene and to get her up and out of bed. So marked deterioration in health, largely age-related, I suppose. She’s gone from just being elderly and managing to being, being frail. She’s stopped being able to go out, and her friends used to take her out on trips and to go shopping. So now she’s not going out, so shopping is brought to her and friends come to the house”
	Support and treatment of the frail surgical patient	How can GPs, and healthcare staff in general, help meet the additional needs of a frail surgical patient?	“I: Would they benefit from further medical input? GP2: If it was accepted, yes. But if they’re not willing to accept it all you can do is just make them aware that you’re around and that you’re willing to help in any way that they would accept. The door is left open, if you like I: that must be quite difficult as well because you know or at least you have an idea of how things might turn out towards the future GP2: yes, but sometimes that’s the patient’s choice and I think you have to respect that”
General practice	Current general practice	How do GP practices and hospitals currently work with frail surgical patients?	“There’s generally two sides to general practices: dealing with the acute problems they present; and then there’s dealing with chronic disease. And most chronic disease comes under sort of computer generated regular routine surveillance, which is mostly done by nurses following templates”
	Role of the general practitioner	What role do GPs perceive themselves to have with the identification and support of the frail surgical patient?	“Sometimes I think as a GP, your role is acting as a coordinator. So, for example, our practice nurses often see patients with long-term medical conditions, and probably on a more regular basis than I do. I tend to see patients more for the acute problem that comes. Most of our work is done on monitoring patients, who are long-term frail, tends to be done by the practice nurses. We try and anticipate because we know our patients well; if we know something is kind of in the offing, if they’re going to be having some kind of surgical procedure, we try and make sure that we know what kind of support they’re likely to require when they come back out”

2.3.4.1 Theme: Frail patients

2.3.4.1.1 Subtheme: Expectations of the GPs regarding the frail

<u>Essence</u>

"I think the frail patient is much greater at risk. Elderly patients always fear going into hospital, particularly if hospital acquired infection: chest infections; urine infections; wound infections and MRSA, this sort of thing. They're always keen to come out as soon as they can, but they're likely to be concerned about how they manage. A lot of frail patients will be living alone. They may have carers, so there maybe needs to liaise with the carers, make sure that they're coming back once they're discharged. They may be less able to do straightforward things: change a dressing; keeping a wound clean, whatever needs to be done"

The general practitioners reflected that frail patients are often are *"much less active"* than those who are not frail. *GP1 said "Their surgical condition may be less of a hindrance than if they were living a full, active life".* It may be that those who are healthier and undergo surgery have less of a burdensome recovery than those who are frail. Patients who are frail are more likely to have reduced independence and a lack of activity as compared to a healthier person. It was recognised that patients would be debilitated by surgery. A GP commented *"patients won't necessarily come out in their pre-morbid state"* and went to say *"So you know if I had a cholecystitis and went in for a laparotomy, perhaps I wouldn't be as well as I came out as when I went in."*

When asked what GPs think patients expect during their time in hospital and recovery, one GP simply said *"I think it's mostly about getting out of hospital"*. Another GP discussed their experience of the difference between patient expectations and actual post-operative outcomes, following discharge:

GP2: "As soon as they get back home they think they're going to be able to do everything they were able to do before they went in. There is that 'Once I get home I'll be fine.' And often people get home and suddenly find they're not fine! They're not able to do what all the things that they thought they were going to be able to do and quite frustrated when they get home and suddenly *realise that they're exhausted. Even the smaller surgical procedure can leave you feeling as if you've been knocked down by a double-decker bus, for a few days. I think there is that it's trying to have that insight into 'You are going to feel unwell after you've had this procedure done. It's gonna take a bit of time for you to convalesce and to recover"*

Another GP agreed that patient expectations are typically to recover to their pre-operative baseline state:

GP3: "in terms of expectations before surgery because people go in and think they're gonna be cured from whatever and, and the expectations of how quick you can drive and how quick you can walk and what you're gonna feel like. And we do get quite a lot of patients generically across the board, frail, not frail, who come in and say, 'I had surgery kind of a month ago. Still feeling tired. Is that normal?' Umm, err . . . I think some of that's lost, because of the lack of follow-up, you know everyone decided that it wasn't important to have follow-up anymore. And it may not be physically but there is something about umm, treating people as humans and having the chance to ask further questions, and actually GPs aren't necessarily the best people to answer."

When discussing who should be responsible for managing expectations of the frail surgical patients GPs believed that this was the surgeon's responsibility:

GP2: "I think it's principally the role of the surgical team [to manage patient expectations] *because they're going to say what kind of procedure they're going to do, and to inform the patient I think part of the decision of whether you undertake surgery at all. It's going to be having some kind of insight into how the post-operative period is going to be. If, for example, I was having an appendectomy done then it would be quite nice how long am I going to be off work for, and how much I'm going to be able to do. Am I going to be able to drive? Am I going to be able to do normal things around the house? Are there things I can't do / shouldn't do? I think the same extends to any, any patient. So if you've got somebody who's frail, and I think I would look on it as being the role of the surgical team to say, 'Well look this is the procedure we're planning to do.' 'You have to be aware that afterwards you're going to have a recovery period then it's going to be this length of time before you can drive or you can, you can lift anything, or you can do various things around the house.' And it's, it's to give the patient that kind of insight I think that's part of almost asking consent for the operation".*

GPs perceive the role of patient expectation management lies with the surgeons who provide the surgical options for patients, during the surgical out-patient consultation. GPs feel that they are expected to know a considerable about the potential surgical treatments for any given condition that they may refer to surgeons, which is unfeasible.

2.3.4.1.2 Subtheme: Identification of frailty

<u>Essence</u>

"I've just brought up the records of one lady I see, she's 103 now so until she was 102 she was living independently without carers, and while she had a few diagnoses, she wasn't frail. She's had some setbacks recently. She's now definitely frail so her mobility's decreased. She's lost weight. She's become anxious. She's calling us more frequently. She's needed to get in carers to help with personal hygiene and to get her up and out of bed. So, a marked deterioration in health. Largely age-related, I suppose. She's gone from just being elderly and managing to being frail. She's stopped being able to go out, and her friends used to take her out on trips and to go shopping. So now she's not going out, so shopping is brought to her and friends come to the house"

GPs recognise frailty as a syndrome they see in their patients, both through formal measures and informal measures. The electronic frailty index has recently been incorporated into GP practices, where practices are now required to assess patients as frail, according to this model. All GPs interviewed discussed using the electronic frailty index and all discussed the tool with a degree of dislike:

GP1: "we use electronic measures to pick out patients with frailty and try and treat them accordingly.
I: is that the Electronic Frailty Index?
GP: yeah. We've just started to use that
I: how have you found it?
GP: ah [sighs] not really see much of it yet. Um, there's been a series of initiatives trying to identify the most vulnerable patient using computer prediction . . . with generally limited success."

GP2: "[Frailty is] something that we tend to assess. Sometimes using a computer tool we use the Frailty Index. We have a frailty register in the practice. Umm, but by and large we don't tend to use it all that much. It tends to be more a kind of individual gut feeling for how frail a patient is. It's quite common to patients who'd have a frailty index which indicates extremely frail and they pop up on your screen as they walk un-aided into the surgery and look absolutely fine. And then you have someone who will look a little bit more shall we say frail, and on the computer, on the screen, it will say that they, you know don't really fall into the frailty index. So I think it's a guide I think when *you're talking about somebody's frailty. It tends to be, for me anyway, more of a gut feeling with somebody"*

GP3: "at the moment our IT manager will go through and generate a list of people who have been identified and labelled as frail. In terms of people coming in and seeing me, I wouldn't. So I'm not going to code frail cause I've already got enough codes; and if I can make that subjective impression in 30 seconds then what added value, apart from when you're doing paper referrals and for data management data, big data research and all the rest of it then what added value is that to the person in front of me actually. Like how's that going to help them?"

GP4: "so NHS England have asked us to look at frailty patients with a frailty index but there's no real evidence out there to suggest that it's a better measure than experienced GP saying, identifying patients as frail…"

It is felt by the fourth GP especially, but also by the others, that frailty can be identified in other means such as intuition and functional assessments. Currently, the frailty identification measures the GPs have adopted have been delegated to the responsibility of others to screen, such as an IT manager. If the patient attends the surgery for an appointment the GPs will receive a pop-up notification on the electronic health care record that the patient is frail. Some practices have a system where if a patient is identified as frail, patients are reviewed by a GP, or a nurse practitioner, and have either a falls risk assessment or their medications checked.

2.3.4.1.3 Support and treatment of the frail patient

<u>Essence</u>

"I: Would they benefit from further medical input?
GP2: If it was accepted, yes. But if they're not willing to accept it all you can do is just make them aware that you're around and that you're willing to help in any way that they would accept. The door is left open, if you like
I: that must be quite difficult as well because you know or at least you have an idea of how things might turn out towards the future
GP2: yes, but sometimes that's the patient's choice and I think you have to respect that"

When discussing how frail surgical patients are best supported and treated, a number of possibilities were suggested by GPs. The most common response was that these patients need of an individualised-treatment plan. Possible advice includes increasing activity levels, by going "*for a short walk every day"* or nutritional advice: "*eating well and not being under-weight is clearly beneficial*". GPs also commented that the patient may not accept such advice or may lack the capacity to make lifestyle changes. When trying to delve deeper into how GPs manage frailty, through their choices of medications or other interventions, one replied *"they're not conscious decisions"*. They also went to say:

"Interviewer (I): have you reflected on the patients that don't actually, you know "that person did seem frail to me; what was I doing and how . . .
GP3: no [laughs] I'd be really interested. I think, that's a really, a really good question. I think, you know, maybe having [frailty identification] *in the contract will make people think more about frailty, you know. But as a concept, no. And I thought this person, have I reflected on this person as being really old or like not well . . . probably but in-in the mix of everything else. So it depends. The things that I ruminate about are the really complex patients that I worry if I've done the right thing. So some of those will be the older people, and they are the more complex decisions about not investigating and not treating and those are harder, ethically harder, discussions and questions"*

Some GP surgeries have a more resources than others. GP2 said that they *"have a team of nurses, physiotherapists, OTs who can visit that patient* *usually within the same day or at the most 24hrs and try and get some kind of care plan or care package in place for them"*. GP3 didn't believed that this was feasible for their practice. They joked: *"If it was some community physios and OT going and putting handrails in everywhere and some mental health workers to come and check, start working up people with dementia if they want that… and if we were talking properly to people about diet and they had a social worker and getting meals-on-wheels and . . . wouldn't that be great [laughs]"*

2.3.4.2 Theme: General practice

2.3.4.2.1 Subtheme: Current general practice

<u>Essence</u>

"There's generally two sides to general practices: dealing with the acute problems they present; and then there's dealing with chronic disease. And most chronic disease comes under sort of computer generated regular routine surveillance, which is mostly done by nurses following templates"

Current general practice is organised in a way that supports a large array of patient health conditions, both acute and chronic. A GP is required to review the patient's background, perform diagnostic assessments and produce a treatment plan, all within a ten-minute window. The detail within the treatment plan may "*depend how late I am, and sometimes not. And again, if I'm sending them for surgery it depends on how complex they are or what they are*". Most practices, as a result of the time pressures, make efforts to utilise templates to speed up processes. These templates and processes may not allow for bespoke communication of information about complex frail patients between primary and secondary care:

GP1: "I guess probably the area I'm most interested in is the dialogue between the hospital and primary care. Because I've got loads of information, they've probably got loads of information; some of it gets across, some of it is then passed on. So it's partly how we get the useful information out of our records into the hospital and vice versa. How we can transfer this information? The answer's got to be electronically, so we really need systems that'll talk to each other if we're not on the same system"

GPs also reflected that communication from secondary to primary care could be improved. Some GPs said that they would like more information about co-morbidities identified by the hospital, including frailty. In contrast, other GPs said either that this information may not be new to the GP or that sending such information could be seen as condescending.

One GP commented that clinical information is best transferred electronically. Currently, information is passed to GPs in the form of a discharge note. This may have too much information on for all healthcare professionals in the primary care setting, not specifically for GPs. This may restrict how much information being effectively passed on to the GPs. The person writing the discharge summary may not have experience writing these documents, and will not be able to foresee what information the GPs may find of relevance, and what GPs may find condescending:

GP3: "having written discharge summaries as junior doctors, I know it's incredibly hard to summarise sometimes complex things but equally then when you've got what you see as a straightforward thing the worry of giving just generic information, you know... Because we get discharge summaries that say, 'Had this op; on paracetamol and on codeine. No follow up.' And we'll get discharge summaries telling us everything and we've way-too-much stuff. And we'll get discharge summaries that say… but I don't exactly know what I want out of a discharge summary. So I don't know how a house officer who has never worked in general practice with no, how to write one for a GP and to write it for a GP audience knowing that the patient's going to read it".

These interviews suggest that the communication of information about frailty between primary and secondary care settings is not straightforward.

GP practices differ not only in their preferred communication channels between care settings, but also in what they can offer to frail patients whilst in the primary care setting. For patients being considered for surgery, GPs can serve as a filter of which patients are referred:

GP4: "well the guidance for cancer referrals have changed recently so it's more inclusive. It used to be you had to be over 65, with change of bowel habit or looser stools and blood and stool, or blood in the stool. Now the criteria of lax, being more lax I suppose some people, I think what happens generally is they get assessed in clinic and if they're not fit enough to have a colonoscopy they'll have a CT colonoscopy. [pauses / sighs] you get the odd patient who's got rectal bleeding and fit the criteria but I'm not going to say, you know 'What's the outcome here?' Probably less rare for us than other practices, we don't have a nursing home. so if you, if you see a 95 year old in a nursing home who's got PR bleeding you think they've got a rectal cancer you're not going to refer them; you're going treat them pallia-you gonna treat them systematically. So that dilemma . . . discussion, happens a lot less for us given the fact our patients are generally able to live at home, whether that's supported or not. It's rare I have the discussion, 'Look, are we investigating this or not. What's in your best interests?' and have that discussion. Normally *we refer them and then that's a discussion for the surgeon and the anaesthetist whether they're fit to undergo further investigation"*

When a GP refers a patient to the surgeon, this initiates a process to put the patient through assessments that support the referral (such as a colonoscopy) as well as asking the surgeon to have the initial consultation with the patient. GP3 especially believed that sometimes, there are a host of assumptions made as part of this referral process, including that the patient wants surgery, will be fit for surgery, that the surgeon will manage patient expectations regarding surgery and that the surgeon may think the GP is recommending surgery rather than asking for a surgical opinion:

GP3: "we might be sending someone to a surgeon for a second opinion to say, 'Is this actually what we think it is? But we're not really expecting you to do anything.' Is the surgeon-is the patient assuming because we're sending them to a surgeon that they're gonna have something done. And is the surgeon assuming, because we're sending this patient, they want something done, and, and so on. And that's a poorly discussed, medically assumed, eternality, chain of events that probably does start in general practice; and how far it continues, I don't know"

GP3: "there are probably again subconscious decisions or semi-conscious decisions that I'm making about how to pass someone forward. But equally then, I have an expectation that when they go forward to see a surgeon, the surgeon's gonna have a similar discussion again and that... I'm not... I don't always have confidence that that happens again"

These assumptions are also shared by GP4, when they said:

"It's rare I have the discussion, 'Look, are we investigating this or not. What's in your best interests?' and have that discussion. Normally we refer them and then that's a discussion for the surgeon and the anaesthetist whether they're fit to undergo further investigation"

2.3.4.2.2 Subtheme: Role of the general practitioner

<u>Essence</u>

"Sometimes I think as a GP, your role is acting as a coordinator. So, for example, our practice nurses often see patients with long-term medical conditions, and probably on a more regular basis than I do. I tend to see patients more for the acute problem that comes. Most of our work is done on monitoring patients, who are long-term frail, tends to be done by the practice nurses. We try and anticipate because we know our patients well; if we know something is kind of in the offing, if they're going to be having some kind of surgical procedure, we try and make sure that we know what kind of support they're likely to require when they come back out"

A GP is often the first port-of-call for patients with new symptoms. If the patient requires referral for a surgical opinion, the GP may feel expected to provide insights into what procedures may be involved in the patient's care*: "I can't know specifics about how people should feel after every single surgery, and remember them, even the common ones"*. When discussing the role of the GP for surgical patients in relation to frailty identification and treatment, the essence of this subtheme is that GPs are co-ordinators. However, this clarity is not entirely shared:

GP3: "I don't entirely know what the GP role is in it. I doubt it would be a big part of our role like it doesn't-I'm not just saying that just to be awkward. We don't see enough surgery. . . like they're not our bread and butter . . . so to do something different it would be changing a lot for a small part of our job"

Even though the frailty identification and support of treatment has been predominantly delegated from the GPs to others in their practice, such as the nurse practitioners and their IT leads, GPs still expect themselves to be a part of this process. GP4 mentioned*: "I hope GPs still try and look at prevention of sickness. Unfortunately, when you're fire-fighting; you're busy and you don't have as much time. But I think certainly, I'd like to think, that people try and identify frail people and optimise them. Umm . . . before we, before surgery* *and you refer them, things like that".* The same GP also provided insight into their expectations and experiences with post-operative frail patients:

"Certainly in all the practices I've worked in, letters come in, the get scanned onto the patient record and then put for a GP to review. So every day I do 50 or 60 letters I've got to look at and just decide what we have to do. If a discharge letter comes in and the medications there, I'll check that it lines up with their medication we've got on the system. If there's medication changes you have to call pharmacy, especially on the dosset box, make sure they're not dishing out the rampiril that caused their AKI or make sure they've got enough pain relief if they come out after surgery. The quality of discharge letters now they're electronic is so much better. I know, I know people whinge about issues with them and for some unknown reason they send them electronically and then they post them still, which is just madness. I think, I think they're moving to, I think mid-Yorkshire are moving to just electronic thankfully because it winds me up"

Some patients receive specific medical reviews or home visits from their GPs post-operatively. Some GPs may consider providing post-discharge support for all patients a major challenge:

GP3: "hopefully that patients not gonna come back and see me because I've dealt with that issue and referred them on. So I haven't told them to come back and see me. So you know there was no point . . . and also so I will have referred them to a surgeon to confirm whatever it is, and I won't tell them what surgery they're gonna have cause I won't know (because that decision hasn't been made). So they may not come back to see me before their surgery, and that's my, I guess that's what usually happens with frail and not frail. And again, when they're discharged, we don't see everyone. We don't go and see them, we don't have time to go and see everyone that's discharged. So what is the expectation for me after surgery? Like, if people are doing well and they're not calling me out for help then I'm not going to go and see them. But that doesn't mean that they might be really struggling and having told when to seek help and . . . am, am I doing all that . . . ideal-world extra stuff about talking about what they're eating and moving and who, whose job is it well is it to do that?"

2.3.4.3 Key points

These interviews with GPs, to understand their experiences and perceptions of frailty in surgical patients, provided a number of insights:

- There is a perceived to be a high prevalence of frailty in general practice,
- The role of the GP in managing frail surgical patients varies across practices, with multiple members of the practice team involved with both the long-term and the pre- and post-operative care of these patients,
- GPs believe that both non-frail and frail surgical patients expect that they will recover to their pre-operative baseline following surgery, and that patients regardless of frailty status will simply want to be discharged from hospital back to their pre-operative place of residence,
- GPs believe that it is their role to refer patients for a surgical opinion and it is surgeons who are responsible for managing patient expectations regarding the surgical procedures,
- The electronic frailty index is currently in use, being implemented into the GP electronic health records in April 2017. GPs agree that they do not like this tool, that this is one of many they could potentially use to identify frailty and they have found it has limited use and clinical value
- GPs are too pressed for time to do additional assessments and delegate work around supporting frail patients to others in the practice,
- GPs disagreed with each other regarding the information they would like to receive from hospitals. One discussed wanting information that may already be known to them as it may be reassuring or useful in the future, whereas others consider this repetition of information may be condescending,
- GPs reflected that if a patient is referred for a surgical opinion, this may be taken to imply that want or expect an operation. This may limit discuss of other management options.

2.3.5: Conclusions and Limitations

This chapter sought out the perceptions and experiences of surgical patients, surgeons, pre-operative surgical assessment staff and general practitioners regarding frailty in a surgical patient. Each population was asked questions through a semi-structured topic guide, designed for that population to address population-specific research questions.

A general limitation of this work is that there is no certainty that data saturation was achieved. Data saturation is the point where no further or limited new information can be collected from additional investigations in the same or other participants in the population being researched. Data saturation allows for the results of the interpretation to be considered 'the whole picture'. This study adopted a pragmatic approach due to the time limitations of what could be considered as realistic to complete as part of a comprehensive PhD body of work. A decision was made to collect data across several groups. This allowed exploration of the differences between perceptions within each group, but limited the number of individuals in studied in each group. This study does report perceptions and experiences that warrant further study. The understanding of the purpose of surgical pre-assessment varies between staff, similar to the detailed understanding of frailty identification by clinical staff. It would be useful to further explore the different perceptions of care between frail and non-frail individuals. Frail patients seemed to consider nursing staff to be too busy to provide the care they require, whilst non-frail individuals report nursing staff to spend too much time (including time where the nurse was not meant to be working) with those patients.

2.3.5.1 Patients

There were challenges with the recruitment of male patients into the study. Patients were invited to focus groups if they were involved in the FAST study (described in Chapter 5:) and gave consent to be approached for focus groups.. Unfortunately, we were unable to recruit males, both frail and non-frail, into focus groups. One piece of feedback we received was: "I don't want to sit around talking about my problems with a group of other people". A possible solution to this would be to offer individual patient interviews to both men and women. It was not possible to undertake this additional study with the time and funding constraints of the current work. What this work does display is the perceptions of female surgical patients and allows a fair comparison between both frail and non-frail groups. Patients were not told if they were classified as frail or non-frail as the intention was to make as unbiased comparison as possible of the experience of surgery between frail and non-frail patients. This work shows that patients who are frail tend to feel less supported by nursing staff in hospital, and believe they will go back to being a robust, independent person post-operatively, similar to those who are non-frail pre-operatively. Understanding how to manage frail patient expectations better could to support nursing staff in meeting the needs of a frail person whilst they are in-hospital, and help surgeons provide information pre-operatively in a way to ensure the frail patients expectations are managed. This may also benefit the patient from being fully informed pre-operatively to make the decision as to whether surgical intervention is a treatment option they wish to pursue.

Two facilitators were involved in the patient focus group work, being the author of this thesis and a second researcher. Whilst there could have been a difference in approach between the two facilitators the second facilitator had training on focus groups, was fully briefed and was familiar in conducting semi-structured focus groups. They were not told if the patients in a group were frail or non-frail, to ensure that this information was not passed on to the participants. The transcription and analyses were performed in a consistent manner across both facilitators.

2.3.5.2 Surgeons

The surgeons invited to interview were from the St. James' Hospital, Leeds Teaching Hospitals Trust, colorectal department. This research was co-supervised by Mr Dermot Burke - one of the colleagues of the consultants involved in this research. As noted in the methods, transcription was performed by a transcriber out-with the Trust and analyses were performed solely by the primary investigator of the research. This was explained to the surgeon participants in the hope that they would be forthcoming with their experiences and perceptions on the subject.

2.3.5.3 General practitioners

Recruitment of GPs proved to be difficult with an initial call to all local GPs getting only one response. A word-of-mouth approach using personal contacts was more successful but does raise the question of whether the interview sample was drawn from GPs who were already aware of this work from conversations with the research team. A further study with a sample recruited through the Clinical Research Network Specialty Group and the Royal College of General Practitioners may be of value.

2.3.5.4 Pre-assessment clinic staff

The pre-assessment staff include administrative staff, healthcare assistants, staff nurses, and charge nurses. For the purposes of this research, we did not include the administration staff in the focus group. Even so, the focus group was large in comparison with the other groups. This could have had the potential to inhibit some participants if they were either shy or did not want to express their opinions in front of others. This was addressed at the outset of the focus group by explaining that those involved in the research will not be identifiable following the analysis of the results and that all opinions are welcome throughout the focus group. A comment was made by the primary facilitator, which was vocally supported by a secondary facilitator present, about people should feel able to have contrary views with each other as perceptions and experiences differ between individuals. There were contradictory statements made within the focus group, and the discussion was very fluid and inclusive, with the facilitators ensuring that those who were quiet were asked specifically if they would like to include their opinions to ensure a fair representation of views from the staff. It may be that there are differences in perceptions between healthcare assistants and nursing staff, which would not be easy to identify with this focus group due to the different roles within the group. The aim of the research was to scope the current perceptions and experiences of the pre-assessment clinic staff as a group, though future work may wish to consider if there are differences between clinical and support staff, as well as between different experience levels of the staff, such as between charge nurses and staff nurses.

2.3.5.5 Analyses

As noted in the methods, the focus group transcriptions for pre-assessment staff were independently analysed by the author and a second researcher. There were no incidences where the two involved in the analysis differed, and very few occasions where codes could have been applied to other themes within the analysis. The same key points from the focus groups were the same by both of the researchers. This provides validation for the results of this work. Because of resource limitations the results of the other three populations were only interpreted by one researcher, without validation or comparison to another's interpretation of the same transcription.

An experienced qualitative researcher collaborated on the study and assisted in the design of the study and formation of the semi-structured topic guides. On the advice of this collaborator a thematic approach was used for data analysis to provide an overview of perceptions and experiences within the different populations. For a more in-depth approach to the work, it would be recommended to use either interpretative phenomenological analysis approach or a phenomenological approach to analysing the results of the work. This work would also benefit from having additional researchers analysing the same transcripts, meeting regularly to discuss the results and the key points.

This work does not provide literature with a saturated viewpoint from each of the four populations explored. Some populations have come closer to a point of saturation than others. One example of near saturation is that surgeons all consider frailty to be of clinical importance but delegate this to the nursing staff to co-ordinate. An example of where further exploration would support the push towards saturation is with the surgical pre-assessment nursing staff, where there was a small difference of opinion with regards to the benefit of the addition of frailty identification into routine practice.

2.4: Conclusion

One strikingly clear observation from all four groups is that, regardless of the presence of frailty, patients want to return home to live their lives as they did prior to having any symptoms. These expectations are managed to some extent by surgeons, though GPs and pre-assessment clinic staff were not sure this happens routinely.

Surgeons try to provide all patients with sufficient information prior to surgery to ensure all patients can make an informed decision but though some frail patients believed that did they do not receive enough information. Non-frail patients believe the information they receive is adequate prior to surgery. Non-frail patients report that nursing staff are incredibly supportive and make time to deliver great patient care. This feeling is not shared by the frail surgical patients, who believe that the nursing staff are incredibly busy and sometimes are not able to provide the amount of support that they would ideally like.

Both frail and non-frail patients commented that they were aware that their health post-operatively may be improved if they engaged with pre-operative interventions. The data supports the notion that patients who are frail would be less likely to engage in pre-operative interventions for frailty than those who are non-frail. Surgeons, GPs and pre-assessment staff commented that there are nutritional and physical interventions that can be offered to patients, but did not provide details on these and said that, at the time of the study, there was no formalised advice for patients. Surgeons were unclear on how preoperative interventions would be best structured and who would be ideally responsible for running these interventions.

Frail patients are more likely to be more sedentary than those who are non-frail. The surgeons and pre-assessment clinic staff try to provide advice on increasing activity levels but some patients find that there are barriers to doing so. A few members of pre-assessment clinic's staff believe that by identifying someone as frail, the label may do the patient a disservice and aggravate the patient. This could lead to them becoming less engaged with pre and postoperative interventions. The hazards of labelling patients were supported by GPs, who shared experiences where doing so had caused some undue unrest and anxiety in their patients.

The surgeons participating in the study reported that frailty impacts on surgical decision making patient recovery and on the degree of care and support their patients may require. When it comes for care provision for frail patients, surgeons defer to their other professional groups to identify additional care and either provide this or refer to services for the patient to receive this. The surgeons do not currently use frailty identification tools, and instead rely on intuition and experience in order to tailor surgical planning to their patient needs. This intuitive treatment of frailty is also done by the GPs. Colorectal surgeons do regularly encounter frailty in their patient population. When discussing expectations with patients, there are times where a patient believes a procedure would be beneficial when a surgeon disagrees, but this rarely occurs in the reverse. This is perhaps due to patients believing that they will survive a procedure and fully recover, whereas surgical experience may be more realistic and the surgical approach more cautious. Surgeons agree that a robust frailty identification tool would be useful as part of pre-operative work up, and that this would help inform surgical planning. This, they suggested, could be done by the pre-assessment clinic following the surgical out-patients' clinic, when surgery has been suggested as a viable treatment option.

Pre-assessment clinic staff were the population who expressed the most disagreement. Due to the local clinic being in a '*state of change*' at the time of this study, there is no consensus on what key function the pre-operative assessment clinic performs. Staff agree that healthcare professionals working with patients should identify frailty but there was debate over where the responsibility for this lies. Some participants suggested that it is the role of the general practitioner, though the majority considered pre-assessment to be a key place for surgical patients to be identified as frail. In order for the clinic to incorporate frailty identification tools into the current proforma, a rapid assessment involving an end-of-bed test, or utilising questions that are already asked as part of pre-assessment would be preferred. This would avoid undue increases in workload. In contrast to patients, pre-assessment staff already feel too rushed for their current workload. One other barrier to incorporating frailty identification into their workload is that pre-assessment staff would need to know that the inclusion of any additional test would provide additional support to patient care, and that the results of the test would serve a function. When discussing who would treat patients who are frail in order to optimise the surgical patient pre-operatively, pre-assessment staff said they were too busy to make additional referrals and have a history of receiving poor outcomes when doing so, such as general practitioners *'washing their hands of the patient'* or district nurses '*being too busy'* to support the patient. They believed that post-operative ward staff would be best placed to support the frail patient, though this would not serve the pre-operative optimisation efforts which they identified could be of value.

General practitioners are currently identifying frailty, using the electronic frailty index, which has been implemented as a result of a contractual change. This has been met with frustration, and often GPs will either not use this information themselves and rely on intuition or combine it with their own preferred methods of assessing patient physical performance. A concern many GPs have is labelling patients as 'frail' and needlessly upsetting patients who do not understand what is meant by this. Different GPs reported having different levels of support available for patients. There was agreement across the GPs that district nursing staff are likely the best placed to be able to proactively support these patients, especially if the GP surgery does not cover a large nursing-home population and their elderly are independent in the community. GPs themselves are limited in their role to be able to proactively support the frail patients pre-operatively and are limited with having to predict the support their patients may require post-operatively.

All populations involved in this body of work understood the concept of frailty, though the formal definitions of frailty were not discussed. Participants were unfamiliar with frailty assessments other than the ones they had encountered in their setting already, such as the electronic frailty index in general practice. There is agreement across healthcare professionals that frailty identification would be useful for both their insight into the patient and for the patients' safety but no group identified themselves to be the ones best placed to provide additional support for these patients – this is likely incorporates, to some degree, a feeling of a lack of resource in order to provide this support. Work with district nurses, nursing home carers and ward staff may provide more insight into how these professionals perceive their role in supporting frail patients.

GPs identified frailty communication between primary and secondary care is variable. Pre-assessment was discussed to be the best place for the identification frailty by surgeons and pre-assessment staff alike for surgical patients in secondary care settings.

This chapter highlights that frailty is recognised as condition by healthcare staff and brings with it additional healthcare needs. Preassessment was identified as the ideal part of the surgical pathway for frailty identification to occur. However, this would bring an additional workload to an already busy service and staff would wish to know how systematic screening for frailty would improve care. Surgeons identified that prehabilitation may suit frail patients better than the current ERAS system, which may not meet the needs of frail individuals.

2.5: Investigations arising from these findings

This chapter investigated the perceptions around frailty by four different groups involved in the colorectal surgical pathway. Surgeons identified that frailty is a problem, and they may consider modifying clinical practice to support these individuals further whilst they are under their care. However, surgeons and pre-assessment staff both discuss not routinely identifying frailty using a formal method, and that should a person be identified as frail pre-operatively, it should take place in the surgical pre-assessment clinic. Frailty identification should have clinical value and will require sensitivity, so as not to offend patients who are frail and are averse to being identified as such. Patients who are frail have similar expectations to non-frail individuals, in terms of their recovery, but literature mentions that recovery for those who are frail may potentially be more protracted. It is only through the identification of frailty in surgical patients pre-operatively that patient expectations can be managed and a fully informed decision to undergo surgery can be made.

There are numerous perceptions outlined in this work regarding frailty and no clear consensus on how to identify frailty in surgical patients. Objective and reproducable measures for the identification of frailty is required in order to investigate the impact of frailty further. The following chapters look at the different measures to identify frailty, the prevalence of frailty, and the relationship between frailty and surgical outcomes.

Chapter 3: Frailty Screening and Identification

The work in this chapter compares three widely used frailty assessments and explores the prevalence of frailty within a colorectal surgical population.

3.1: Introduction

Frailty can be described as the loss of physiological reserves and functional ability due to the ageing process. Frailty invokes a significant health burden on older adults (Clegg *et al*. 2013), and represents a substantial public health challenge in many, if not all, developed economies. The UK has an ageing population; the proportion of the population aged over 65 years, currently 17.7%, is expected to rise to 19.9% by 2024. The number of people in the UK aged over 90 years has increased by 25% between 2005 and 2015 (Office for National Statistics 2017).

Elective colorectal surgery is usually performed for either malignancy or degenerative disease, with many patients aged between 70 and 85 years. The colorectal surgical population has a significant prevalence of frailty. One study identified 43% of colorectal cancer patients as frail (Ommundsen, Torgeir B Wyller, *et al*. 2014). Colorectal surgery is associated with significant risks (Horzic *et al*. 2007) and these are greater in the elderly (Morris *et al*. 2011). Identifying frailty pre-operatively may help clinicians to help tailor care in the peri-operative period.

It is increasingly recognised that frailty is relevant to surgical treatment decisions (Partridge *et al*. 2012; Tan *et al*. 2012; Reisinger *et al*. 2015). Surgical pre-assessment is generally conducted within a time-constrained pathway, where nursing staff have a predetermined 40-minute window with the patient to assess many aspects of a patient's health and lifestyle, in preparation for surgery. Frailty is generally not formally assessed. Therefore, were a frailty assessment to be included within pre-assessment, the

requirements would be that it is clinically useful information and does not add unduly to the workload of preassessment.
The identification of frailty in surgical patients, however, remains a contentious issue. A number of clinical scoring systems for the identification of frailty are available (Fried *et al*. 2001). The best scoring system for identifying patients at risk of complications, and indeed the extent of agreement between these scores in surgical patients is unclear.

Two of the most widely accepted frameworks to identify frailty are the accumulation deficit (AD) and the frailty phenotype (FP) models. The AD model is based around the concept that frailty is brought about by previous health conditions, cumulatively depleting physiological reserves; the more comorbidities a patient has, the more frail they are considered to be (Song *et al*. 2010). The FP model gives an assessment of frailty based on assessments in five domains: weight loss, mood, activities of daily living, functional gait speed and grip strength. It is based on the construct that frailty is the reduction in functional ability due to mood, muscle wasting and general health (Fried *et al*. 2001). Both the AD and FP have been validated in several settings (Ravindrarajah *et al*. 2013; Chang & Lin 2015; Rockwood *et al*. 2006; Eeles *et al*. 2012; Bouillon, Sabia, *et al*. 2013; Bouillon, Kivimaki, *et al*. 2013).
Informally so, people are often considered frail from a simple visual assessment in an end-of-bed review. The Clinical Frailty Scale (CFS) is an assessment based on a physician’s perception of a patient’s physical capabilities (Rockwood 2009). This assessment requires no training, is based on brief “thumbnail” descriptors of each of nine categories of frailty and does not provide any details about the way frailty presents. It has been validated as an end of bed test for a rapid perspective of the patient’s presenting frailty status (Gregorevic *et al*. 2016; Rockwood & Song 2005; Basic & Shanley 2014).

The primary aim of the study described in this chapter was to assess the agreement between the CFS, AD and FP measures of frailty in the colorectal surgical population. A further aim of this study was to determine which of the three frailty assessments is the most accurate at identifying post-operative complications (as classified by Clavien Dindo classification), length of stay beyond expected and 30-day readmission.

This study was a feasibility study to identify the challenges of collecting data on frailty in the preassessment clinic and to garner initial data on the extent of agreement between the three assessments in a surgical population.

3.2: Methodology

This study received ethical approval from the West Midlands United Kingdom Ethics Committee (15/WM/0148). Adult elective colorectal surgical patients were screened in and recruited from St. James' Surgical Pre-assessment clinic, Leeds Teaching Hospital Trust. Patients were initially screened for eligibility by the researchers, approached by the pre-assessment nursing staff, and consented into the research study by researchers. Patients recruited were both cancer and non-cancer patients.

The inclusion criteria for the study were: 18 years or older, fluent in English or had an NHS translator present at the time of their pre-assessment visit. Patients taking anti-Parkinsonian medication or taking anti-depressants were excluded. The side-effects from these medications can be mistaken as aspects of frailty-related conditions, such as fatigue, confounding results (Clegg *et al*. 2013).

Following informed consent, the patients underwent frailty assessment using the three tools in the order - CFS, AD then FP. Patients were classified as robust, pre-frail or frail using each of the tools. Full details of the CFS, AD and FP tools can be found in Appendix 4, and cut-offs for the methods in Table 7.

Table 7: Outline of the assessment score ranges and associated cut-offs for the three frailty assessments used. CFS: Clinical Frailty Scale, AD: Accumulation Deficit, FP: Frailty Phenotype.

Method	Score range	Healthy	Pre-frail	Frail
CFS	0-9	≤3	>3, <6	≥ 6
AD	0-100%	≤8%	>8%, <25%	≥25%
FP	0-5	0	1-2	≥3

Each frailty assessment was timed. As the CFS is a rapid assessment which relies on the global impression of the patient, it was performed first in order to prevent it being biased by information obtained in the other two assessments. The CFS timed with five-second increments. A second assessor supported the data collection of patients, who underwent training. This training involved observations of assessments being performed, reading supporting literature behind the assessments, as well as comparing the results of how both assessors identified frailty in the same patients. Surgical, ward and anaesthetic staff were blinded to the results of the frailty assessments, avoiding any impact onto routine care.

In addition to the frailty assessments routinely-collected preoperative clinical data were collected. This includes ASA grade, self-reported cognitive impairment and indicators of falls risk (previous history of falls, fear of falling, and walking with an ambulatory aid). Length of stay was derived from BUPA recommended guidelines for surgery, adjusted by the surgeons where appropriate.

Pre-operative data were collected from the pre-assessment proforma. Post-operative data were collected from electronic and paper clinical care records. This included post-operative complications, readmission to hospital within 30-days of being discharged, difference in length of stay between what was predicted by surgeons and what was observed, and mortality. Post-operative complications were classified according to the Clavien Dindo score (Clavien *et al*. 2009); a score of one is any deviation from normal post-operative recovery without pharmacological or surgical intervention. Two is when pharmacological treatment, blood transfusion, and total parenteral nutrition is required. Three is requiring any surgical intervention or intervention that requires local, regional or general anaesthesia. Four is increased care level to intensive care, whilst five is death.
The difference in length of stay between observed and expected was calculated to allow comparisons to be drawn between the length of stays of patients who underwent different surgical procedures.

The initial recruitment target for this study was 100 patients over one year, which was deemed appropriate. In the absence of data on which to base a power calculation, it was felt likely to generate sufficient data to allow initial comparisons between the three different frailty scores and their association with surgical outcomes and to inform the design of a larger study. However, following concern about the rate of collection of outcome data, with surgery being deferred or declined in a number of patients and discussions with the Ethics Committee chair, it was agreed the study should increase the target recruitment to the study to 200 patients.

3.2.1: Statistical approach

Analyses for this study were performed using SPSS (SPSS Inc. 2016). The primary researcher for the study performed the analyses, and details of the analysis are given in the appendix 7.

The differences between each of the frailty assessments were analysed by the chi squared statistic. Correlation between the three frailty assessments was examined using Spearman's correlation. The Kappa statistic was employed to determine the agreement between frailty measures. The differences in time taken to perform the AD and FP methods were analysed using a paired t-test. It is possible that the assessment of frailty takes longer in more frail patients. We therefore examined the correlation between the time taken to complete the FP and AD scores and the frailty scores themselves using Pearson's correlation coefficient. The differences between frailty scores by sex was analysed using a Mann Whitney-U test.

Contingency tables were used to investigate the relationship preoperative falls have with preoperative frailty. Additional contingency tables were used to investigate the relationship of self-reported cognition, as collected routinely by pre-assessment nursing staff, has with frailty.

Considering the results retrospectively, fewer patients were diagnosed as frail by the CFS and FP methods. We therefore grouped pre-frail and frail, for analysis of surgical outcomes. Analyses of contingency tables for grouped frailty and surgical outcomes were used to examine the ability of the frailty assessments to positively and negatively predict surgical outcomes. Risk ratios and likelihood ratios were used to identify whether knowledge of the frailty score would change the surgical expectations of the patient's post-operative recovery.

3.3: Results

3.3.1: Patient characteristics

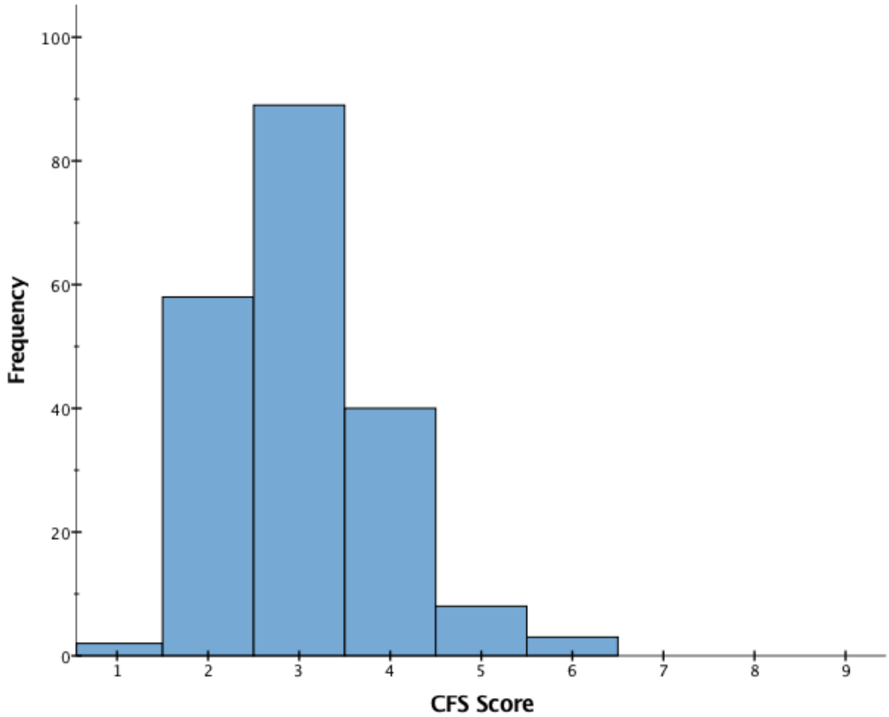
200 patients (92 males) were recruited from the surgical pre-assessment clinic. No patients withdrew from the study. The mean (range) age of the recruited population was 57 (18-92) years. Thirty-nine percent of patients were aged 65 years of age or older.

3.3.2: Prevalence of frailty

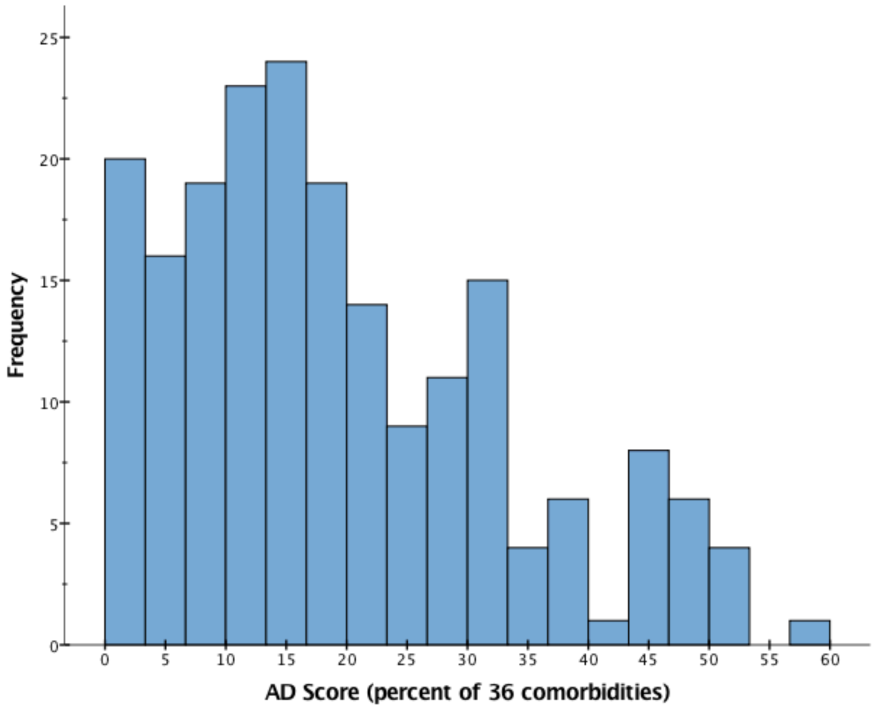
Identification of frailty as measured by the CFS, AD and FP tools is shown in Graphs 6, 7 and 8 respectively. Table 8 presents the results of the three frailty assessments, with prevalence by gender. The prevalence of frailty varied, depending on the assessment used, from 1.5% to 32%. There was a significant difference across the three frailty assessments, (CFS-AD chi squared 35.7, CFS-FP chi squared 60.0, AD-FP chi squared 50.9, all significance levels $p<0.001$, degrees of freedom: 2). There was no significant difference in the distribution of frailty between males and females for any of the frailty assessments (Mann-Whitney U test; CFS U=4749.5, p=0.530; AD U=4482.5, p=0.196; FP U4479.5, p=0.183).

Table 8: Prevalence of frailty within an elective colorectal surgical population, as defined by the clinical frailty scale (CFS), accumulation deficit (AD) and frailty phenotype (FP) methodologies

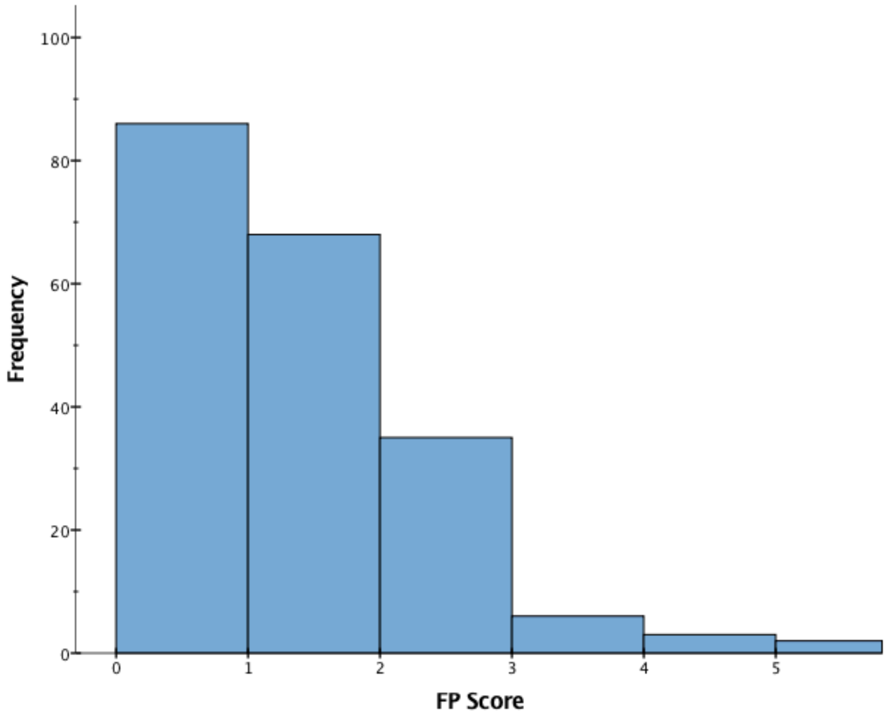
Assessment method		Non-frail	Pre-frail	Frail
CFS		64 (32.0%)	133 (66.5%)	3 (1.5%)
AD		31 (15.5%)	105 (52.5%)	64 (32.0%)
FP		86 (43.0%)	103 (51.5%)	11 (5.5%)
CFS	Male	31 (15.5%)	59 (29.5%)	1 (0.5%)
	Female	33 (16.5%)	74 (37.0%)	2 (1.0%)
AD	Male	16 (8.0%)	50 (25.0%)	25 (12.5%)
	Female	15 (7.5%)	55 (27.5%)	39 (19.5%)
FP	Male	43 (21.5%)	45 (22.5%)	3 (1.5%)
	Female	43 (21.5%)	58 (29.0%)	8 (4.0%)



Graph 6: Histogram of the clinical frailty scale (CFS), with frequency of patients identified as a score between 1 and 9. Patients were robust with scores of 1-3, pre-frail with scores of 4-5, and frail with scores of 6+.



Graph 7: Histogram of the accumulation deficit (AD), with frequency of patients identified as a percentage score between 0 and 100. Patients were robust with a score of below 8%, pre-frail with scores of 8.1-24.9%, and frail with scores of 25%+.



Graph 8: Histogram of the frailty phenotype (FP), with frequency of patients identified as a score between 0 and 5. Patients were robust with scores of 0, pre-frail with scores of 1-2, and frail with scores of 3+.

3.3.3: Agreement between frailty results

Pairwise Spearman’s correlation and pairwise Kappa (*K)* statistics were performed to investigate the correlation and agreement between the three frailty assessments (Table 9). There were moderate correlations across the three different measures, ranging from 0.244 to 0.452. There was, however, little agreement across the measures. Agreement ranged from *K*=0.078 to 0.163.

		Spearman’s Correlation x 10^3 Significance x 10^3		
Cohen’s Kappa Agreement x 10^3 Significance x 10^3		CFS	AD	FP
	CFS		R = 408 P < 001	R = 244 P < 001
	AD	K = 078 P = 064		R = 452 P < 001
	FP	K = 172 P = 005	K = 163 P < 001	

Table 9: Relationship grid between the the clinical frailty scale (CFS), accumulation deficit (AD) and frailty phenotype (FP). K: Cohen's Kappa, R: Spearman’s correlation, P: significance. Key underneath (McHugh, 2012).

Spearman’s Correlation x10^3	Kappa agreement x10^3
Non-significant	Non-significant
000 – 200 None	000 – 200 None
201 – 400 Fair	201 – 400 Fair
401 – 600 Moderate	401 – 600 Moderate
601 – 800 Substantial	601 – 800 Substantial
801 – 1000 Almost perfect	801 – 1000 Almost perfect

Out of the three frailty assessments, the mean (SD) time to perform the CFS was the shortest 7.23 (3.0) sec. The mean (SD) times for the AD and FP tools were 224.08 (108.3) sec and 340.33 (82.5) sec respectively. Using paired t-tests, the AD was statistically significantly quicker than the FP ($p<0.001$), and the CFS quicker than the AD ($p<0.001$). Correlations were investigated between the time taken to perform the frailty assessment, and the classification the frailty assessment identified the patient as. The CFS and FP had weak correlations (Table 9), whereas the AD had a moderate correlation ($R=0.279$, $p<0.001$; $R=0.154$, $p<0.001$; $R=0.549$, $p<0.001$ respectively).

3.3.4: Frailty and the relation with outcomes

Eighty percent (160) of the patients underwent surgery during the study period, out of the 200 recruited. Two patients were medically unfit for surgery, one had surgery delayed due to ill health, one patient died prior to surgery and the remaining 36 patients had not had their surgery by the time the study was completed. Out of those who underwent colorectal surgery: 71 had examination under anaesthesia, 23 had hernia repairs, 10 patients had sacral nerve stimulation surgery, 18 had colon resections, 28 had rectal resections and 10 patients had laparotomies.

Eighteen (11.3%) patients had a post-operative complication and 10 (6.3%) were readmitted within 30-days. Of the 18 patients with post-operative complications, six had Clavien Dindo scores of 1, six a score of 2 and six patients a score of 3 (Table 10). The difference between actual and expected length of stay ranged from -2 to 21 days, with a mean of 1.55 (SD 3.2) days and a median of zero days.

Table 10: Incidence of surgical outcomes, being Clavien Dindo, post-operative complications and causes of 30-day readmission, measured within the study

Outcome measure		
Clavien Dindo Grade		(3.75%) (3.75%) (3.75%) (0%)
Post-operative complications	Anastomotic leak	(0.63%)
	Bleeding	(1.25%)
	Constipation	(0.63%)
	Fever	(0.63%)
	Fistula formation	(0.63%)
	Hypotension	(1.25%)
	Infection	(0.63%)
	Pain - requiring management	(1.25%)
	Pneumonia (hospital-acquired)	(1.25%)
	Small bowel obstruction	(0.63%)
	Stoma dysfunction	(0.63%)
	Wound drainage required	(1.25%)
	Other	(0.63%)
Readmission causes	Abdominal herniation	(0.63%)
	Acute kidney injury	(0.63%)
	Anastomotic leak	(0.63%)
	Bleeding	(0.63%)
	Bowel obstruction	(1.25%)
	Clinical review for other services	(1.88%)
	Further surgery required/ reoperation	(1.88%)
	Stone formation (pancreatic)	(0.63%)
	Vomiting	(0.63%)
	Wound infection	(0.63%)

Post-operative outcomes do not equal 18, as patients often presented with more than one complication during their recovery.

The sensitivity, specificity, positive predictive value and negative predictive values of the three frailty scores for each of the following outcomes are reported: change in the length of stay beyond expected, post-operative complication and 30-day readmission (Table 11). It will be seen that the sensitivity of all three frailty tools was high for all outcomes. However, many patients classified as frail within the grouped analysis did not suffer adverse outcomes, resulting in a high false-positive rate and low specificity for all three instruments. For the surgical outcomes studied (extended length of stay, post-operative complications and 30-day hospital re-admission), positive predictive values ranged from 15.97 to 49.57, and negative predictive values ranged from 68.89 to 94.44. For post-operative complications, the sensitivity of the assessments ranged from 90.00 to 97.10, whereas the specificity ranged from 11.82 to 17.58 depending on the frailty assessment tool used.

To examine the predictive value of the three frailty assessments, likelihood ratios are reported. The likelihood ratios for post-operative complications were 1.02, 1.09, and 1.17; for 30-day readmission were 1.03, 1.03 and 1.12; and for extended length of stay were 1.22, 1.14 and 1.23 (CFS, AD, and FP respectively). As the likelihood ratios are close to unity, classifying an individual as frail or pre-frail using any of the three tools studied does not materially change the expectations of an adverse outcome for an individual. Despite the association between frail and pre-frail groups and the adverse outcomes, many frail and pre-frail patients did not suffer a complication.

Table 11: Analyses of frailty, as defined by Clinical Frailty Scale (CFS), Accumulation Deficit model (AD) and Frailty Phenotype (FP) and their ability to pre-operatively identify patients at risk of post-operative complications, 30-day readmission and an extended length of stay. PPV; positive predictive value, NPV; negative predictive value. In this table, the 'frail' and 'pre-frail' states are collapsed into frail.

Post-operative complications					
Method	Risk ratio (Confidence Interval)	PPV	NPV	Sensitivity	Specificity
CFS	1.18 (0.50-2.80)	31.69	72.22	90.00	11.82
AD	3.15 (0.31-32.23)	16.90	94.44	96.00	12.59
FP	6.07 (1.50-24.51)	47.18	88.89	97.10	17.58
Re-admission within 30 days					
Method	Risk ratio (Confidence Interval)	PPV	NPV	Sensitivity	Specificity
CFS	1.36 (0.51-3.65)	31.94	75.00	92.00	10.91
AD	1.30 (0.32-5.24)	15.97	87.50	92.00	10.37
FP	3.37 (1.09-10.41)	46.53	81.25	95.71	14.44
Extended Length of Stay					
Method	Risk ratio (Confidence Interval)	PPV	NPV	Sensitivity	Specificity
CFS	1.82 (1.16-2.84)	35.65	80.00	82.00	32.73
AD	1.48 (0.32-5.24)	17.39	88.89	80.00	29.63
FP	1.77 (1.09-10.41)	49.57	68.89	80.28	34.83

3.4: Discussion

3.4.1: Prevalence of frailty

It is increasingly considered that frailty has an impact on surgical outcomes and there are numerous tools available to identify frailty (Clegg *et al.,* 2013; British Geriatrics Society, 2014). Our study shows that the estimated prevalence of frailty in elective colorectal surgical patients differs depending on the tool used. It is likely that the value of 1.5% of patients measured by the CFS as frail is an under-estimate, based upon the limitations of a visual and perhaps subjective assessment. There is need of a robust, agreed case definition for use in both clinical practice and research.

All three tools used in this study identified a substantial burden of pre-frailty, ranging from 51.5% to 66.5%. This finding is important in a surgical population. A high-level definition of frailty is 'a reduction in the ability to return to baseline following a stressor event' (Clegg *et al.,* 2013), and each illness or adverse event suffered by an individual is a stressor that reduces their state of health and wellbeing (Song *et al.,* 2010). Surgery and anaesthesia are stressors that may move an individual further along the path to dependency. Our data suggest that 51.5%-66.5% of elective colorectal surgical patients are pre-frail, and up to 32% are frail patients who have an increased risk of further deterioration. Our study identified a high prevalence of pre-frailty in a young population. The study was not of a sufficient size to determine if pre-frail younger patients were as prone to complications in comparison to their older peers.

The pre-operative identification of frailty support clinical staff discuss surgical options and risks with the patient, as part of the surgical consent process. This information may also direct the use of pre-operative interventions for frailty to optimise a frail patient before surgery (Gill *et al*. 2003; Carli *et al*. 2010; Hubbard & Story 2014). The lack of concordance between tools are a cause for concern and suggests that none of the instruments studied here is ideal for the surgical setting. Directing 32% of patients through a pre-operative optimisation pathway, based upon a method that has a high false-positive rate, would overwhelm resources, be costly and, for the most part, be ineffective.

We did not identify an effect of sex. A systematic review found that females are almost twice as likely to be frail as males. A recent report concluded similarly, reporting 8.5% of females and 4.1% of males are frail as defined by the FP model (The British Geriatrics Society 2014; Baylis *et al*. 2013). In our study, there were more frail females (2-42%) than frail males (1-27%), but this did not achieve statistical significance. This may be as a result of a lack of power, though the Baylis study (referenced by the British Geriatrics Society for their values) also had an older population in comparison to those in this study (Baylis *et al*. 2013).

Whilst correlations between frailty assessments ranged from mild to moderate (R=0.279-0.463), there was very poor agreement (K=0.078-0.163) and a statistically significant difference between all assessments. This may reflect the use of different constructs in the design of the three different tools. The FP is an assessment of function (grip strength and walk speed) with brief questions on leisure activity, depression and exhaustion. The AD assumes the increased history of co-morbidities indicates increased frailty severity. The CFS is based on the observer's perception of functional ability to perform activities of daily living. All are used in non-surgical settings and it is of note that they are not consistent in their assessment in a surgical population.

A limitation of this study is the fixed order of frailty assessments. This could potentially induce bias with the scoring of a later assessments being influenced by the earlier one. A possible solution would have been to randomise the order of the assessments. However, we weighed this against the risk that the CFS, which is based on an overall impression of the patient, could have been biased by the scores from the other two tools and there used the CFS tool first in all cases.

3.4.2: Frailty assessments in clinical practice

Pre-operative assessment is now a standard component of the patient pathway practice in most, if not all, surgical units in the UK. The current practice of frailty identification in surgical pre-assessment is varied.

The time taken for an assessment to be performed will impact on its implementation into current practice. The CFS was quick to perform but was poor in its association with outcomes. The AD was quicker than the FP, though had the poorest association with outcomes out of all three assessments. The FP was a consistent tool in its time to complete, and has the best associations with outcomes, out of the three tools investigated. The FP is also more in-line with current literature for community-dwelling older adults, to which this elective surgical population may be similar. The measures in the FP assessment can give key clinical information leading up to surgery. The FP would require a greater change to implement into the surgical pathway, which would incur additional costs. Pre-assessment units may struggle to accommodate frailty identification through this method without restructuring.

Recent work in Yorkshire has led to the development and testing of an electronic frailty index (eFI) which uses a score derived from routine data in the primary care electronic health record. This tool has been supported by the Improvement Academy as a tool for screening for frailty in general practice. The eFI was designed from the 36-point AD assessment for frailty, which utilises comorbidity codes from the GP database SystmOne, and derives a frailty score based on the proportion of comorbidities a patient has within a pre-determined subset. The adoption of the eFI took place after the start of this study, meaning the majority of patients presenting for surgery would be unlikely to have an eFI score available for analysis. It cannot be assumed that the eFI will be of value in predicting surgical outcomes as it is derived from the AD model of frailty, which we found to be of limited value in this regard. A further potential issue with the eFI is that it does not currently permit deficits to be removed and may over-identify frailty in those where treatment has improved their health.

This study extended recruitment from 100 patients to 200 patients. The cause of the extension was due to the number of patients who were recruited at pre-assessment who then did not go to have surgery within the study time. The majority of these patients had their surgical procedure cancelled due to the NHS pressures faced over the winter months and were rescheduled.

3.4.3: Relationship between frailty and colorectal surgical outcomes

Whilst we identified some statistically significant risk ratios supporting an association between frailty and outcome, the likelihood ratios are close to unity suggesting that the three frailty tools used in a surgical setting may be of limited value for the prediction of post-operative outcomes in this population. Current frailty tools may require modification for use in the surgical setting, if to be used for adverse outcome prediction.

An important finding of this study is that three widely accepted frailty identification tools are associated with, but in our study not predictive of, adverse surgical outcomes. Associations between frailty and peri-operative outcomes have been demonstrated in various surgical settings (Basic *et al.,* 2014; Hubbard *et al*., 2014; Oakland *et al.,* 2016). Whilst association is reported, the predictive value of frailty for adverse surgical complications is less clear. Current literature on frailty identification commonly reports the predictive value of frailty has on adverse surgical outcomes (Robinson *et al.,* 2011), however we have shown that frailty has only an association with these measures.

The tools studied here score patients along a continuum. We used cut-off points for the classification of patients as pre-frail and frail that have been developed for use in elderly care. It may be that adjusting these cut-off points, or choosing a single cut-off allowing a binary classification, would improve the predictive value of these tools for identifying high risk surgical patients. The FP indicated a greater risk of patients suffering post-operative complications, for two of the three surgical outcomes. This study suggests the FP construct has most promise for use in the surgical population.

A binary classification of patients into frail and non-frail groups may be useful for planning patient care. It may be that using the frailty measures could be refined for use in the surgical setting by redefining cut-offs based on their predictive validity for surgical outcomes. This may support the direction of patients to additional interventions or indeed a “frail surgical pathway”.

Frailty has been shown to have an association with an increased risk of falls. Frailty is also considered, in many definitions, to include a degree of ‘cognitive frailty’, or aspects of cognitive impairment. Currently, St James’ Pre-assessment clinic staff identify patients for pre-operative falls risk and cognitive impairment through self-reported measures and use this to determine further assessments or interventions to best support patients. A potential development of this work would be to include a measure of cognitive impairment and to investigate whether frailty has an association with pre-operative cognitive impairment and with pre-operative falls risks and whether frailty data adds value to that already available on cognitive impairment and falls risk.

3.4.4: Limitations

The work regarding the initial identification of frailty was performed by two assessors. There is little work published in the way of the inter-rater reliability of frailty assessments. The second assessor received training on how to identify frailty as part of this study, in 10 patients prior to his recruitment. This training involved observations of assessments being performed, reading supporting literature behind the assessments, as well as comparing the results with the lead researcher on a number of patients. There were no inter-rater agreement calculations performed between the two assessors, which would have provided insight into how aligned the assessors were following the training period. The assessors did, however, meet frequently to discuss any concerns with patients and to discuss particulars of individual patients to ensure the right data was being captured.

The tools studied in this work identified very few patients as frail, but a significant proportion of the surgical population as pre-frail. We grouped ‘pre-frail’ and ‘frail’ into one group to investigate the association between frailty and surgical outcomes. This data reduction is a potential limitation of the study.

The three tools had a degree of association, but a poor predictive relationship with surgical outcomes in this study. This work includes what could be considered a small number of participants to draw specifics between identification of frailty and their predictive ability, and was not powered to accurately identify the relationship between frailty and outcomes. This study does not propose the implementation of pre-operative frailty identification into clinical care for the prediction of post-operative adverse outcomes – which is a limitation of this work. However, this study does provide useful pilot data for future studies in this field and highlights the length of time taken for a formalised frailty assessment. This time is unlikely to be routinely available in the busy clinical environment.

3.5: Conclusion

We studied three different frailty tools: the clinical frailty scale, accumulation deficit and frailty phenotype. These three frailty assessments cannot be used interchangeably and are different constructs. The assessments each identified a high prevalence of pre-frailty in the elective colorectal surgical population, but a notably low prevalence of frailty. All three assessments have poor specificities, and limited predictive value for adverse surgical outcomes, though we demonstrated there is an association between frailty scores and adverse surgical outcomes. Of the three assessments, the frailty phenotype is the most strongly associated with post-operative complications. The frailty phenotype may be the most clinically useful method of identifying frailty out of the three included in this study, however there are still challenges with regards to its implementation.

There is a growing body of literature showing an association between frailty and surgical outcomes, providing an argument that frailty should be included into surgical assessment. However, clear evidence is required that as well as being associated with adverse outcome, frailty has predictive value.

Loss of muscle bulk, known as sarcopenia, is often used as a marker of frailty. The next two chapters investigate the relationship between sarcopenia, frailty and adverse surgical outcome in colorectal surgery patients.

3.6: Investigations arising from these findings

I have identified that frailty is prevalent in our colorectal surgical population, at St. James' Hospital, Leeds. This is supported by the perceptions of the pre-assessment nurses, who highlight that more people are presenting for surgery who are frail, than there used to be. With an increasing number of physiologically-depleted individuals at risk of adverse postoperative recovery, it could prove important to be able to successfully identify those at risk. The three frailty measures assessed in Chapter 3 do not show agreement with each other, and suggest that they are not suitable for pre-assessment clinic in their current format.

Frailty, as described by Clegg (*et al.* 2013), is accompanied with changes in skeletal muscle, and maintenance of skeletal muscle involves an intricate balance between protein loss, dietary intake, muscular cell production and inflammatory markers. Following surgery, having disease or being elderly are all factors where there may be an off-set of the intricate balance between maintenance of skeletal muscle mass and loss of muscle. This may tilt homeostasis towards muscle degradation processes, furthering loss of physical performance as a result of increased fatiguability and loss of strength and muscle bulk. Domains of several frailty assessments overlap with sarcopenia. Muscle strength and gait speed are in both the European Working Group of Sarcopenia in Older Persons assessment of sarcopenia, and in Fried's frailty phenotype assessment. It may be that sarcopenia identification provides the clinical value surgeons hope frailty identification would provide, and fit within the pre-assessment nursing staff's time limit. Sarcopenia has been reported to be measurable on radiological imaging alone. This could be measured by staff trained to read radiological images and would not require the patient to be present.

There is need for more objective measures to assess for risk as a result of ageing processes. Chapter 4 investigates the prevalence of sarcopenia as identified by radiological imaging alone, as well as the validity and repeatability of these objective measures.

Chapter 4: Sarcopenia Screening and Identification

The work described in this chapter compares two methods of identifying sarcopenia from computed tomography images and the association of sarcopenia with post-operative outcomes. This work also includes inter- and intra-rater validation studies.

Sarcopenia is the reduction of skeletal muscle due to the biological ageing process (Dodds *et al*. 2015), as previously discussed in section 1.5. Sarcopenia may be quantified by measurements of muscle strength, performance and muscle mass (Studenski *et al*. 2014; Cruz-Jentoft *et al*. 2010). A number of reports suggest that sarcopenia can be measured by muscle mass alone (Baracos 2010; Zhuang *et al*. 2016; Cruz-Jentoft *et al*. 2014; Jones *et al*. 2015).

There are several techniques to quantify muscle mass, using computed tomography (CT). These techniques all stem from measurements of muscle areas on CT slices. There are multiple versions of this assessment, using different vertebral levels, different cut-offs and different muscle groups (Shen *et al*. 2017). Muscle mass is often measured by calculating the total cross-sectional area of all abdominal muscles (Figure 11) (Shachar *et al*. 2016). Sex-specific cut-offs are applied to total cross-sectional area measurements, in order to identify sarcopenia.

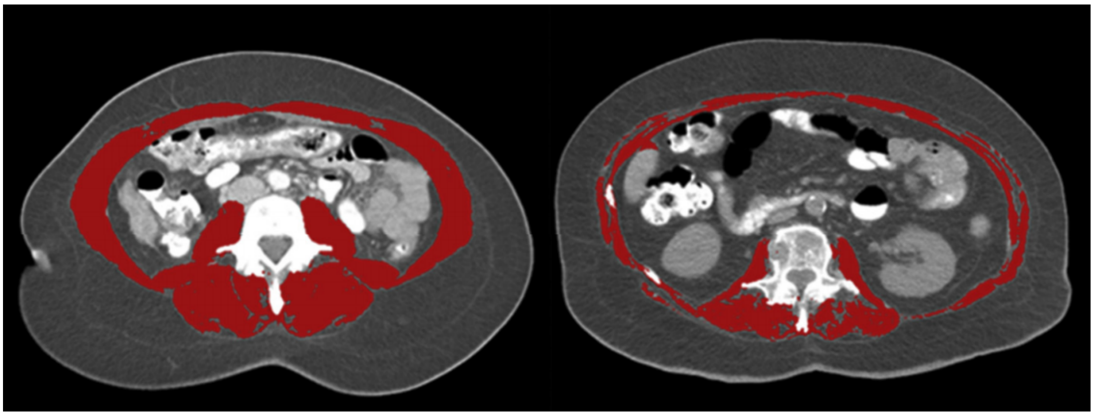


Figure 11: Comparison of a typical (left) and sarcopenic (right) patient, with muscles highlighted in red. Scans were of females, who had metastatic disease, with the same body mass index (Shachar *et al*. 2016)

CT-derived assessments of sarcopenia offers benefits over the functional performance test on patients that is included in the aforementioned European Working Group of Sarcopenia in Older People (EWGSOP) criteria (described earlier, in section 1.5). The use of CT scans alone is arguably quicker than the measures that use functional ability; cross-sectional area assessments on CTs do not require the patient to be present, unlike physical tests. There is minimal risk of events such as falls during assessment with CT scan derived sarcopenia, as opposed to assessing gait speed. Functional tests are relatively expensive due to the staff time and the space required. CT-derived sarcopenia assessments in surgical populations have been widely applied (M J Englesbe *et al*. 2010; Fukuda *et al*. 2016; Zhuang *et al*. 2016).

Whilst assessments are used in literature using similar methods, variance in methodologies is present. Muscle cross-sectional area measurement is predominantly reported at the third lumbar level of the abdomen (Shen *et al*. 2017). Whilst this appears to give a fixed anatomical landmark, there is variance in what structures are present at the third vertebral level. Variation can also arise from the part of the vertebrae the measurement is taken from; the third lumbar vertebrae has a mean vertebral body height of between 28.7mm (Standard Deviation (SD) 2.2) and 29.9mm (SD 2.3) for females and

30.6mm (SD 1.8) to 30.7mm (SD 2.1) in males (Zhou *et al*. 2000). There is limited information available in the literature regarding how best to ensure consistency in the transverse cross analysed, regardless of which vertebrae is identified (Cruz-Jentoft *et al*. 2010). For example, methodologies may use L3 to identify the transverse cross section, however with a height of approximately 29.0mm and CT scan images being taken between 3.0-5.0mm thickness, depending on how the radiologist has performed the scan (Rubin & Rofsky 2009). This means that there could be between 6-10 different transverse scans on which to identify muscle mass measurements from, and for the methodology to be scientifically rigorous it needs to be reliable and repeatable.

Sarcopenia, as measured by cross-sectional area, takes two main forms: all muscles from the transverse cross-sectional area (TCSA) are included, or only the psoas area muscle bulk (PA). Within each form of assessing CT-derived sarcopenia, there are variations on how to measure a reduced muscle mass. Comparisons between how they identify sarcopenia and their validity in terms of predicting post-operative outcomes in surgical patients is under-explored.

There are few studies comparing functional assessments of sarcopenia with radiologically identified sarcopenia, or comparing different radiological identification methods. The use of more abbreviated scores, such as the psoas-only method of sarcopenia identification, has little content overlap in comparison to other working definitions like the EWGSOP. Further work may be required to compare the different approaches to assessing sarcopenia from CT scans and how these relate to the EWGSOP definitions of sarcopenia. There is limited literature regarding how measurements vary between different assessors, between the same assessor, how these different working definitions of sarcopenia relate with each other and how these different working definitions of sarcopenia relate with worse outcomes in surgical populations.

Sarcopenia has been reported to be associated with surgical outcomes (Du *et al*. 2014), though is not consistent across surgical populations (Tegels *et al*. 2015). Sarcopenia, measured by the EWGSOP criteria, was associated with increased odds of post-operative complications following colorectal cancer resections (Odds Ratio (OR) 4.5, 95% Confidence interval (CI) 1.6-12.9, P=0.007) (Huang *et al*. 2015). With CT scans being part of standard care for a substantial number of patients, such as those with complex anatomy or diagnoses of cancer, it may be feasible to perform a sarcopenia assessment on the images already available. When using CT scans alone to identify sarcopenia in a colorectal cancer resection cohort, sarcopenic patients were at greater odds of suffering complications that ranked higher on the Clavien Dindo scale than robust patients (OR 5.4, 95% CI 1.5-20.2, P=0.01) (Jones *et al*. 2015). At the time of writing, I was unable to identify any extant systematic reviews or meta-analysis of the relationship between sarcopenia and post-operative outcomes in colorectal patients. The variation between methods of measuring sarcopenia and in the reporting of its relationship with post-operative outcomes (Peng *et al*. 2012; Huang *et al*. 2015; Friedman *et al*. 2015; Lieffers *et al*. 2012) highlights a gap in knowledge about the validation of CT-derived assessment of sarcopenia for use in a surgical setting.

This chapter describes a study of the prevalence of sarcopenia in a colorectal surgical population as determined by the two of CT-derived sarcopenia assessments; TCSA and PA sarcopenia. The inter-rater agreement for CT-based assessments of sarcopenia was also examined.

Finally, I analysed the association in colorectal surgery patients between the these CT-based sarcopenia assessments and post-operative adverse events.

ssessments

This study received ethical scrutiny from University of Leeds Medicine and Health Research Ethics Committee (MREC16-099). Comparisons of radiological sarcopenia measures were performed on CT scans from patients identified as having scans performed between January and June 2015. Following consultation with the Leeds Teaching Hospitals Trust, this work was approved as a service evaluation from the perspective of NHS.

Patients were identified for inclusion by an MDT co-ordinator using the colorectal MDT database. Patients were included if 18 years of age or older and undergoing elective colorectal bowel. Both cancer and non-cancer patients were included. Patients were excluded if CT scans were not available or were taken over 6 months prior to the surgical resection.

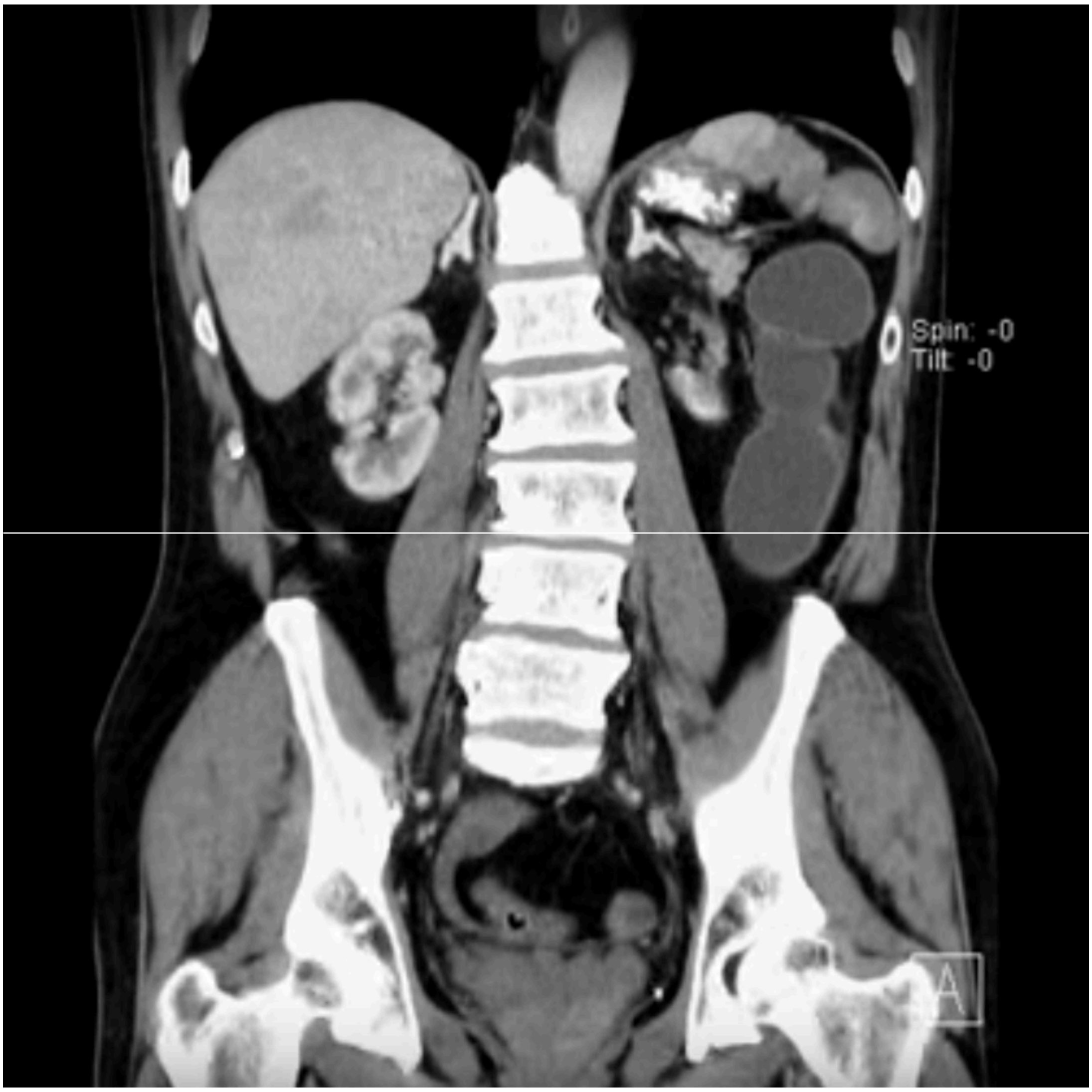


Figure 12: Coronal section of an abdominal computed tomography scan, with a white line representing the the most inferior aspect of the third lumber vertebral body, without including the intervertebral disc. This method is used to identify the corresponding transverse plane to view, in order to measure transverse cross-sectional area.

To measure the full cross-sectional area of abdominal muscles, the most inferior aspect of the L3 vertebral body was identified on a transverse CT image on a Picture Archiving and Communication System (PACS) monitor. This was either guided by a corresponding coronal view (Figure 12) or measured from the sacrum moving superiorly. If L3 was measured from the sacrum, the scans were first assessed for variations in the lumbar-sacral vertebral fusion (Vasuki *et al*. 2016). The section was chosen at the section where the vertebral body was predominantly cortical bone, with minimal intervertebral disc present. All muscles in this section were identified as groups: rectus abdominis, obliques & transversus abdominis, latissimus dorsi, quadratus lumborum, erector spinae, and psoas muscles. The boundaries of these muscles were identified by their density, using the PACS machine in-built Hounsfield Unit (HU) measure. HU is measured by the absorption of radiations by tissues within the body, identified by a CT image. The denser structures, such as bone, are seen as lighter on the monochromal image and has a higher HU value (Hounsfield 1980). Muscle has a HU density ranging between -29 and 150HU, whereas fat and surrounding tissues are between -190 and -30HU (Hounsfield 1973; Mourtzakis *et al*. 2008). Each muscle was individually identified and the perimeter outlined by the freeform mark-up tool, available on PACS. This resulted in a computed value for cross-sectional area and density for the outlined muscle. More detailed information can be found in the standard operating procedure (Appendix 5), which was employed to ensure consistency in methodological approach.

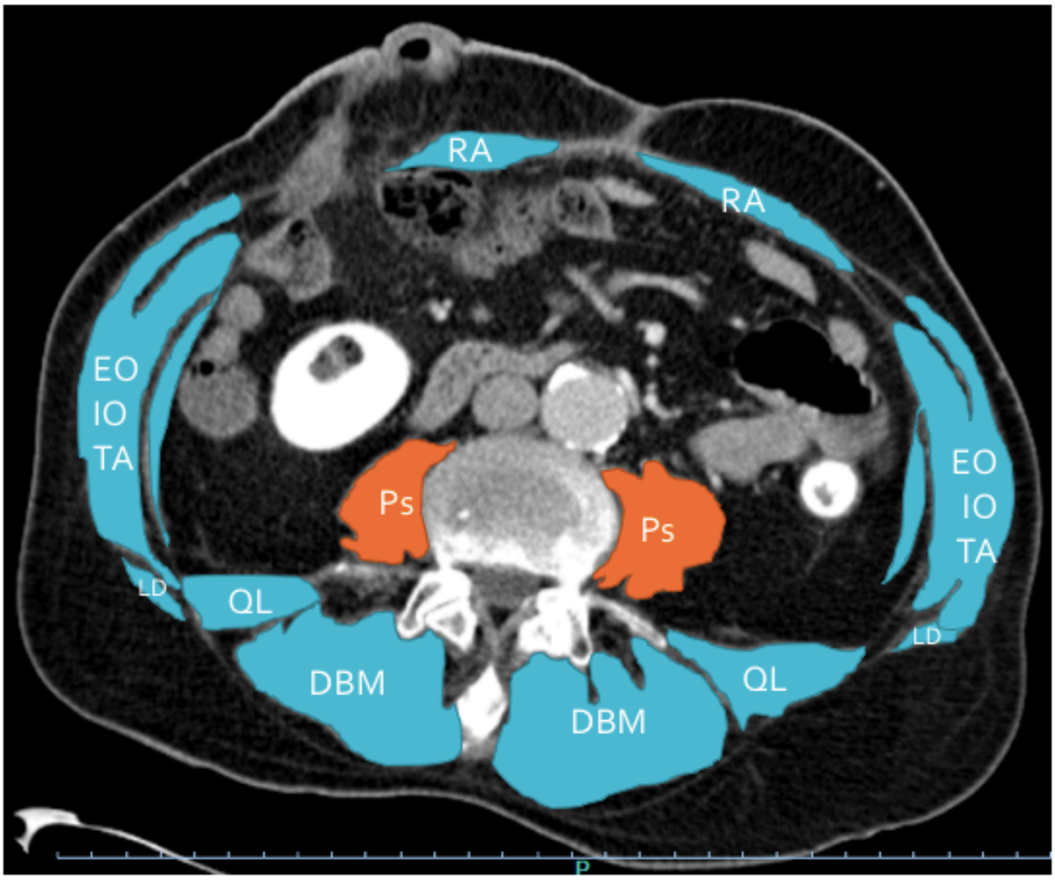


Figure 13: L3 computed tomography cross section highlighting all abdominal muscles involved in CT-derived sarcopenia methodology. RA: rectus abdominis. EO: external obliques. IO: internal obliques. TA: Transversus abdominis. LD: latissimus dorsi. QL: quadratus lumborum. Ps: psoas muscle group. DBM: deep back muscle group. The orange psoas muscles indicate those muscles involved in Psoas-area measurements of sarcopenia. All blue and orange muscles are involved in the total cross-sectional area measurements of sarcopenia.

An example of sarcopenia measurements can be seen in Figure 13. For the TCSA method of assessing sarcopenia: the areas of all lumbar muscle groups were added, in order to get the total muscle cross sectional area. This value was then divided by height-squared and applied to cut offs published by Baracos and colleagues (Baracos 2010), allowing for patients to be classified as sarcopenic or robust. These are $55.4cm^2/m^2$ for men and $38.9cm^2/m^2$ for women.

The measures of PA sarcopenia identification were performed on the same CT images. Using the same freeform mark-up tool on PACS, the perimeters of the psoas muscles were identified and outlined. The PACS machine automatically calculated the cross-sectional areas and densities for both sides. The cross-sectional areas were summed together, divided by the height-squared and applied to cut offs published by Jones and colleagues (Jones *et al*. 2015) to classify patients as robust/ sarcopenic. These are $545mm^2/m^2$ for men and $385mm^2/m^2$ for women.

4.3.1.1 Statistical plan for the comparison of radiological assessments

Analyses were performed using SPSS (SPSS Inc. 2016). The association between the TSCA and PA cross-sectional areas, before normalisation, was examined using Pearson's correlation statistic. These comparisons were drawn to aid determining whether differences found between the two methodologies occur as a result of the measurements or from the cut offs involved in the methodologies. A low R statistic would indicate that the difference in prevalence between the two methods is because the measures are entirely different in their approach. A high R statistic indicates that the methods are relatively similar in their approach to measuring sarcopenia, and the difference is likely a result of the thresholds in the two methods.

Differences in prevalence of sarcopenia between the two methods was analysed by chi squared statistic. Differences in left and right paired muscles were measured using the chi squared statistic. Agreement between TCSA and PA were analysed using the Kappa statistic, using the standard cut-offs for the two methodologies. Sensitivity, specificity, negative and positive predictive values and likelihood ratios were used to analyse the relationship between sarcopenia measures and surgical outcomes.

Receiver operating characteristic curves were used to define the optimum cut-off within for the identification of sarcopenia for each sex, for each methodology, set against the risk of complications following surgery.

Two-tailed hazards sample size calculations based on the association between sarcopenia and perioperative outcome were performed in Stata (StataCorp 2013). The power of the rater variability was set to 0.8, with a significance level of 0.05. Literature available around the hazards of sarcopenia for post-operative outcomes is unclear (Lieffers *et al*. 2012; M J Englesbe *et al*. 2010; Zhuang *et al*. 2016), so a hazards ratio of 4.5 was used as an estimate. For the association with post-operative outcomes, the sample size was calculated to be 44.

A further study was undertaken to assess inter- and intra-rater variability of the assessment of sarcopenia from abdominal CT scans. This was included within the ethical approval granted for this work.

Patients undergoing CT-scans between July and December 2015 were identified from the MDT database by an MDT co-ordinator. A gastrointestinal radiology fellow, two final-year medical students and an anatomist (the author) analysed the same CT scans independently. The raters were blinded to the measures the other assessors and to the outcomes of the patients.

The researcher re-analysed CT scans to provide an assessment of intra-rater agreement. The re-analyses occurred with at least a 6-month window separating the initial and second readings, and without access to the results of the first measures.

At each analysis the rater measured the cross-sectional areas and densities of all muscles. This study also examined the consistency of identification of the same cross section at each rating of a scan. This was done by recording the CT slice series number series number used was also recorded. PACS identifies CT transverse slices using a series number. The series number is a set of continuous integers that provides a numerical value to the image viewed in the series of images that make up the full CT scan. This value is a reproduceable image number for clinicians to refer back to, in order to view the same slice at any time point.

4.3.2.1 Statistical plan for rater variability

To determine the agreement on the vertebral level identified by the assessors for the L3 cross-section, pairwise Kappa statistics were applied to the series number of the CT. Pairwise Kappa statistics were also used to assess the agreement of sarcopenia identification of the different assessors, and of the two sets of measurements made by the author.

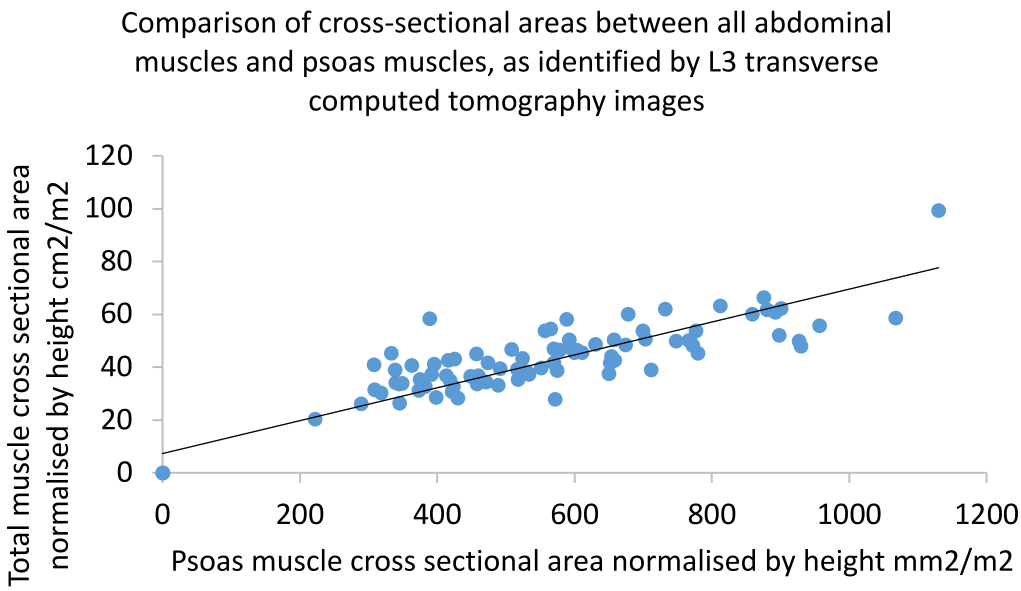
There is minimal information available in the literature on the inter-rater agreement in sarcopenia measures, so estimate values were adopted. Two-tailed sample size calculations were performed in Stata (StataCorp 2013). The power of the rater variability was set to 0.9, with a significance level of 0.01. The standard deviation within groups was set at the maximal value of one, and an estimation of a standard deviation of 0.2 was used for the variance between groups. For the rater variability, the sample size was calculated to be 27.

This study aimed to collect over 50 patients to meet the requirements for both rater variability and to assess for relationships with post-operative outcomes.

Ninety-six patients were identified through MDT records to have undergone colorectal resections and had CT images available within the six month window prior to surgery, taken between January and June 2015. Out of this population, 45 (47%) were females, with the mean (SD) age of 70 (12) and 67% were aged 65 or older. Patients had a mean body mass index of 27.5kg/m^2 (SD 6.1kg/m^2). Out of the 96 patients, 74 (77%) were presenting for cancer resection.

Seventy-one patients (85%) were sarcopenic based on the TCSA method. The prevalence of sarcopenia measured by the PA method was 48% (40 patients) (Table 12). The difference between these two values was statistically significant (Chi square, $p<0.001$), and little agreement measured between the two identification methods (Kappa $K=0.239$, $p=0.002$). There were 25 sarcopenic females and 46 males measured by TCSA, in comparison to three sarcopenic females and 37 sarcopenic males by PA. The prevalence of sarcopenia in males was greater than females in both methodologies ($p<0.001$ for both methods).

The mean (SD) total cross-sectional area was 12293.3 (3571.1) mm^2, and the mean (SD) cross-sectional area for combined psoas cross sectional area was 1615.4 (621.0) mm^2 (Table 13). Of the 96 patients, measurement of heights - and therefore, sarcopenia diagnoses - were available for only 84 (88%) patients. After normalising both values against height, the psoas-combined values had a strong correlation with the total cross-sectional area (Pearson's Correlation, $R=0.784$, $p<0.001$) (Graph 9). There were no differences identified between paired muscles, such as between the left and the right psoas ($p>0.05$).



Graph 9: Values for both total abdominal and psoas-alone cross-sectional areas, normalised by patient heights

Table 12: Comparison of total cross sectional area and psoas area methodologies and their relations with outcomes

Change of the in-hospital level of care required post-operatively						
Method	Chi Square P values	RR (CI)	PPV	NPV	Sensitivity	Specificity
TCSA	0.71	1.22 (0.51-4.31)	16.39	86.96	76.92	28.17
PA	0.32	1.43 (0.79-2.60)	55.74	56.52	77.27	32.50
Change of discharge location to an increased care facility						
Method	Chi Square P values	RR (CI)	PPV	NPV	Sensitivity	Specificity
TCSA	0.81	1.28 (0.10-15.91)	15.79	87.50	92.31	9.86
PA	0.38	0.65 (0.44-7.65)	53.95	62.50	93.18	12.50
Post-operative complications						
Method	Chi Square P values	RR (CI)	PPV	NPV	Sensitivity	Specificity
TCSA	0.39	0.70 (0.37-1.30)	13.33	79.17	61.54	26.76
PA	0.49	0.79 (0.42-1.48)	50.00	41.67	68.18	25.00
Re-admission within 30 days						
Method	Chi Square P values	RR (CI)	PPV	NPV	Sensitivity	Specificity
TCSA	0.93	0.92 (0.06-13.01)	15.39	83.33	92.31	7.04
PA	0.90	1.10 (0.20-6.00)	52.56	50.00	93.18	7.50
Extended Length of Stay						
Method	Chi Square P values	RR (CI)	PPV	NPV	Sensitivity	Specificity
TCSA	0.28	1.53 (0.85-2.76)	19.57	89.19	69.23	47.14
PA	0.61	1.48 (0.77-1.68)	54.35	51.35	58.14	47.50

TCSA; Total cross-sectional area sarcopenia, PA; Psoas-alone sarcopenia, RR: Risk Ratio, CI: 95% Confidence Interval, PPV: Positive Predictive Value, NPV: Negative Predictive Value

Table 13: Average muscle mass for total cross sectional area and psoas area methods of identifying sarcopenic patients before normalisation

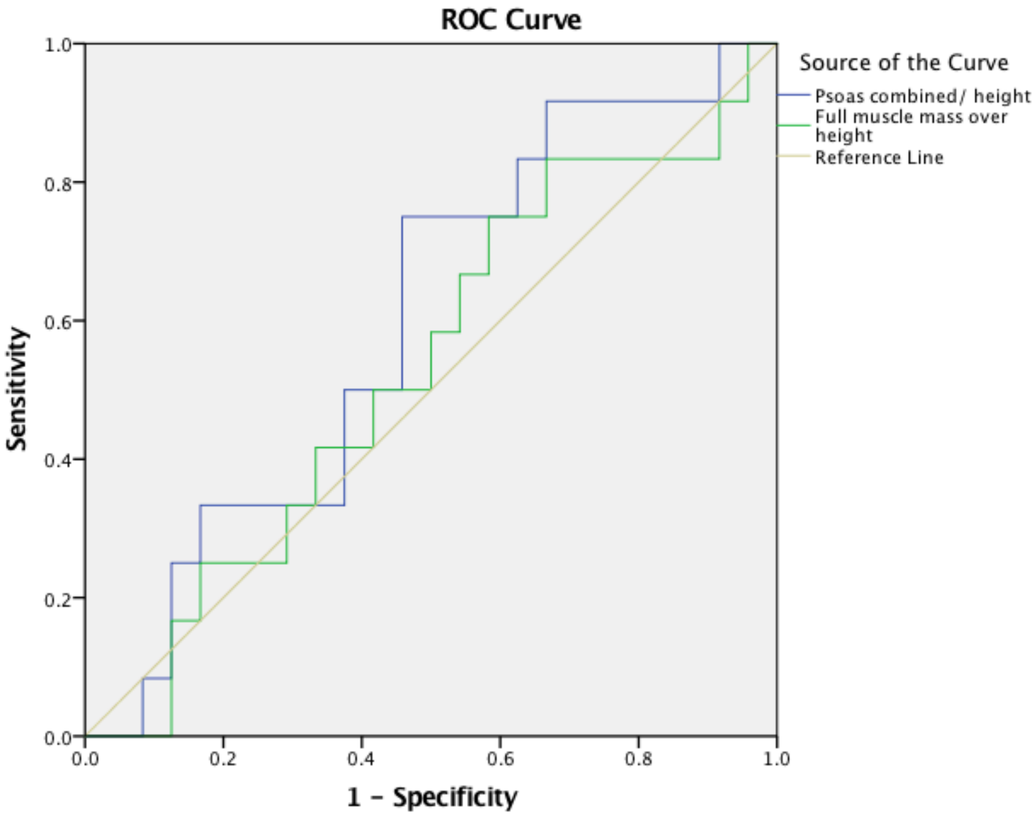
	Cross sectional area												
Methods	Ps left	Ps right	ES left	ES right	QL left	QL right	LD left	LD right	OT left	OT right	RA left	RA right	Sum
TCSA (SD)	790.1 (312.3)	825.2 (329.3)	2112.8 (512.6)	2104.1 (511.8)	471.2 (224.4)	441.7 (225.1)	96.9 (116.5)	100.1 (121.7)	2130.7 (739.6	2286.3 (798.2)	482.3 (194.8)	451.8 (210.9)	12290 (3570)
PA (SD)	790.1 (312.3)	825.2 (329.3)											1615.4 (621.1)
T test P value (between left and right muscles)	0.4		0.9		0.3		0.8		0.1		0.3		

TCSA: total cross sectional area, PA: psoas area, SD: standard deviation, Ps: Psoas, ES: Erector Spinae, QL: Quadratus Lumborum, LD: Latissimus Dorsi, OT: Obliques and Transverse muscles, RA: Rectus Abdominis, SD: Standard Deviation.

There were no intra-operative complications recorded. Nine patients had an increased level of care required upon discharge from hospital. Thirty patients (31%) had at least one post-operative complication as graded by the Clavien-Dindo scale (21 grade 1, 5 grade 2, 1 grade 3 and 3 grade 4). Seven patients were readmitted within 30-days died discharge, and 3 patients died post-operatively, in-hospital. On contingency analyses, there were no differences between sarcopenic and robust patients, for either methodology, for all outcome measures. (Table 12) The likelihood ratios for TCSA and PA were 1.1 and 1.2 for a change of immediate post-operative care level, 1.0 and 1.1 for an increased care requirement following discharge, 1.3 and 1.1 for an extended length of stay, 0.8 and 0.9 for post-operative complications, and 1.0 and 1.0 for 30-day readmission to hospital respectively.

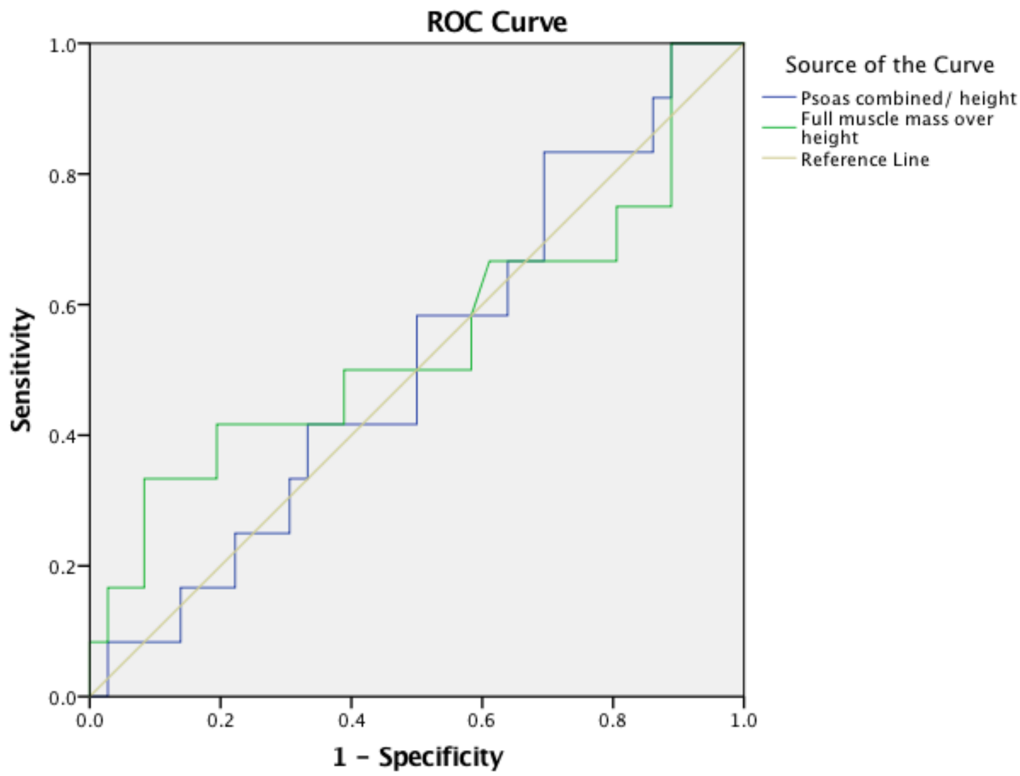
As planned in the analysis, Receiver Operating Characteristic (ROC) curves for females (Graph 10) and males (Graph 11) were investigated to provide initial insight into possible sex differences. These ROC curves were produced from the normalised values of muscle area by the patient's height, before these values were applied to sarcopenic-defining cut-offs .

Inspection of the ROC curves indicated that reliable cut-off values could not be derived for either sex or measure.



Graph 10: Receiver operating characteristic (ROC) curve for females, determining sensitivity and specificity for post-operative complications. Associated co-ordinates below.

	Positive if Greater Than or Equal To	Sensitivity	1 - Specificity
Psoas combined/ height (mm^2/m^2)	372.3348	1.000	1.000
	558.1859	.917	.875
	627.7465	.833	.667
	707.3669	.750	.458
	767.4374	.500	.417
	778.1611	.333	.375
	895.3102	.250	.167
	928.1803	.083	.125
	1131.0847	.000	.000
Full muscle mass/ height (cm^2/m^2)	30.2844	1.000	1.000
	39.3182	.917	.958
	41.5152	.833	.917
	46.6527	.750	.667
	50.3661	.500	.417
	54.1284	.333	.333
	61.2020	.167	.167
	100.2309	.000	.000



Graph 11: Receiver operating characteristic (ROC) curve for males, determining sensitivity and specificity for post-operative complications. Associated co-ordinates below.

	Positive if Greater Than or Equal To	Sensitivity	1 - Specificity
Psoas combined/ height (mm^2/m^2)	221.3011	1.000	1.000
	335.8513	.917	.861
	385.9953	.750	.694
	397.1338	.667	.639
	453.0137	.417	.500
	517.0826	.333	.306
	598.0819	.083	.139
	700.9134	.000	.000
Full muscle mass/ height (cm^2/m^2)	19.1656	1.000	1.000
	30.4903	.750	.889
	32.9450	.667	.806
	36.5350	.500	.583
	43.6648	.417	.194
	46.1921	.333	.083
	59.2532	.000	.000

y

For the assessment of inter-rater variability, 78 patients were identified from the MDT records between July and December 2015. Five scans were inaccessible and 73 scans were reviewed by the assessors. Thirty-eight of the study patients were female, with a mean (SD) age of 63 (14), and 57% were aged 65 or older.

The total number of patients categorised as sarcopenic varied slightly between the assessors (Table 14). 'Slices' of CT scans are organised in a continuous thread of integers, called series numbers. A Kappa test was performed on the image number of the transverse image from the CT scan, to identify whether the assessors agreed on the image on which measures were taken (Table 15). The agreement and differences between assessors can be seen in Table 16.

Table 14: Prevalence of sarcopenia as measured by the four assessors involved in this study. TCSA – Total Cross-Sectional Area.

	Healthy (%)	Sarcopenic (%)
TCSA method		
Medical Student 1	4 (5.5)	69 (94.5)
Medical Student 2	5 (6.8)	68 (93.2)
Consultant Radiologist	4 (5.5)	69 (94.5)
Anatomist	2 (2.7)	71 (97.3)
Psoas method		
Medical Student 1	61 (83.6)	12 (16.4)
Medical Student 2	60 (82.2)	13 (17.8)
Consultant Radiologist	53 (72.6)	20 (27.4)
Anatomist	54 (74.0)	19 (26.0)

For the examination of inter-rater agreement, there was a statistically significant agreement between the author's first analyses of CT scans, with the second measures taken by the anatomist (K=0.770, p<0.001)

Table 15: Kappa analysis measuring the agreement between transverse choice of cross-sectional plane used in the analysis of inter- and intra-rater variability. A colour code key for the kappa analyses is provided below the table

		Significance x 10^3				
		MS1	MS2	CR	A[1]	A2
Cohen's Kappa Agreement x 10^3	MS1		<001	<001	<001	<001
	MS2	865		<001	<001	<001
	CR	571	603		<001	<001
	A[1]	497	555	409		<001
	A[2]	771	764	651	770	

MS: medical student, CR: consultant radiologist, A: anatomist

Key for value of Kappa x10^3	Significant	Non-significant
Negative Disagree		
000 – 200 None		
201 – 400 Fair		
401 – 600 Moderate		
601 – 800 Substantial		
801+ Almost perfect		

Table 16: Kappa and Fisher's exact grid, exploring the agreement and differences between medical students, a consultant radiologist and an anatomist, for two methods of identifying sarcopenia

		Total cross-sectional area				Psoas-alone sarcopenia			
		Significance x 10^3				Significance x 10^3			
		MS1	MS2	CR	A	MS1	MS2	CR	A
Cohen's Kappa Agreement x 10^3	MS1		<001	<001			<001	<001	<001
	MS2	882		<001	<001	759		<001	<001
	CR	736	645		<001	528	498		<001
	A	654	554	654		717	604	615	
Fisher's exact x 10^3	MS1		<001	<001	<001		<001	<001	<001
	MS2			001	004			001	<001
	CR				002				<001
	A								

MS: medical student, CR: consultant radiologist, A: anatomist

Key for value of Kappa x10^3	Significant	Non-significant
Negative Disagree		
000 – 200 None		
201 – 400 Minimal		
401 – 600 Weak		
601 – 800 Moderate		
801 – 900 Strong		
901+ Almost perfect		

There is a growing body of research on sarcopenia, with various methods of measurement. This study suggests that prevalence of sarcopenia is highly dependent on the method used; with between 16% and 97% of patients presenting for colorectal surgery classified as sarcopenic depending on the method and cut-off used. This raises concerns regarding the use of this methodology for the diagnosis of sarcopenia, as does the lack of association between sarcopenia and post-operative complications in this series. Our study identified limited positive predictive power for both methods of measurement of sarcopenia, with likelihood ratios close to unity. Many patients who did not suffer post-operative complications were identified as sarcopenic, giving a high number of false positives in both methods for the predictive association between sarcopenia and adverse outcomes.

The reported PA measure of sarcopenia had poor agreement with the TCSA method. This study raises concerns about the validations of these individual methods, in terms of their clinical value. There was a strong correlation between the total cross-sectional areas measured by the two methods. This strong correlation suggests that a potential cause of the disparity between the sarcopenia methods is derived by the cut-off points for the individual measures. This is limited by the fact that psoas muscle area is also measured as a component of the total abdominal muscle cross-sectional area, meaning that there will likely be some degree of correlation between the two methods. The other muscles involved in the total abdominal muscle method would potentially cause some discrepancy in the correlations if the two methodologies were fundamentally different. Our data suggest that the PA and TCSA methods are relatively similar in their identification of muscular cross-sectional area, yet the difference between prevalence rates of sarcopenia may stem from the cut-offs. The difference may also come from additional information being provided by the inclusion of the additional abdominal muscle groups.

The two methods in this study are established measures of sarcopenia but show a difference in prevalence of sarcopenia and in their relationship with post-operative outcomes. The difference in prevalence may be due to one of, or a combination of, three factors: differing populations may require specific cut-offs; sarcopenia publications may report internally validated findings but there are limitations as to the external validation of these methods; there may be bias in publications.

Different study populations can vary both clinically and anthropometrically. Clinically, patients may have a cancer that increases the risk of cachexia – a wasting syndrome – which can in turn increase the likelihood of presenting as acutely sarcopenic. Patients are also at risk of becoming cachexic as a result of non-surgical treatment, such as neoadjuvant chemotherapy. These acute presentations are a result of the patient's clinical condition as opposed to their chronic depletion of muscle mass due to ageing, which is the definition of sarcopenia. It may be that acute muscle depletion effects individual muscle groups more than others, which could explain some variance in the prevalence of sarcopenia in this study. The acute wasting, on top of those presenting with sarcopenia, may skew the results of the relationship with post-operative outcomes and increase the prevalence of sarcopenia as identified by CT scans.

With regards to validation of sarcopenia measurements, a number of publications have reported an association between of CT-derived measures sarcopenia and post-operative outcomes (Friedman *et al*. 2015; Lieffers *et al*. 2012; Wang *et al*. 2016; Tegels *et al*. 2015; Peng *et al*. 2011). Our data do not support this association. Some studies in sarcopenia literature adopt a cut-off determined by the lowest quartile of skeletal muscle area or by internally-derived cut-offs modelled against outcomes (M J Englesbe *et al*. 2010; Peng *et al*. 2012). Using internally-derived cut-offs, modelled to fit observed data in individual studies, comes with tight limitations. In addition to the inability to robustly externally-validate the measure, publication of additional thresholds brings about further confusion to the literature. The use of internally-derived cut-offs also increases the likelihood of identifying a relationship with an outcome measure (Potgieter *et al*. 2015). Unfortunately, this study has raised questions around the external validation of these measures, and that further refinement or exploration into confounders may support the clinical value of these results. There is a body of work looking into the different anthropometrics of people of different ethnicities and sexes, which will shed light onto the different morphologies of the abdominal muscles used in these sarcopenia measures (Zhou *et al*. 2000; Thornton *et al*. 1994; Lee & Gallagher 2008; Gallagher *et al*. 1996). A large prospective, multi-centre study in tightly-controlled population criteria resulting in regression modelling would provide an initial indication as to what confounders are appropriate to consider. This would then provide a platform on which larger studies could explore these confounders in controlled trials, isolating their true impact on sarcopenia identification, determining whether these assessments add clinical value.

Negative results are often unpublished though can provide valuable insight into the intricate dynamics around methodologies. This study may not be the only work that highlights similar concerns, though those with similar results may also not be published works, skewing the literature into suggesting sarcopenia measured in this way provides more clinical value than it may. Potgieter published a systematic review and meta-analyses (Potgieter *et al*. 2015), which identified that the internal derivation of thresholds can artificially inflate the predictive capabilities of measurements. A key point made is that the over-estimation seen in this approach to deriving cut-offs is further amplified in small studies (Baracos 2010; Jones *et al*. 2015). The TCSA method Baracos and colleagues describe originates from a study, by the same authors, in an obese gastrointestinal cancer population (Prado *et al*. 2008). This study has internally-derived cut-offs from 325 patients. Not only is this a potentially small number, there may be a possibility that fat infiltrates the muscle, increasing the muscle cross-sectional area. This potentially inflates the cut-offs from what they would be in those with BMIs in a healthier range.
The PA method used by Jones and colleagues are externally-validated, yet come from investigating cancer cachexia (Fearon *et al*. 2011), not sarcopenia

– two different physiological processes. Our data indicate that these studies do need further validation performed to understand the scope to which they are clinically and scientifically useful methods.

The cut-offs identified from the ROC curves have poor sensitivity and specificity. The cut-offs from literature (Baracos 2010; Jones *et al*. 2015) are different to the cut-offs suggested by the ROC curves in this study. It may be that published cut-off points are not appropriate for all populations (as many are internally-validated only, or have yet to be validated in colorectal surgical populations) and may require further fine-tuning before sarcopenia can be used routinely for this population to inform clinical decision making. This is unlikely to be the entire cause of the difference. This study for example, and most sarcopenia studies, does not adjust for ethnicity as part of their models. Body anthropometrics differ between ethnicities (Deurenberg *et al*. 1998), which could be of value to add into a sarcopenia model. Future works in this area could include modelling the impact of ethnicity and the predictive value sarcopenia may have on post-operative adverse outcomes.

Cross-sectional area is arguably not a measure of muscle mass. The cross-sectional areas identified by only CT analyses do not take into consideration the composition of the muscle within the areas identified. It may be that some muscles are infiltrated with fat deposits, which may alter composition and density of the area identified on PACS, and may impact the quality of the muscle itself.

Even if the cross-sectional area were a true measure of muscle mass, our data suggest that CT-derived sarcopenia measures cannot be used to replace functional measures such as grip strength and their gait speed. It may be that our methodologies do not accurately assess sarcopenia in a way that has prognostic value for adverse outcomes, unlike that which is reported in the literature (Fukuda *et al*. 2016), due to the physical measures missing from this work. The variation in our radiological measures may account for some of the difference between individual measurements of muscles, but would not account for the sizable difference between sarcopenia prevalence rates.

Our data do not support the associations between these published methods and post-operative adverse outcomes, such as complications or re-admission to hospital. The work performed as part of this thesis to identify the prevalence of sarcopenia, through two radiological methods, provides reason to look into this field further. This study has highlighted questions about both the appropriate cut-off values for populations in different methodologies, as well as possible publication bias. This study, however, is relatively small and whilst our data hint to there being no effect. The confidence intervals, relating to risk ratios, of the measures reporting on post-operative outcomes are relatively broad, indicating a lack of power in this work to say with certainty whether the risk ratios are reliable. A larger study may provide more insight into the nuances of how to measure sarcopenia in a way to be clinically valuable.

This study found reasonable agreement between assessors regardless of their radiological experience or clinical background. My data suggest that if sarcopenia measures were to be adopted into clinical practice, using routinely collected CT scans, the measures do not need to be done by a consultant radiologist. Instead, they could be performed by someone with minimal experience in the PACS monitors, with some training and following a detailed standard operating procedure to ensure consistency. This supports the premise that sarcopenia assessments may be feasible to complete as part of routine practice, though our data indicate the information would not be clinically valuable.

The data in this study also suggest that the methods of assessing CT-derived sarcopenia are reliable, in terms of their repeatability. The repeatability of a measure is a key component of construct validity (the degree to which an assessment measures its intended construct); clinical information needs to provide the same measure, regardless of the time difference between the first time the scan was measured and any of the following measures. Our data indicate that analyses of muscle cross-sectional area have reasonable repeatability. It is possible that this information may support the use of CT-derived sarcopenia measures in routine clinical practice, if the working definition is refined and proven to allow identification of patients at risk of adverse post-operative outcomes.

This retrospective study only compares two methods of assessing CT-derived sarcopenia on patients. A larger prospective study would enable further analyses to be performed and progressively explore the intricacies of sarcopenia. The results of the CT-derived sarcopenia assessments would benefit from being compared to the complete EWGSOP criteria, to determine how valid these assessments are as an abbreviated measure of EWGSOP sarcopenia.

The conclusions of our work suggest that these two methods may not be appropriate to use clinically, in their current format, for a colorectal surgical population.

This study is a retrospective analysis of CT scans for sarcopenia, from a single centred study with sample sizes limited by time period. Single-centred trials lack external validity, and are not an appropriate foundation to implement changes of care. A publication by Bellomo and colleagues identified that there has been an incidence where a positive association identified in a single-centred trial was found to potentially be actively harmful in a multi-centre trial (Bellomo *et al*. 2009). The results of our study highlight the limitations of the TCSA and PA methods of identifying sarcopenia and work towards external validation.

The retrospective nature of this study is a potential limitation. Retrospective studies are often limited by ‘missing data’ (Anthonisen 2009). This study is limited by the potential missing data caused by its retrospective approach, and by using an MDT database to identify eligible patients. It may be that the MDT database accessed retrospectively does not represent all relevant colorectal surgical patients. This may reduce the applicability of the results of this study to inform clinical practice. Prospective cohort studies would be required to provide the further validation required to determine if the results could be applied to a clinical population. Our study may be limited in terms of a small sample size, however the lack of effect suggests that a larger sample size would give similar results.

Sarcopenia is considered a geriatric syndrome that is reported to have an association with post-operative outcomes in a colorectal surgical setting. The literature suggests the adoption of CT-derived sarcopenia assessments in the clinical setting. However, the work in this study suggests that currently these assessments may not be clinically valuable in their current format. Further studies are needed to refine these CT-alone sarcopenia definitions to ensure there is consistency and clinical value to the results. Understanding the prevalence of sarcopenia by using the more functional measures and its relationship with colorectal surgical outcomes, and a comparison of this with CT-derived sarcopenia measures would be useful to understand whether cross-sectional area could be used as a reliable short-cut method.

Sarcopenia is related to frailty. Both frailty and sarcopenia are reported to be associated with outcomes following colorectal surgery. Understanding how these two conditions relate and their association with post-operative outcomes may support the adoption of one of these assessments into routine clinical practice.

4.8: Investigations arising from these findings

In this thesis so far, building on our understanding of perceptions around frailty, I have explored some of the different identification methods used to identify frailty and sarcopenia. What this work has shown is that there are multiple ways to identify frailty, the relationship they have with each other is poor, and they are associated yet not predictive of adverse surgical outcomes in this population. My data suggest these frailty assessments are unfeasable to perform in surgical pre-assessment in their current format.

Sarcopenia as identified by radiological imaging has similar issues, in that the different methods of assessment do not have a strong relationship with each other, nor with surgical outcomes. These are derivatives of the EWGSOP criteria. These derivatives may not be valid when scaling up to the original sarcopenia algorithm. The next chapter explores the relationship between frailty and sarcopenia, and how patients recover both in hospital and following discharge.

The work discussed so far in this thesis has highlighted that frailty and sarcopenia are both clinical problems in a colorectal surgical population. These are both conditions that are thought to be scalar, and literature suggests that they are potentially reversible with an intervention. In parallel with the study investigating the relationship with frailty, sarcopenia and outcomes, Chapter 6 explores the pilot of an intervention for older adults, testing the feasiblity a potential intervention that could be applied to a clinical population. The work described in chapters 5 and 6 was performed simultaneously.

Chapter 5: Frailty, Sarcopenia and Colorectal Surgical Outcomes

The work in this chapter aims to investigate the association between frailty measures. Secondarily, this work looks at the relationships frailty measures have with sarcopenia, cognitive impairment, risk of falling, and with surgical outcomes.

5.1: Introduction

5.1.1: Frailty identification measures

Section 1.4: identified that whilst it is possible to identify frailty in the surgical pre-assessment, there is still a question as to which frailty assessment would be best implemented at this stage of the elective surgical pathway. The clinical frailty scale (CFS) (Rockwood 2009; Cockburn *et al*. 2015) is very rapid, the accumulation deficit (AD) (Song *et al*. 2010; Rockwood & Mitnitski 2007; Rockwood & Mitnitski 2011) follows the current process in this particular pre-assessment clinic, yet the frailty phenotype (FP (Fried *et al*. 2001; Op het Veld *et al*. 2015)) appears to have the strongest relationship with postoperative outcomes. There are, however, numerous methods to diagnose a patient as frail (Milte & Crotty 2014). Literature searches into frailty highlight several commonly-used assessments (Table 17).

There is limited evidence regarding the agreement between frailty assessments (Hoogendijk *et al*. 2013). Agreement may vary between populations (Tessier *et al*. 2018; Melvin *et al*. 2018; Kotlarczyk *et al*. 2018; Buta *et al*. 2018). The 'white book of frailty' (Vellas *et al*. 2013), is intended to provide rules and key messages related to frailty yet there was no comment on agreements between methodologies. This chapter aims to provide further information about the agreement between the frailty measures described in Table 17. These frailty assessments are prevalent through literature and show face validity in their attempts to measure frailty (Rockwood & Song 2005; Song *et al*. 2010; Afilalo *et al*. 2010; Fried *et al*. 2001; Cesari, Demougeot, *et al*. 2014; Cherubini *et al*. 2015; Rolfson *et al*. 2006; Morley *et al*. 2012; Hebert *et al*. 2003).

Table 17: Frailty assessments frequently found in literature

Authors	Frailty assessment	Components	Relationship with outcomes
(Rockwood & Song 2005)	CFS	Clinical judgement	Increased risk of death (HR: 1.30) Increased risk of entry into institution (HR: 1.46)
(Song *et al*. 2010)	AD	Medical history	Increased risk of death (RR: 1.57)
(Afilalo *et al*. 2010)	Gait speed	Functional performance	Increased mortality or major morbidity (OR: 3.17)
(Fried *et al*. 2001)	FP	Gait speed Handgrip strength Mood Activity levels Loss of weight	Increased odds of postoperative complication (OR: 4.1)
(Cesari, Demougeot, *et al*. 2014)	FiND	Mobility impairment Weight loss Activity levels	Information unavailable in a surgical population
(Kennedy *et al*. 2000)	Polypharmacy	Medical history	Medication unrelated to surgical procedure increased risk of postoperative complications (RR: 2.7)
(Cherubini *et al*. 2015)	GFST	Loss of weight Fatigue Mobility impairment Cognition Gait speed Clinical judgement	Information unavailable in a surgical population
(Rolfson *et al*. 2006)	EFS	Cognition General health Functional independence Social support Medications Nutrition Mood Continence Functional performance	Increased odds of postoperative complication (OR: 5.02) Lower chance of being discharged home (40%)
(Morley *et al*. 2012)	FRAIL	Fatigue Resistance (climbing stairs) Ambulation (mobility) Illness (comorbidities) Loss of weight	Increased odds of mortality (OR: 4.19)
(Hebert *et al*. 2003)	PRISMA 7	Age Gender Activity levels Social support Walking impairment	Information unavailable in a surgical population

CFS: clinical frailty scale, AD: accumulation deficit, FP: frailty phenotype, FiND: frailty non-disabled assessment, GFST: Gerontopole frailty screening tool, EFS: Edmonton frail scale, HR: Hazards ratio, OR: Odds ratio, RR: Risk ratio.

5.1.2: Frailty association with surgical outcomes

Accepted surgical outcome measures include are mortality, complications, readmission and length of stay (LoS). LoS can vary depending on the surgical procedure, the patent's general health and nonclinical factors (Brasel *et al*. 2007). An extended length of stay (ELoS) measure has been recommended from a retrospective colorectal study, investigating 199 hospitals (Krell *et al*. 2014), to account for the possible confounding variables. There is variation in the way readmission and mortality are measured – for example, within 30-days or how many days post-surgery (Fischer *et al*. 2014; Clarke 2004; Begg CB *et al*. 1998), and the cause of either outcome could either be directly related, indirectly related or unrelated to the surgical procedure. Readmission and mortality are impacted by hospital process, surgical quality and patient health (Grocott *et al*. 2007; Bate *et al*. 2008; Shahian *et al*. 2007). Analyses should take account of confounding factors in order to allow for accurate interpretation of the data.

Post-operative complications are also an outcome of interest. A well-validated, widely accepted method of measuring post-operative complications is the Clavien Dindo score (Clavien *et al*. 2009). This assesses the severity of a complication a patient may have following their surgical procedure by ranking the adverse outcomes between 0 and 5:

0 – Typical recovery

1 – Any deviation from the normal post-operative course, including some therapeutic medications

2 – Required pharmacological treatments not cleared by score 1, blood transfusions, antibiotics and total parenteral nutrition

3 – Requires surgical, endoscopic, radiological or other intervention requiring anaesthesia

4 – Life-threatening complications that include intensive care management

5 – Patient demise

Other outcomes that are of interest include various aspects of post-operative in-hospital morbidity. The post-operative morbidity survey (POMS) has been validated in surgical settings in order to systematically collect data on morbidities severe enough to hinder a patient's discharge (Grocott *et al*. 2007). The POMS is comprised of nine domains: pulmonary, infectious, renal, gastrointestinal, cardiovascular, neurological, haematological, wound, and pain. A recent systematic review of post-operative outcomes in older surgical patients reports that frailty is associated with increased morbidity, yet only one in twenty-three studies included assessed morbidity. This was in a cardiovascular population (no studies assessed morbidity in a general or colorectal patient population (Lin *et al*. 2016)). This study used a morbidity assessment recommended by the Society of Thoracic Surgeons (Shahian *et al*. 2007). A meta-analysis of frailty as a predictor of morbidity and mortality in abdominal surgery reported that frailty significantly increases the odds of post-operative morbidity (odds ratio (OR) 2.56, 95% confidence interval (CI), 2.08-3.16) yet again, the morbidity assessments included in any of the 35 studies were not assessed using POMS (Sandini *et al*. 2017). This raises the question: how, if at all, does the frail colorectal surgical patient differ from a healthy colorectal surgical patient, in terms of the prevalence of postoperative morbidity?

5.1.3: Sarcopenia, cognition and falls

Assessment of sarcopenia may be of clinical value, though possibly not through CT-derived methodologies in their current format. More comprehensive assessments may identify sarcopenic patients who are at risk of adverse outcomes. The European Working Group of Sarcopenia in Older Persons (EWGSOP) uses grip strength, gait speed and muscle morphometric measures to determine the presence of sarcopenia (Cruz-Jentoft *et al*. 2010). The terms frailty and sarcopenia are used inter-changeably at times, but they describe two separate constructs. If there is substantial agreement between these two constructs, it may be that sarcopenia could be integrated into routine practice as opposed to a more comprehensive frailty assessment, or vice versa.

The Comprehensive Geriatric Assessment (CGA) has been described as the gold-standard measure to identify support frail patients (Clegg *et al*. 2013; The British Geriatrics Society 2014). The CGA however does not provide a diagnosis, nor is it a measure, of frailty. Rather, it provides a framework for the global assessment of an individual's health and social wellbeing. The CGA includes five domains: medical, mental health, functional capacity, social circumstances, and environmental (J. S L Partridge *et al*. 2014). Cognitive impairment is not only more common in the frail (Brigola *et al*. 2015) but is also recognised to occur following anaesthesia and surgery (Rundshagen 2014). A systematic review of 19 studies identified many comparisons between the FP with cognition, yet in non-surgical elderly patients in non-UK locations (Brigola *et al*. 2015). Frailty assessments sometimes include a component of mental health measurements, imitating this aspect of the comprehensive geriatric assessment, though do not thoroughly investigate cognition as a separate construct. For example; the FP assessment includes two questions from the geriatric depression scale, to determine low mood (Fried *et al*. 2001); the AD includes questions regarding memory and emotional problems (Song *et al*. 2010); the EFS asks patients to draw a clock (Rolfson *et al*. 2006).

Clinically, either the Montreal Cognitive Assessment (MoCA) or the mini mental state exam (MMSE) is used to formally identify cognitive impairment (Rundshagen 2014; Buchman *et al*. 2007; Royal College of General Practitioners 2014), however these assessments are not routinely used in surgical pre-assessment. There is evidence to suggest that the MoCA is the better assessment, with less ceiling-effect and more sensitivity, though MMSE is often adopted due to convenience (Dong *et al*. 2012; Trzepacz *et al*. 2015). Whilst the relationship between some frailty tools and the MoCA has been explored somewhat (Chen *et al*. 2018), there is still uncertainty as to how this relationship presents in a UK colorectal surgical population. This uncertainty is also found with how cognition, as identified by the MoCA, relates with colorectal surgical outcomes and a cognitively impaired patient's recovery post-operatively. Patients who are cognitively impaired are at risk of post-operative delirium and cognitive dysfunction (S Deiner & Silverstein 2009).

The 4AT, a rapid delirium assessment tool, has been proven useful to identify post-operative delirium and cognitive dysfunction (Monacelli *et al*. 2018).

A secondary aim of this study is to investigate the relationship cognition (as identified by the MoCA) has with frailty and with post-operative delirium (as identified by the 4AT). This may help identify whether frailty measures are supportive of identifying a degree of cognitive frailty, or impairment, or whether the use of a separate cognitive assessment is more appropriate.

5.2: Methods

Ethical approval for this study was granted by the York and Humber Research Ethics Committee (15/YH/0513). Patients were screened for eligibility from the colorectal multi-disciplinary team meetings. Patients were eligible for the study if they were admitted for elective colorectal surgery at the age of 65 or over. Patients were fluent English speakers, or have an NHS translator present, and have capacity at the time of the initial consenting process. Exclusion criteria for this study were: not meeting inclusion criteria, those who are not proceeding with surgery, involved in another clinical trial that affects clinical outcomes recorded in this study, or taking carbidopa, levodopa, donepezil hydrochloride or anti-depressant medication (previous studies have found that these medications cause symptoms that are potentially collinear with domains of frailty (Fried *et al*. 2001)) and had a previous stroke or Parkinson disease.

The design of the study is shown in Figure 14. Patients were approached and consented into the study by surgical research nurses at St James' Hospital Surgical Pre-assessment clinic and at the colorectal outpatient clinic. Following informed consent, the research nurse assessed the patients for frailty, cognitive function and quality of life (quality of life data was not completed by the time of thesis write-up, so is not included in this work).

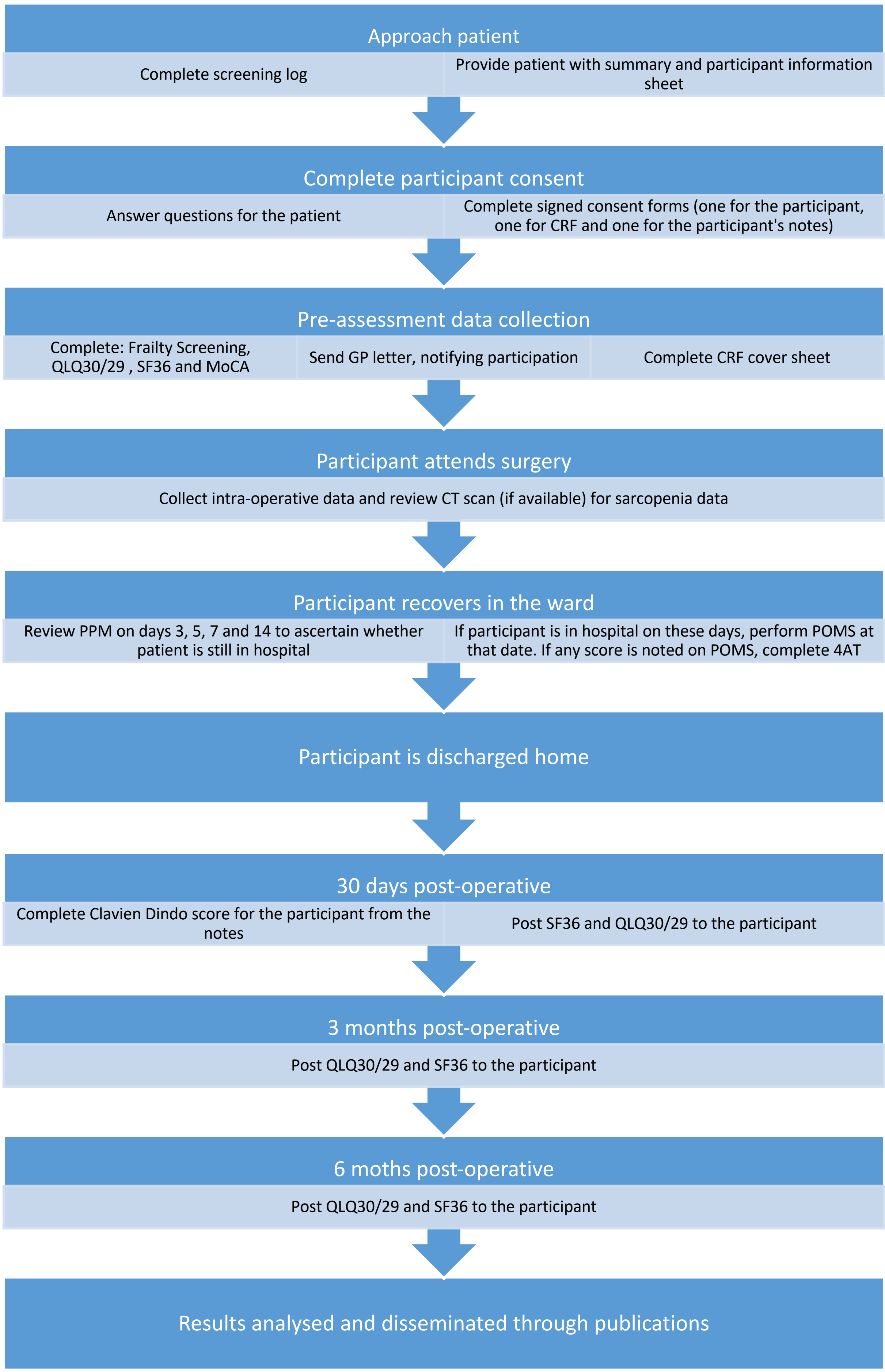


Figure 14: Study design from approach of patient through to the 6-month follow up

5.2.1: Pre-operative and baseline data

Baseline and characteristic data such as sex, age, BMI and ASA grade was collected from the pre-assessment proforma and electronic patient records. These data included the patients falls risk, which is indicated by a positive marker of one or more of the three falls risk questions, and cognitive function, which is indicated by a patient's self-reporting of cognitive impairment.

5.2.2: Frailty assessments

The frailty assessments performed in this study were the clinical frailty scale (CFS), accumulation deficit (AD), frailty phenotype (FP), frail non-disabled assessment (FiND), the FRAIL scale, Edmonton frailty scale (EFS), Gerontopole frailty screening tool (GFST), polypharmacy and the PRISMA-7 toolkit. These assessments were merged, into one frailty assessment proforma, with duplicate questions removed (Appendix 6). The decision to condense the frailty assessments was made to increase engagement with the project, reducing the burden on participants who would have already had a long pre-assessment clinic appointment and potentially an out-patient visit prior. Before the use of this proforma in the study, a pilot was performed to ensure responses to the proforma could be mapped back to each of the frailty assessments.

In order to make the frailty assessments comparable, each assessment was converted into having one cut-off for frailty (Table 18). This was done by combining all levels of frailty, such as pre-frail, moderately frail or severely frail into the classification of frail, and non-frail was left as its original value. Whilst this data reduction will lead to a reduction of information to be drawn out of the analysis, splitting the assessments into a dichotomy allows for comparisons to be made.

Table 18: Frailty scores involved in this study, identifying the range of possible scores within the assessment and the ranges of what is considered non-frail, and what is considered frail.

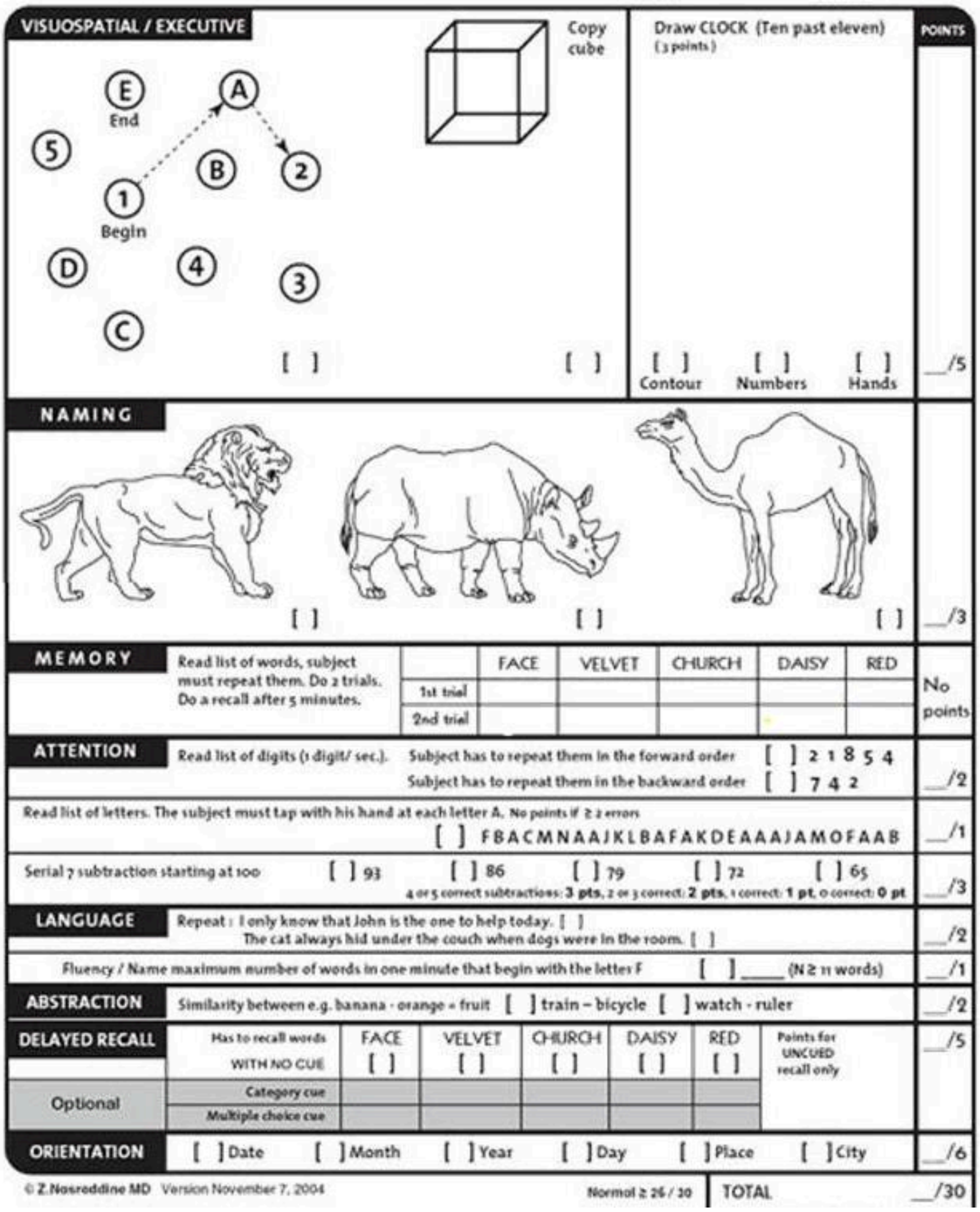
Frailty assessment	Range	Non-frail	Frail
CFS	1-9	≤3	>3
AD	0-100%	≤8%	>8%
FP	0-5	0	1-5
FRAIL	0-5	0	1-5
EFS	0-5	0	1-5
GFST	0-6	0	1-6
Poly	Continuous	≤4 medications	>5 medications
PRISMA 7	0-7	0-2	3-7
FiND	0-3	0	1-3
Gait speed	Continuous	Men: <7s for height ≤173cm <6s for height >173cm Women: <7s for height ≤159cm <6s for height >159cm	Men: ≥7s for height ≤173cm ≥6s for height >173cm Women: ≥7s for height ≤159cm ≥6s for height >159cm

CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale,

5.2.3: Cognition and delirium

During the pre-operative period, patient-reported cognitive impairment and a measured cognitive impairment were collected. Patient self-reported cognition was collected from the routine pre-assessment proformas. Baseline cognitive function of patients was tested using the Montreal Cognitive Assessment (MoCA). The MoCA measures a patient's cognition out of a score of 30, where a score of 26 or above is considered not cognitively impaired (Figure 15).

Figure 15: An example of the Montreal Cognitive Assessment used in this study



Post-operatively, delirium was assessed using the 4AT score if the patient had any morbidities throughout their time recovering as an in-patient. This measures the patients alertness, ability to recall their age, date of birth, current location and the current year, as well as measuring their attention and any fluctuations. This is measured out of a total score of 12, with zero being no delirium, one to three indicating possible cognitive impairment, and a score of four or above indicating possible delirium and cognitive impairment.

5.2.4: Sarcopenia

Sarcopenia data were also collected for patients from this pre-operative assessment; hand grip strength and walk speed data were collected as part of the FP assessment. These are also key components of the European Working Group of Sarcopenia in the Older Population (EWGSOP) classification of sarcopenia (Cruz-Jentoft *et al*. 2010). Sarcopenia in this study was defined by the EWGSOP criteria. The EWGSOP algorithm was followed. Gait speed was collected by asking the patient to walk a timed 4 meters, at their typical pace. The hand grip strength was collected using a Takei 5401 handgrip dynamometer, with the participant using their non-dominant hand. Computerised tomography (CT) scans were assessed for muscle mass, when available. The method used to identify muscle mass for the EWGSOP, demonstrated in Chapter 4:, is explained by Cruz-Jentoft (Cruz-Jentoft *et al*. 2010). Where CT scans were not available, participants who would have been required to have their muscle mass measured by the EWGSOP algorithm were described as ‘at risk of being sarcopenic’.

5.2.5: Intra-operative and post-operative data

Intra-operative data were collected from the operative note, available from the electronic patient records, such as any complications and volume blood loss. Participants were visited post-operatively on days 3, 5, 7, 14 and every week following then until they were discharged from hospital. Participants were assessed during their in-hospital recovery for morbidity, as measured by the post-operative morbidity scale (POMS), and post-operative delirium, as measured by the 4AT delirium assessment. Participants who had one or more morbidities recorded by the POMS assessment had a 4AT assessment performed where possible, whereas those who had no morbidity measured did not have a 4AT completed. Researchers also checked the patient medical records to assess whether delirium was documented by the healthcare staff. This is due to post-operative delirium being easy to miss and can ebb and flow in terms of severity.

At 30-days, surgical outcomes were recorded. Surgical outcomes collected for this study were post-operative complications (as defined by the Clavien Dindo classification system), discharge location, extended length of hospital stay (ELoS) and mortality. ELoS was measured by a difference of three or more days longer than the expected length of stay, which in turn was measured by BUPA surgical guidelines (BUPA 2005) and adjusted by the operating surgeon where appropriate using the routinely collected surgical prediction of length of stay.

5.2.6: Statistical analyses

Statistical analyses for this study were performed on SPSS (SPSS Inc. 2016). The data were normally distributed, using individual Q-Q plots. For all analyses, missing data were treated in line with pair-wise deletion (Graham 2009). The Kappa statistic was used to measure the agreement between the frailty assessments. The relationship between frailty assessments and cognitive impairment, as identified by the MoCA, was investigated. Spearman's correlation was used to analyse the correlation, the Kappa statistic was used to assess the agreement, and an independent T-test was used to determine the association between frailty assessments and cognitive impairment.

A T-test was used to determine if there was a difference between cognitive impairment as identified by the MoCA and the routinely collected cognitive impairment information, from the pre-assessment proforma. A Mann-Whitney U test was employed to determine if there was a difference in those who had post-operative delirium between those who were cognitively impaired pre-operatively and those who were cognitively robust as determined by the MoCA. This non-parametric test was chosen as this was felt to be more appropriate, considering how the MoCA is scored. The relationship between frailty assessments and pre-assessment falls indicators was investigated to determine whether there is a significant difference between the two measures. Spearman's correlation was used to analyse the concordance, Kappa statistics were used to assess the agreement, and independent T-tests were used to determine a difference between frailty assessments and falls.

T-tests were used to determine if there was a statistical difference between frail (by all methods of assessment) and healthy participants with regards to the following outcomes: ELoS, extended surgical duration, post-operative complications, re-admission to hospital, change of residence from pre-operative to post-operative, and 30-day mortality. T-tests were used to investigate the difference between cognitively impaired patients and post-operative outcomes. T-tests were also used to investigate differences between sarcopenic patients and post-operative outcomes. Contingency analyses were used to assess the likelihood ratios for the predictive value of frailty, sarcopenia and cognitive impairment and for post-operative outcomes.

External statistical advice was sought to determine power of this study. The primary aim of the study is to determine agreements between the different frailty assessments. Independent statistical advice was sought, and a Cohen's kappa-based two-tailed sample size calculation for this study was performed. The statistical significance level for this study was set at $P<0.05$, with a power of 0.8. A conservative standard deviation estimate of 1.0 was assumed, and a further 16% participants was added for the use of non-parametric analyses. This sample size calculation identified that this study required 94 subjects.

5.3: Results

One hundred and one participants were recruited, 54 of whom were male. The mean (SD) age of participants was 74 (6), with 7 participants aged over 85 years old. Seventy participants had cancer at the time of their surgical pre-assessment. The mean BMI (SD) was 28.0 (5.2). The median ASA grade was 2, ranging from 1 to 4 (Table 19). Ninety-one operations were performed at the time of writing this thesis. Ninety seven participants were planned to have in-hospital stays, with the remaining four being planned as day cases. The surgical procedures performed can be seen in Table 20.

Table 19: Participant preoperative and postoperative characteristics

		101 participants (100%) Number (%)
Mean age (SD), years		74 (6)
Age range		65 - 89
Sex		
	Male (%)	54 (53.5)
Mean Body Mass Index (SD)		28.0 (5.2)
ASA score		
	Median	2
	IQR	2-3
Postoperative environment		
	Home (%)	3 (3.3)
	Ward (%)	64 (70.3)
	HDU (%)	23 (25.3)
	ICU (%)	1 (1.1)
Median postoperative ELoS		7
Inter-quartile range		5-7
Discharge destination		
	Home (%)	89 (97.8)
	Nursing home (%)	1 (1.1)
	Died in hospital (%)	1 (1.1)

Data are presented as Mean (standard deviation (SD)) or Number (percentage) where indicated. ELoS: extended length of hospital stay.

Table 20: Frequency of surgical procedures in 91 participants recruited into the study

Surgical procedure	Frequency (%)
Left hemi-colectomy	3 (3.3)
Right hemi-colectomy	30 (33.0)
Anterior resection	40 (43.9)
Laparotomy	5 (5.5)
Mesh Rectopexy	4 (4.4)
Surgery for intestinal continuity	2 (2.2)
Proctocolectomy	3 (3.3)
Examination under anaesthesia	4 (4.4)

5.3.1: Agreement between frailty assessments

The frailty assessment outcomes and the kappa statistics are shown in Table 21. There was a wide spread cross different assessments of how many participants who were identified as healthy (range 26.7% - 84.2%) and those who were identified as frail (range 15.8% - 73.3%).

Table 21: Prevalence of frailty and Kappa statistic agreement between frailty assessments

Upper triangle: Significance x 10^3; lower triangle: Cohen's Kappa Agreement x 10^3

	CFS	AD	Gait	FP	FiND	Poly	GFST	EFS	FRAIL	Prisma7	
CFS		008	544	341	823	093	145	544	001	<001	
AD	129		869	456	126	<001	008	869	<001	<001	
Gait	-058	-010		<001	457	526	<001	042	074	722	
FP	-047	-074	224		672	951	124	632	250	447	
FiND	022	077	-072	022		756	291	625	<001	784	
Poly	123	369	-055	-005	023		070	526	<001	011	
GFST	083	261	297	151	062	171		420	<001	266	
EFS	-058	-010	203	030	047	-055	057		953	162	
FRAIL	252	395	156	101	273	346	431	-005		<001	
Prisma7	448	235	-035	-050	026	224	082	-139	317		
Prevalence											Mean (s.d.)
Healthy # (%)	85 (84.2)	27 (26.7)	76 (75.2)	28 (27.7)	84 (83.2)	51 (50.5)	35 (34.7)	76 (75.2)	52 (51.5)	74 (73.3)	58.1 (23.0)
Frail # (%)	16 (15.8)	74 (73.3)	25 (14.8)	73 (72.3)	17 (16.8)	50 (49.5)	66 (65.3)	25 (24.8)	49 (48.5)	27 (26.7)	42.2 (21.9)

Key for value of Kappa	Significant	Non-significant
Negative Disagree		
000 – 200 None		
201 – 400 Fair		
401 – 600 Moderate		
601 – 800 Substantial		
801 – 1000 Almost perfect		

Kappa analyses between nine frailty assessments: CFS; clinical frailty scale. AD; 36-point accumulative deficit. Gait; gait speed. FP; frailty phenotype. FiND; frailty, non-disabled. FRAIL; fatigue, resistance, ambulatory, illness and loss of weight. EFS; Edmonton frailty scale. GFST; Gerontopole frailty screening tool. Poly; polypharmacy, 5+ medications. Results displayed as Value x 10^3 and background colour of Kappa agreement explained in key above. Statistical significance $P < 0.05$.

5.3.2: Surgical outcomes: occurrence, association and prediction

Table 22: Post-operative complications, re-admission to hospital for the 91 participants

Outcome measure		
Clavien Dindo Grade	0	62 (68.1%)
	1	8 (8.8%)
	2	15 (16.5%)
	3	5 (5.5%)
	4	0 (0%)
	5	1 (1.1%)
Post-operative complications	Anastomotic leak	1 (1.1%)
	Bleeding	1 (1.1%)
	Constipation	1 (1.1%)
	Fever	8 (8.8%)
	Hypotension	3 (3.3%)
	Ileus	13 (14.3%)
	Infection	6 (6.6%)
	Pain - requiring management	2 (2.2%)
	Pneumonia (hospital-acquired)	2 (2.2%)
	Small bowel obstruction	2 (2.2%)
	Wound drainage required	2 (2.2%)
	Other	5 (5.5%)
Readmission	No readmission	81 (89.0%)
	Readmitted	9 (9.9%)
	Died in-hospital prior to initial discharge	1 (1.1%)
Readmission causes	Anastomotic leak	1 (1.1%)
	Bleeding	1 (1.1%)
	Bowel obstruction	1 (1.1%)
	Pain	2 (2.2%)
	Vomiting	1 (1.1%)
	Wound infection	1 (1.1%)
	Other	2 (2.2%)

Patients may have suffered one or more complications as part of their surgical recovery. Values in post-operative complications do not equal the total number of patients who had complications as a result of one or more complication being present in an individual patient's recovery.

Descriptions of post-operative complications can be seen in Table 22. The mean difference between the observed length and expected length of stay was 4.0 days (SD 13.7). The mean overall length of stay in hospital was 10.4 days (SD 14.0). There was no statistically significant difference between the difference in length of stay between those who are frail and those who are healthy (p>0.05). There was also no difference identified for those with cognitive impairment (p=0.38) and those with sarcopenia (p=0.40) (Table 23).

Twenty-nine patients had post-operative complications, 11 with more than one complication. There was no statistical difference between those who were frail or healthy, as defined by any frailty assessment, and occurrence of post-operative complication (Chi Square p>0.05). There was also no significant difference seen in patients with cognitive impairment (p=0.58) or sarcopenia (p=0.17) (Table 25). The results for similar analyses for 30-day post-operative readmission can be seen in Table 26. Participants were assessed in hospital throughout their post-operative recovery using POMS (Table 27) and, if morbidity was recorded, 4AT for delirium (Table 28).

Table 23: Analysis of contingency tables, investigating associations and predictive relationships between frailty, sarcopenia and cognitive impairment with extended length of stay

Extended Length of Stay						
Method	RR (CI)	PPV	NPV	Sensitivity	Specificity	LR
CFS	1.27 (0.66 - 2.44)	86.44	18.75	66.23	42.86	1.16
AD	1.02 (0.64 - 1.64)	28.81	71.88	65.38	35.38	1.01
Gait	0.86 (0.54 - 1.37)	23.73	71.88	60.87	33.82	0.92
FP	0.88 (0.47 - 1.64)	71.19	25.00	63.64	32.00	0.94
FiND	1.27 (0.80 - 2.00)	55.93	53.13	68.75	39.53	1.14
Poly	0.87 (0.40 - 1.88)	81.36	15.63	64.00	31.25	0.93
GFST	0.86 (0.54 - 1.36)	32.20	62.50	61.29	33.33	0.92
EFS	1.09 (0.62 - 1.94)	74.58	28.13	65.67	37.50	1.05
FRAIL	1.37 (0.87 - 2.16)	55.93	56.25	70.21	40.91	1.19
Prisma7	1.55 (0.95 - 2.53)	79.66	34.38	69.12	47.83	1.33
MoCA	1.51 (0.89 - 2.57)	35.59	76.67	75.00	37.71	1.20
Sarcopenia	0.87 (0.47 - 1.59)	64.29	31.03	64.29	31.03	0.93

RR: risk ratio, CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value, LR: likelihood ratio, CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale, MoCA: Montreal Cognitive Assessment

Table 24: Analysis of contingency tables, investigating associations and predictive relationships between frailty, sarcopenia and cognitive impairment with an increased post-operative care level

Increased post-operative care level, unplanned						
Method	RR (CI)	PPV	NPV	Sensitivity	Specificity	LR
CFS	1.38 (0.63 - 2.99)	86.36	20.00	74.03	35.71	1.15
AD	1.60 (0.81 - 3.16)	31.82	80.00	80.77	30.77	1.17
Gait	3.89 (1.14 - 13.27)	31.82	92.00	91.30	33.82	1.38
FP	1.76 (0.98 - 3.15)	77.27	40.00	77.27	40.00	1.29
FiND	1.03 (0.57 - 1.86)	53.03	48.00	72.92	27.91	1.01
Poly	0.89 (0.36 - 2.23)	81.82	16.00	72.00	25.00	0.96
GFST	3.79 (1.51 - 9.53)	42.42	88.00	90.32	36.67	1.43
EFS	0.70 (0.30 - 1.63)	71.21	20.00	70.15	20.83	0.89
FRAIL	1.36 (0.77 - 2.40	54.55	56.00	76.60	31.82	1.12
Prisma7	1.39 (0.73 - 2.66)	77.27	32.00	75.00	34.78	1.15
MoCA	1.18 (0.65- 2.15)	32.81	72.00	75.00	29.51	1.06
Sarcopenia	10.14 (5.14 - 20.00)	86.67	84.00	92.86	72.41	3.37

RR: risk ratio, CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value, LR: likelihood ratio, CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale, MoCA: Montreal Cognitive Assessment

Table 25: Analysis of contingency tables, investigating associations and predictive relationships between frailty, sarcopenia and cognitive impairment with post-operative complications

Post-operative complications						
Method	RR (CI)	PPV	NPV	Sensitivity	Specificity	LR
CFS	1.15 (0.54 - 2.45)	85.48	17.24	68.83	35.71	1.07
AD	0.89 (0.53 - 1.48)	27.42	68.97	65.39	30.77	0.94
Gait	1.26 (0.73 - 2.17)	30.65	75.86	73.08	33.85	1.11
FP	1.19 (0.66 - 2.15)	74.19	31.04	69.70	36.00	1.09
FiND	1.58 (0.97 - 2.59)	58.07	58.62	75.00	39.54	1.24
Poly	0.75 (0.31 - 1.85)	80.65	13.79	66.67	25.00	0.89
GFST	1.62 (0.94 - 2.81)	38.71	75.86	77.42	36.67	1.22
EFS	0.89 (0.45 - 1.76)	72.58	24.14	67.16	29.17	0.95
FRAIL	1.51 (0.92 - 2.48)	56.45	58.62	74.47	38.64	1.21
Prisma7	0.94 (0.48 - 1.85)	74.19	24.14	67.65	30.44	0.97
MoCA	1.21 (0.72 - 2.03)	33.33	72.41	71.43	34.43	1.09
Sarcopenia	1.55 (0.91 - 2.62)	70.69	44.44	73.21	41.38	1.25

RR: risk ratio, CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value, LR: likelihood ratio, CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale, MoCA: Montreal Cognitive Assessment

Table 26: Analysis of contingency tables, investigating associations and predictive relationships between frailty, sarcopenia and cognitive impairment with 30-day readmisison to hospital

Re-admission to hospital within 30 days						
Method	RR (CI)	PPV	NPV	Sensitivity	Specificity	LR
CFS	3.55 (0.91 - 13.83)	87.81	37.50	93.51	23.08	1.22
AD	2.84 (0.22 - 37.67)	30.49	87.5	96.15	10.94	1.08
Gait	0.97 (0.19 - 5.08)	24.39	75.00	90.91	8.82	1.00
FP	1.56 (0.38 - 6.48)	73.17	37.50	92.31	12.00	1.05
FiND	3.43 (0.64 - 18.40)	56.10	75.00	95.83	14.29	1.12
Poly	1.67 (0.34 - 8.18)	84.15	25.00	92.00	13.33	1.06
GFST	3.68 (0.28 - 49.14)	36.59	87.50	96.77	11.86	1.10
EFS	Unable to perform; no frail patients readmitted			87.88	0	0.88
FRAIL	1.82 (0.43 - 7.66)	53.66	62.50	93.62	11.63	1.06
Prisma7	4.58 (1.13 - 18.65)	76.83	62.50	95.46	20.83	1.21
MoCA	3.27 (0.25 - 43.38)	33.75	87.50	96.43	11.67	1.09
Sarcopenia	1.90 (0.49 - 7.42)	67.11	50.00	92.73	13.79	1.08

RR: risk ratio, CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value, LR: likelihood ratio, CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale, MoCA: Montreal Cognitive Assessment

Table 27: Post-operative morbidity results from post-operative follow up of 91 participants

Post-operative morbidity survey		Day 3	Day 5	Day 7	Day 14	Day 21
Discharged from hospital		31 (34.1)	45 (49.5)	63 (69.1)	82 (90.1)	84 (92.3)
In hospital without morbidity		25 (27.5)	21 (23.0)	7 (7.8)	2 (2.1)	3 (3.3)
In hospital with morbidity		35 (38.4)	25 (27.5)	21 (23.1)	7 (7.8)	4 (4.1)
Morbidity*	Pulmonary	13 (38.2)	1 (4.0)	1 (4.8)	0 (0.0)	0 (0.0)
	Infectious	6 (17.6)	9 (36.0)	6 (28.6)	5 (71.4)	2 (50.0)
	Renal	22 (64.7)	13 (52.0)	11 (52.4)	3 (42.9)	0 (0.0)
	Gastrointestinal	11 (32.4)	10 (40.0)	10 (47.6)	0 (0.0)	1 (25.0)
	Cardiovascular	2 (5.9)	0 (0.0)	1 (4.8)	0 (0.0)	0 (0.0)
	Neurological	2 (5.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Wound	0 (0.0)	0 (0.0)	2 (9.5)	1 (14.3)	1 (25.0)
	Haematological	1 (2.9)	1 (4.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Pain	17 (50.0)	7 (28.0)	6 (28.6)	1 (14.3)	1 (25.0)
Ambulation**						
	Unaided	37 (62.7)	32 (69.6)	18 (64.3)	6 (66.7)	4 (57.1)
	Aided	20 (33.9)	13 (19.7)	8 (28.6)	2 (22.2)	2 (28.6)
	Zimmer	0 (0.0)	0 (0.0)	1 (3.6)	1 (11.1)	0 (0.0)
	Bedbound	2 (2.9)	0 (0.0)	1 (3.6)	0 (0.0)	0 (0.0)

Participants frequently had more than one morbidity in-hospital, meaning the sum of morbidities in hospital will not match the number of 'in hospital with mortality' follow up values.
** Percentages of morbidity are related to the number in hospital with morbidity.*
*** Percentages of ambulation are related to the total number of participants in hospital.*

5.3.3: Relationship with frailty and sarcopenia, falls risk and cognitive impairment

5.3.3.1 Sarcopenia

Ten participants did not have CT scans relevant to their surgical procedure, or within 6 months of their operation. According to the EWGSOP guidelines, 45.1% participants had low grip strength, 27.5% had poor gait speed, and 65.9% had low muscle mass. Thirty-one out of ninety-one (34.1%) participants were sarcopenic, as defined by the EWGSOP criteria (Table 29).

5.3.3.2 Cognitive impairment

The pre-assessment clinic routinely identifies self-reported cognitive impairment in the assessment proforma. This process identified that there was no presence of cognitive impairment in the recruited population. Seventy (69.3%) participants were identified as cognitively impaired as a result of the MoCA, which was statistically different to the pre-assessment clinic routinely collected data ($p<0.001$). The majority of assessment points were lost through remembering words over a short-term period of time. Many participants were unable to remember the five words as part of the assessment unprompted; 'Face' (60%), 'Velvet' (44.6%), 'Church' (58.4%), 'Daisy' (70.3%), and 'Red' (60%). There was little association across all assessments for both agreement and correlation with cognitive impairment (Table 28). There was a significant difference between the results of the MoCA and the CFS ($p<0.001$) and FiND ($p=0.019$), though not with the other frailty measures.

Few participants were identified to have post-operative impairment or delirium on day 3 postoperative (5%), or day 7 (1%), as seen in Table 28. There was too low of an incidence for post-operative delirium to identify any meaningful difference between those who were cognitively impaired pre-operatively and those who were cognitively robust ($p=0.25$ to $p=0.62$).

Table 28: Post-operative delirium, as identified by the 4AT assessment, up to 21 days after surgery

Delirium	Day 3	Day 5	Day 7	Day 14	Day 21
Not performed	71 (70.3)	73 (72.3)	80 (79.2)	97 (96.0)	100 (99.0)
Healthy	25 (24.7)	28 (27.7)	20 (19.8)	4 (4.0)	1 (1.0)
Impaired	2 (2.0)	0 (0.0)	1 (1.0)	0 (0.0)	0 (0.0)
Impaired & delirium	3 (3.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Mann Whitney U with pre-operative cognitive impairment (P)	0.250	1.000	0.617	1.000	1.000

'Not performed' accounts for patients who have been discharged and who have not had the 4AT assessment performed that day, due to limited availability of the research nursing staff to perform the post-operative morbidity survey, which prompts the use of the 4AT delirium assessment.

5.3.3.3 Falls

The relationship between pre-operative frailty and pre-operative falls risk was investigated as a secondary aim of this study. Six participants had experienced two or more falls in the past year, Eighteen had difficulties walking and 10 had a fear of falling. One or more of the falls questions in the routinely collected pre-assessment proforma indicates a falls plan requirement. This study identified 20 participants as being at risk of falls. There was a very weak to moderate correlation identified between frailty and falls ($R=0.199$, $p=0.046$ to $R=0.446$, $p<0.001$). Six frailty assessments (CFS, AD, Polypharmacy, GFST, FRAIL and PRISMA 7) showed a statistical difference between those who were either a falls risk or not a falls risk (Table 31).

Table 29: Correlation, agreement and differences between sarcopenia, as identified by the European Working Group of Sarcopenia in Older People criteria, with frailty assessments

Sarcopenia		CFS	AD	Gait	FP	FiND	Poly	GFST	EFS	FRAIL	PRISMA7
Spearman's	R	-0.049	0.027	0.436	0.442	-0.194	0.002	0.370	0.009	0.156	-0.027
	P	0.642	0.801	<0.001	<0.001	0.065	0.988	<0.001	0.934	0.141	0.801
Kappa	K	-0.043	0.020	0.426	0.327	-0.174	0.001	0.302	0.009	0.150	-0.027
	P	0.637	0.798	<0.001	<0.001	0.064	0.988	<0.001	0.933	0.138	0.798
Independent T-test	P	0.642	0.801	<0.001	<0.001	0.065	0.988	<0.001	0.934	0.141	0.801

CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale.

Table 30: Correlation, agreement and differences between cognitive impairment, as identified by the Montreal Cognitive Assessment, with frailty assessments

Cognition		CFS	AD	Gait	FP	FiND	Poly	GFST	EFS	FRAIL	PRISMA7
Spearman's	R	-0.044	0.206	-0.022	-0.044	-0.036	-0.128	-0.013	-0.007	0.059	-0.045
	P	0.664	0.042	0.830	0.664	0.724	0.210	0.900	0.946	0.562	0.659
Kappa	K	-0.029	0.103	-0.022	-0.029	-0.036	-0.068	-0.012	-0.007	0.039	-0.041
	P	0.660	0.041	0.828	0.660	0.721	0.206	0.898	0.946	0.558	0.655
Independent T-test	P	<0.001	0.662	0.404	0.446	0.019	0.881	0.892	0.224	0.675	0.404

CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale.

Table 31: Correlation, agreement and differences between falls indicators routinely collected by pre-assessment staff, with frailty assessments

Falls		CFS	AD	Gait	FP	FiND	Poly	GFST	EFS	FRAIL	PRISMA7
Spearman's	R	0.446	0.119	-0.011	-0.010	-0.035	0.176	0.117	0.102	0.235	0.407
	P	<0.001	0.046	0.912	0.923	0.729	0.079	0.245	0.311	0.018	<0.001
Kappa	K	0.440	0.113	-0.011	-0.006	-0.035	0.144	0.076	0.101	0.194	0.402
	P	<0.001	0.045	0.912	0.922	0.726	0.077	0.241	0.306	0.018	<0.001
Independent T-test	P	<0.001	<0.001	0.822	0.849	0.476	0.017	0.005	0.077	0.004	0.001

CFS: clinical frailty scale, AD: accumulation deficit, Gait: gait speed, FP: frailty phenotype, FiND: frailty non-disabled screening tool, Poly: polypharmacy 5+ medications, GFST: Gerontopole frailty screening tool, EFS: Edmonton frailty scale, FRAIL: the FRAIL scale.

5.4: Discussion

The population recruited in this study had a mean (SD) age of patients at 74 (6) years, mean (SD) BMI of 28 (5.1) kg/m^2, and 53.5% of those whom were recruited male. These values are not dissimilar from other publications in the field for colorectal surgery (Reisinger *et al*. 2015; Gatta *et al*. 2003; Ommundsen, Torgeir B Wyller, *et al*. 2014). indicating that these may be comparable results to others found in literature.

5.4.1: Agreement between frailty assessments

Prevalence of frailty ranged from 15.8% to 73.3%, depending on the frailty assessment tool used. Frailty assessments had varying levels of agreement, from K=0.074 to K=0.448 (from no agreement to moderate agreement). The AD and FRAIL assessments both had moderate agreement with five other frailty measures (ranging from K=0.129 to K=0.369, and K=0.252 to K=0.431 respectively). No measures had strong agreement between each other. The relationship between frailty assessments is incompletely reported, which is problematic due to literature considering frailty diagnosable through so many methods. With little agreement between different measures, practitioners and researchers cannot be confident that it is in fact frailty that they are measuring, but potentially components of frailty or potentially similar conditions. There is a lack of consistency regarding the domains that frailty definitions include. It may be that these tools are specifically constructed to assess frailty in their original populations, and that translation of these tools into other populations may not be entirely appropriate without modification.

Frailty, and sarcopenia, are scalar conditions in that they range from healthy, through stages of pre-frailty and mildly sarcopenic, to severely frail or severely sarcopenic. The methods involved in assessing for these include cut-offs, which separate the results of the assessments into different groups. This work dichotomised patients into robust or frail, classing those who would have been identified as pre-frail as frail, which may increase the sensitivity of the assessments. The assessments being dichotomised also does not allow for investigations into the state of pre-frailty.

5.4.2: Surgical outcomes: occurrence, association and prediction

Twenty-nine out of ninety-one patients had a post-operative complication, nine patients were re-admitted to hospital within 30-days and one patients died. The likelihood ratios for all frailty assessments, sarcopenia and cognitive impairment in relation to adverse surgical outcomes were all close to unity. The knowledge of the result of a frailty assessment would not change our belief about the likelihood of a post-operative complication (McGee 2002). The majority of assessments had poor negative predictive values for an extended length of stay and post-operative complications. There were also high false rates given by low specificities.

The positive and negative predictive values were more supportive for the clinical use of the frailty assessments with regards to identifying those re-admitted to hospital within 30-days. Indeed, PRISMA 7 had the best ratio between positive and negative predictive values (76.8, 62.5 respectively). There was no statistically significant difference between frailty assessments, sarcopenia or cognitive impairment for post-operative readmission, ELoS and post-operative complications. This may indicate that the associations, or even predictive ability, of these pre-operative screening assessments with post-operative adverse events may be limited. This may be linked to the construct validity of these assessments.

The overall construct validity – a validation of whether frailty assessments indeed measure what they are intended to – for the different frailty measures has not been completely assessed in the colorectal surgical population. This is likely because there is no 'gold standard' measure for frailty to compare against, and the definitions of frailty are so varied. Additional work to understand the construct validity of these frailty measures in colorectal surgery is important before using the frailty measures to tailor care for vulnerable surgical patients. These frailty assessments also require consequential, content, structural and generalizability validity assessments to be constructed before a definitive decision could be made as to which frailty assessment is best (Messick 1989).

The risk ratios of the assessments were poor in relation to having an extended length of stay (RR 0.86 - 1.51) and post-operative complications (RR 0.75 - 1.58). CFS, AD, FiND, GFST and PRISMA 7 had stronger associations of patients being re-admitted to hospital within 30-days of discharge (RR 3.55, 2.84, 3.43, 3.68, 4.58 respectively). Gait speed and GFST had the greatest risk ratios for an increase in post-operative care level required, out of the frailty assessments (RR 3.89, 3.79 respectively). All frailty assessments were more sensitive than specific, though the sensitivity of these tools for 30-day readmission is markedly greater than with other outcomes (sensitivity range: 87.88 - 96.78). The specificities of these tools for readmission are quite poor (specificity range: 0 - 23.08) meaning that a large proportion of patients are likely to be identified as frail who do not require re-admission post-operatively. This is reflected in the likelihood ratios of the frailty assessments being close to unity, for 30-day readmission, post-operative complications, unplanned increase of care requirements and extended length of hospital stay.

The results of this study could inform power calculations for specific studies investigating the relationship between frailty and a specific adverse outcome, and to determine whether an intervention would reduce the prevalence of the outcome. This would support the adoption of the frailty assessment into routine practice, and aid how healthcare professionals could support the intervention of frailty in the surgical pathway.

5.5: Relationship with frailty and sarcopenia, falls risk and cognitive impairment

5.5.1: Sarcopenia

Sarcopenia did not have a significant risk ratio for an extended length of stay (RR 0.87, CI 0.47 - 1.59), post-operative complications (RR 1.55, CI 0.91 - 2.62) or 30-days re-admission to hospital (RR 1.90, CI 0.49 - 7.42). Patients who were sarcopenic were 3.37 times more likely to require an unplanned high-dependency or intensive care bed. This may indicate that sarcopenia measured pre-operatively could indicate as to whether patients may require a greater level of post-operative care. Current practice is that clinicians use their current experience and clinical intuition to determine what post-operative bed a patient would require. Formal testing of combining clinical intuition with sarcopenia assessment may collectively aid surgical planning of post-operative care requirements is required.

Patients who were sarcopenia were more 3.37 times more likely to require an increased level of care immediately following surgery than previously expected (RR 10.14, CI 5.14-20.00). This could potentially support the use of pre-operative sarcopenia assessments, especially if CT scans are a part of standard routine care, to predict the likelihood of future patients requiring a high-dependency or intensive care bed following their surgical procedure.

Sarcopenia had statistically significant moderate correlations and agreements with gait speed, FP and the GFST. There was also a statistically significant difference between frail and non-frail patients, as identified by gait speed, FP and GFST, in comparison with their sarcopenia status ($p<0.001$); those who were frail were significantly more likely to be sarcopenic in comparison to those who were more robust. As gait speed is a component of sarcopenia and GFST, and hand grip strength is a component of the FP assessment as well as the EWGSOP sarcopenia classification, a relationship of some descript is not too surprising. However, in GFST, gait speed is only one of many domains (and in FP, gait speed and grip strength are 2/5 domains) that factor in the frailty measure output. It may be that the incorporation of gait and grip into frailty can indicate potential sarcopenia.

5.5.2: Cognitive impairment

Cognitive impairment prevalence, in surgical patients aged 65 years or older, has been reported to be 56%. Pre-assessment identified no patients as cognitively impaired, which was significantly different to our data, where 71.4% of patients were cognitively impaired ($p<0.001$). Only 5.0% had post-operative cognitive impairment/delirium. This may partially be because two different tools were used, though this likely would not account for such a dramatic difference. This difference in prevalence of delirium seems to indicate that you are not necessarily likely to have post-operative delirium episodes if you're cognitively impaired pre-operatively. This is contradictory to publications in this field (Vijayakumar *et al*. 2014; Robinson 2008). A study designed with the relationship between pre- and post-operative delirium or cognitive impairment in the frail surgical patient would be able to prove better insight into this particular dynamic. Consideration should also be made as to the fluctuating nature of post-operative delirium and that it is easy to miss in a busy ward environment without additional observations or additional prompts looking specifically for this (Eeles *et al*. 2012). It may have been that, as a result of our methodology and the nature of delirium, identification was missed and our results are not representative of the true prevalence of post-operative delirium.

Agreement between frailty measures and cognitive impairment may indicate that the particular frailty measure incorporates cognition into its function. There were poor correlations and agreement found between cognitive impairment, as identified by the MoCA, and frailty measures. Only the AD assessment reached significance for its poor agreement ($p=0.041$) and very weak correlation ($p=0.042$) with cognitive impairment. There was a statistically significant difference found between cognitive impairment with the CFS ($p<0.001$) and FiND ($p=0.019$), though not with any other frailty assessment. Neither CFS nor FiND takes into account cognitive impairment, so this is an interesting finding. It may be that this is incidental and that further validation in other populations is needed before integrating these assessments to identify patients at increased risk for cognitive impairment.

Pre-operative cognitively impaired patients were more at risk of re-admission to hospital (RR 3.27, CI 0.26 - 43.38). However, the confidence intervals are wide for this result, and the likelihood ratio is close to unity (LR 1.09). Our results suggest there may be a relationship between cognitive impairment and post-operative complications, though for a more concrete understanding of this relationship, a more specifically designed study to investigate this interaction further would support the idea of revising current practice to incorporate a more subjective assessment of cognitive impairment.

5.5.3: Falls risk

There was a significant difference in a number of frailty measures between those who were identified before surgery as being at increased risk for falls. Significant associations were found for CFS, AD, polypharmacy, GFST, FRAIL and PRISMA 7 ($p<0.001$, $p<0.001$, $p=0.017$, $p=0.005$, $p=0.004$, $p=0.001$ respectively). This suggests that there may be scope for including the assessment of the risk of falls into a wider preoperative frailty assessment.

5.6: Limitations

A limitation could be derived from the consolidation of frailty assessments into one proforma, with duplications removed. A pilot was done to check whether the results of frailty assessments could feed into the condensed proforma, and that the results of our condensed proforma could then be expanded into the frailty assessments individually. There were no differences found in this process. It is unlikely that the flow that frailty assessments have are specifically designed in a way that is more valid than another. Even though this is unlikely, it is still a possibility, meaning conclusions drawn from this work should be mindful of the consolidation of frailty measures.

This study involved the examination of several different measures of frailty, as well as measures of sarcopenia, cognitive impairment and falls risk. Several different outcomes were examined. As a consequence multiple analyses were performed and there is a risk of false positive results. Associations reported in this work will require confirmation in future studies to reduce the possibility that these findings were as a result of chance.

The aim of this study was to compare frailty screening assessments, with secondary aims to investigate the relationship between frailty sarcopenia and cognitive impairment pre-operatively in a colorectal population. Our analyses investigate the relationship between pre-operative frailty measures and adverse surgical outcomes. There was an interesting finding that sarcopenia has a statistically significant relationship with unplanned post-operative increases of care required. It may be that this is a false positive result, and requires confirmation. However, this is still a result that warrants further probing as it may be of clinical relevance.

5.7: Conclusion

The relationship between frailty and post-operative outcomes in this study appears to vary depending on the frailty assessment used. Further work would be justified to identify which frailty assessment to incorporate into the surgical pathway. Sarcopenia as defined by the EWGSOP criteria on the other hand, has reasonable sensitivity and specificity for a change of post-operative increase in care level. Addition of sarcopenia pre-operatively into the work-up of colorectal cancer patients may support planning of post-operative care.

Our data suggest that cognitive impairment is poorly identified in surgical pre-assessment, in comparison to assessing pre-operative impairment using the MoCA. In order for the cognitive impairment information collected pre-operatively to be clinically informative, our data suggests revising current pre-assessment tools from collecting self-reported cognitive impairment to using a validated measures, such as the MoCA and further studies to test this.

Identification of sarcopenia or frailty pre-operatively could provide an opportunity to provide an intervention to optimise patients, in order to support their post-operative recovery. Understanding interventions that are best tailored to intervening sarcopenia, and the physical domains of frailty, may support patient recovery and improve functional independence of patients.

5.8: Investigations arising from these findings

In the thesis so far, I have demonstrated that perceptions of frailty identification differ, but a clear message from nursing staff was that should frailty be identified, there must be a method of supporting a patient. I have shown that frailty can be identified through different measures, and whilst they do not accurately map to each other, the Frailty Phenotype may be the most clinically practicable out of the measures investigated. I have also highlighted that sarcopenia measures may have some degree of association with identifying patients needing increased post-operative care. Sarcopenia may need functional assessments included, as well as the radiological assessment, as seen in the European Working Group of Sarcopenia in Older Persons algorithm.

In Chapter 5, I have shown that there are some associations with outcomes for both frailty and sarcopenia, and that whilst these may be difficult to incorporate in their current forms, there appears to be a dearth of information regarding the intervention of frailty and sarcopenia in the elderly. In order for screening measures to be of value, there should be an acknowledged treatment for the condition. Whilst a comprehensive geriatric assessment supports individuals considered to be frail, literature is growing regarding exercise interventions in the elderly. Translating an effective intervention into clinical practice is a significant undertaking, and requires evidence of the intervention being agreeable and efficacious.

The next chapter explores an exercise intervention in community-dwelling adults. This study collects pilot data for translating novel exercise science technology into a clinical population, showing feasibility for exercise interventions in frail or sarcopenic surgical patients.

Chapter 6: Supporting the Frail or Sarcopenic Patient

The work in this chapter investigates the feasibility of using a novel exercise trainer (the Eccentron^{TM}) to increase strength on older adults, with a short-term training intervention. This work occurred concurrently with the work in Chapter 5.

6.1: Introduction

When investigating how best to support the older adult in terms of intervening in frailty or sarcopenia, the extensive literature suggests that multiple methods are available (Lee *et al*. 2012; Ng *et al*. 2015; Cruz-Jentoft *et al*. 2014; Theou *et al*. 2011). A recent scoping review of interventions for frailty in community-dwelling older adults identified interventions in the following areas: exercise with or without nutrition, exercise with both nutrition and memory training, home modifications, prehabilitation physical therapy, and geriatric assessments (Puts *et al.*, 2018). There is need for clarity on each individual intervention before producing a larger scale complex intervention or implementing into a pre-operative setting. It may be possible to provide prehabilitation for patients, in order to optimise their health, prior to surgery (Gill *et al.*, 2003; Carli, Charlebois and Stein, 2010) though there is a limited time window in which pre-operative interventions can be performed. Interventions for frailty should either reduce the severity of frailty itself, or at least minimise the impact frailty has on a person's life.

The ideal intervention is clinically effective, feasible and cost effective. Nutritional interventions have often been reported as lacking efficacy (Ng *et al*. 2015; Forster *et al*. 2009). Exercise interventions are reported to have a direct impact on muscle strength and functional mobility – key domains of the frailty syndrome, as defined by the frailty phenotype (Forster *et al.*, 2009; Chen, Mao and Leng, 2014; Clegg, Dunhill and Trust, 2016). Exercise studies, however, are variable in how they are designed. Some exercise regimes have addressed balance issues patients may have, some on reducing falls and others into mobility (Labra *et al.*, 2015). The exercise can take the form of aerobic or resistance, or a variety of both (Labra *et al.*, 2015). Both forms of exercise are feasible in older adult populations (Carvalho, Mota and Soares, 2003). The American College of Sports Medicine has previously recommended the adoption of strength training into exercise interventions in order to support older adults with muscular strength and musculoskeletal health (Hurley and Hagberg, 1998; Carvalho, Mota and Soares, 2003). A meta-analysis of resistance exercise in older adults identified a possible 29% increase in strength (Peterson *et al.*, 2010).

Strength is vitally important in performing activities of daily living, and retaining independence. Strength in lower limbs is associated with mobility and balance, in comparison to upper body strength being used during carrying shopping and doing housework such as vaccuuming (Bautmans *et al*. 2008; Lauretani *et al*. 2003; Cockburn *et al*. 2015; Guralnik *et al*. 2000; Al Snih *et al*. 2004). Lower limb strength is also of clinical value for surgical patients. An increased lower limb strength supports mobility and balance, which is critical for the early mobilisation requirements of enhanced recovery after surgery (Ljungqvist *et al*. 2017). In order to increase strength enough to support patients with in-hospital post-operative mobilisation, efforts to engage in exercise must occur pre-operatively.

Resistance exercise occurs in three different ways: concentric, eccentric and isometric (Verlag *et al.*, 1986). This can be understood through a comparison to movements found in cycling. Concentric exercise occurs when the feet press against the pedals, following the movements of the pedals. For concentric exercise, muscles shorten as they contract. Eccentric exercise is the opposite; eccentric exercise occurs when the pedals are moving forwards and the feet aim to move in the reverse motion, to resist the movement of the pedals. Muscles lengthen as they contract with eccentric exercise. Another example is the work done by the brachial muscules as they gently lower a heavy weight. Isometric exercise does not require movement. Isometric exercise takes place if force had to be applied to hold the pedals stationary.

The muscles remain the same length as they contract. Eccentric exercise, especially in clinical settings, has potential for training in older adults (Lastayo *et al.*, 2014). Eccentric exercise in older adults has been shown to involve less cardiovascular strain than concentric exercise (Vallejo *et al.*, 2006), with significant decreases in peak heart rate, systolic blood pressure and expired ventilation rate. The potential benefits this has are many, for example patients with diminished cardiopulmonary reserves may tolerate eccentric exercise more than concentric and engage better with this training modality. Another benefit is that eccentric may provide similar, or better, strength changes at the same exercise intensities in older adults without feeling as strenuous for the participants.

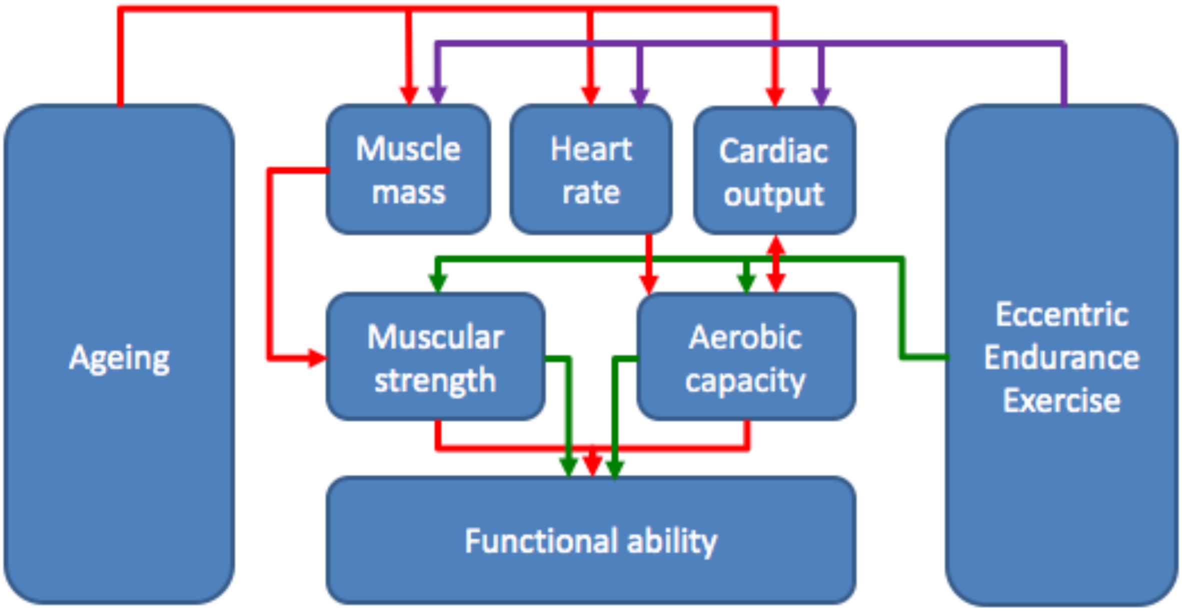


Figure 16: An illustration detailing the relationship between eccentric exercise, ageing and functional ability. EEE: eccentric endurance exercise, Red arrow: negative impact of ageing. Green arrow: positive effects of eccentric endurance exercise, Purple arrow: effects of eccentric endurance exercise not known (Gault *et al.*, 2013).

There is an understanding that eccentric exercise can be employed to counteract the decreased muscular strength present in older adults (Figure 16) (Gault *et al.*, 2013). There is currently an unknown relationship between eccentric exercise and muscle mass. There is also a lack of understanding of how eccentric exercise impacts functional ability. Understanding how eccentric exercise impacts on both functional ability and muscle mass loss due to ageing would support the design of exercise interventions for geriatric conditions, such as frailty and sarcopenia.

There are multiple ways to perform eccentric exercise (Tinwala *et al*. 2016). Eccentric resistance training can be done using free weights, resistance bands or with specialist equipment that promotes eccentric recruitment of muscles. With most methods, a degree of concentric exercise is employed. For example, resisting free weights eccentrically when leaving a bicep curl from a flexed position; concentric exercise was used to position the free weight in the flexed position initially. In order to understand the effects of eccentric exercise, it is necessary to isolate this training muscle action and measure its effects. A novel exercise machine, the Eccentron™, provides the opportunity to deliver isolated concentric, eccentric or isometric training. The Eccentron™ is a stepper ergometer, where a participant is seated, with their feet placed on pedals in front of them. The pedals move on a cycle, and the participant performing the training applies force through the pedals, which is measured by the Eccentron™ force plates, connected to the pedals (Stone *et al.*, 2018).

This novel equipment is currently being used to explore the effects of exercise interventions in athletes. I studied the Eccentron™ in older adults to ascertain whether it may be feasible to use in a clinical context. This study is the first interventional body of work in this thesis, using new technologies. Therefore, it was decided this work would be best targeted towards a healthy older adult population before considering its application in the infirm.

The primary aim of this study was to assess the feasibility of using an eccentric stepping ergometer in an older adult population with the intention of gaging if this could be brought into clinical contexts. The main outcome measure was to improve mean eccentric, concentric and isometric strength by 20% in an older adult population, using the novel Eccentron™ stepping ergometer to perform isolated eccentric exercise. It is hoped that by showing an increased strength, this may prove the training modality feasible to progress into a clinical context, as it would be feasible to show that the exercise intervention is acceptable to participants in the format our methods outline.

Additional aims were to investigate the impact that a short-term eccentric exercise training regime has on a range of geriatric functional measures, including frailty, sarcopenia, cognition and mobility.

6.2: Methodology

Ethical approval was received from the University of Leeds Biological Sciences Research Ethics Committee (BIOSCI15-031). This work was performed as a collaboration between the School of Biological Sciences' Sports and Exercise Science group, and the Frailty Unit of Leeds Institute of Biomedical and Clinical Sciences.

This study recruited community-dwelling participants, aged 65 years or over. Participants were approached through word-of-mouth, publicly available fliers, and through the University of Leeds Medical School community engagement group. Participants approached the researchers with an expression of interest, and were asked to complete a screening questionnaire before providing informed consent. Cardiovascular abnormalities are a rare but possible cause of death in studies involving exercise. To limit this risk, a full atherosclerotic cardiovascular disease risk factor assessment was conducted as per the American College of Sports Medicine guidelines. This assessment included a full health and activity status questionnaire including assessment for signs and symptoms associated, as well as inclusion of cardiovascular disease risk factors in the grading. Only mild or moderate risk participants were included in the study, with high risk subjects being excluded. It could be that frail or sarcopenic participants were excluded from the study as a result of the cardiovascular risk assessment screening. This feasibility assessment was designed to determine if short-term exercise changes using an Eccentron were possible and safe, before applying this into a clinical or frail population to determine whether it is a feasible intervention.

Participants were invited to attend sessions at the Sports and Exercise Sciences laboratory, University of Leeds, for each stage of the study, which is outlined in Figure 17. Over the entire duration of the study, all participants were routinely instructed to cease exercise if they experienced any discomfort or had any concern for their well-being.

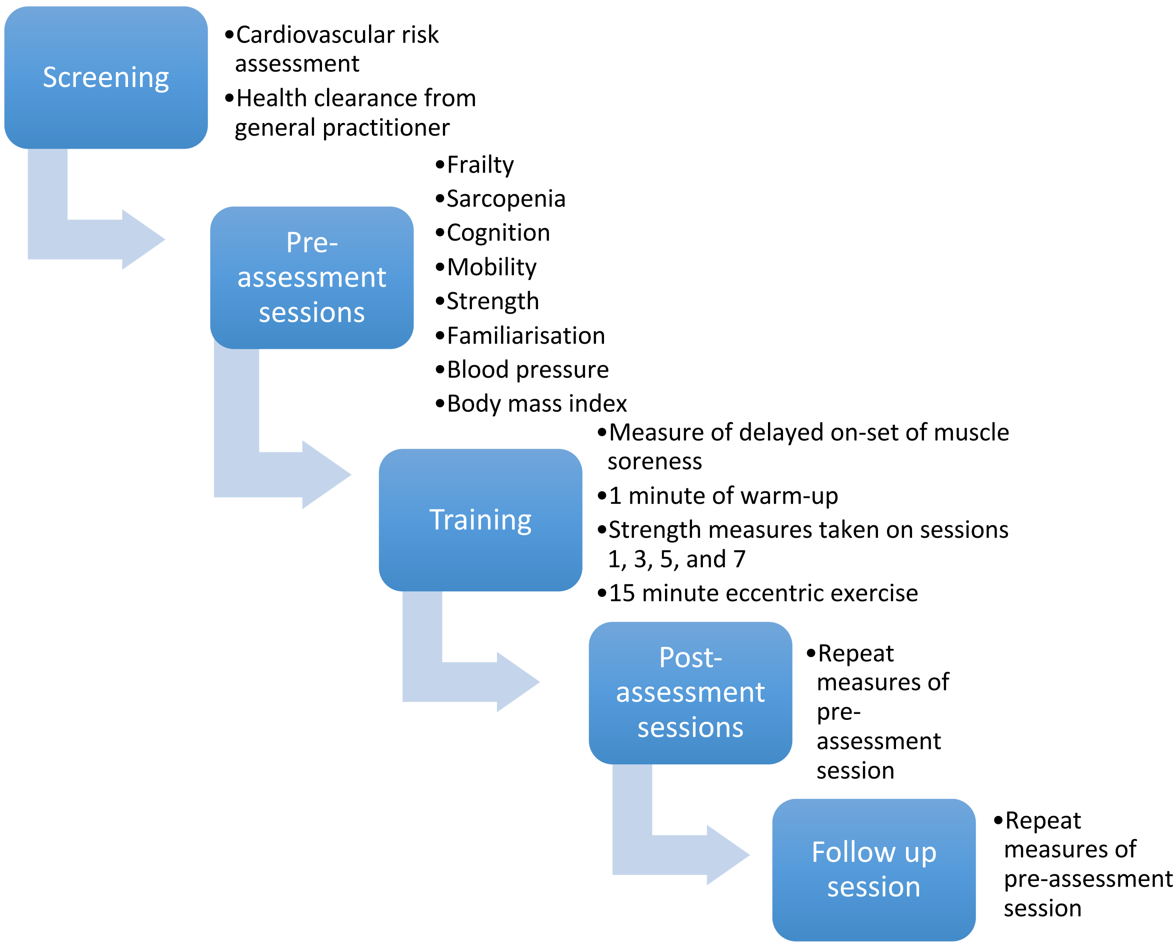


Figure 17: Outline of exercise intervention adopted by this study, including measures taken throughout

As part of the pre-assessment phase, participants had two sessions of familiarisation with the stepper ergometer. Eccentric exercise is, in the first instance, quite tricky to perform due to the method being the opposite of the traditional exercise modality, concentric. This familiarisation opportunity not only allowed for participants to become accustomed to the stepper ergometer, but it also allowed the removal of the 'learning effect' that could be visible when performing maximal voluntary contractions, where participants become more accustomed to the exercise modality and provide more reliable results. For example, if a person was not to understand eccentric exercise and be tested on their eccentric strength, the output may be lower than if they did understand what was involved in eccentric contractions. Participants who were unable to perform the exercise were not able to proceed into the training component of the study.

Participants attended two training sessions a week over four weeks for eccentric exercise training, between the pre-assessment and post-assessment. The eight sessions all lasted 15 minutes, with 1 minute warm up. The machine was calibrated before each training visit, and maintained regularly throughout the study duration.

The target participants were aiming for, for each of the training sessions, was related to the Borg rating of perceived exertion (Borg, 1998) for how difficult the exercise was (Figure 18). The target in training session 1 was of 11 (fairly light), the target in training session 2 was 13 (somewhat hard), and the target for training session 3 onwards was 15 (hard). The researchers changed the target force each session, asking participants their perceived exertion frequently throughout the session to ensure the training session was maintained at the target rating of exertion. In order to reach the target of 'very light' in the first session, the target force was set to half of the maximum voluntary contraction from pre-assessment. This was then adjusted throughout the session should the participant find the work too strenuous or easy. The training sessions following the first had incremental increases to the target force to encourage stronger contractions, with the target perceived exertion being 'hard' for sessions 3-8.

There was only one study group, in this feasibility study. The study offered travel reimbursements up to £5 per visit, in exchange for receipts of travel or parking.

Figure 18: Rate of Perceived Exertion (RPE) scale to determine how participants perceive their exercise is in terms of intensity (Borg, 1998)

6.2.1: Measures included in this research study

Assessments made at pre-assessment visits, post-assessment visits and follow-up assessment visits were the same to allow comparisons drawn across the training program. The assessments included: body mass index (BMI), strength, blood pressure, elderly mobility scale (EMS), frailty phenotype (FP), an indicator of sarcopenia, and cognitive impairment. An incremental shuttle walk time (ISWT) test was performed during the pre-assessment visit and the post-assessment visit – due to the perceived burden of research on the participants, it was decided when constructing the study design to not include the ISWT on the follow-up visits with the aim to prevent attrition prior to follow-up.

6.2.1.1 Measures taken during pre-assessment, post-assessment and follow-up visits

6.2.1.1.1 Strength

Strength was measured using the Eccentron^{TM} ergometer that was also used in the exercise training program. Concentric, eccentric and isometric strengths were measured in Newtons. To take these measurements, participants were asked to voluntarily contract to their maximum strength in a pre-randomised order. Participants were asked to perform three rounds of contractions, and a mean was taken of each method of contraction. Strength was measured three times consecutively during each of pre-assessment, post-assessment and at follow-up.

6.2.1.1.2 Frailty

The FP assessment was chosen on the basis the results of the work described in Section 1.4: because it includes functional measures and has face validity (Fried *et al.*, 2001; Op het Veld *et al.*, 2015). The exercise programme used in this study is intended to improve muscular strength, which may be translated to functional independence and activity levels, which may be captured by the FP. The FP is comprised of measures for self-reported unintentional weight loss, grip strength, gait speed, activity levels and mood.

6.2.1.1.3 Sarcopenia

This study followed the EWGSOP recommendations, with regards to the identification of sarcopenia (Cruz-Jentoft *et al.*, 2010). Should someone have a low walk speed, this would be an indicator of sarcopenia. If a participant had a good walk speed as defined by EWGSOP's criteria, they would be assessed for their handgrip strength. A low handgrip strength would indicate a risk of sarcopenia. Sarcopenia, in this study, was measured once during pre-assessment, post-assessment and at follow-up.

The EWGSOP recommendations suggest that those who are indicated to be at risk of sarcopenia through the above method should then be investigated for low muscle mass. Unfortunately, due to resource limitations, this was impossible to perform.

6.2.1.1.4 Cognitive impairment

Cognitive impairment was measured using the Montreal Cognitive Assessment (MoCA) (Dong *et al.*, 2012; Smith and Yeow, 2018), as described in Chapter 5:. Cognitive impairment, in this study, was measured once during pre-assessment, post-assessment and at follow-up. As cognitive tests involve short-term memory tasks, we used three different versions of the MoCA to negate any learned effects between the three time points. The MoCA is scored out of 30, with any score below 26 being considered as cognitively impaired.

6.2.1.1.5 Elderly mobility scale

The EMS was included as an initial measure of mobility. This measure has been used in clinical settings (Prosser, Canby and General, 1997). The EMS identifies whether participants have decreased mobility as a result of not being able to transition either way between lying down, sitting and standing. This measure also includes a maximal gait speed assessment and a functional reach assessment. These measures are ranked, and provided an overall score out of 20, with participants scoring 14 and over being considered as independent.

6.2.1.1.6 Incremental shuttle walk test

The ISWT (Pulz *et al.*, 2008) was added to the study after the recruitment of two participants, to serve as a more sensitive measure of mobility. This was only performed at the pre-assessment and post-assessment sessions, as the follow up assessment was constrained into one visit. This test involves participants walking around two cones, spaced nine meters apart, doing so between audio-recorded beeps. The beeps on the recording speed up gradually, and the researchers document how far a participant can walk on the test before they either refuse to carry on, or until they are too slow to continue to the appropriate cone between the beeps. There is no threshold to meet for this assessment, as the test aims to compare results against the individual's baseline result.

6.2.1.1.7 Blood pressure

Blood pressure was measured consecutively three times, following a resting period in the laboratory, with a mean taken for each assessment. We used an automatic digital sphygmomanometer to measure blood pressure. Blood pressure measurements were taken once during pre-assessment, post-assessment and at follow-up prior to any exercise being performed, where the participant had sat down at rest for over 5 minutes. Blood pressure was not performed throughout the training sessions as this was thought to be potentially too burdensome and have minimal value in this feasibility study.

6.2.1.2 Measures taken during training exercise

6.2.1.2.1 Strength

At the first, third, fifth and seventh of the eight training sessions the mean of three maximal voluntary contraction measurements for eccentric, concentric and isometric strengths were taken between the minute warm up and the 15-minute training. Participants performed these strength measures in the same randomised order they had performed in the pre-assessment visit. This measure was taken to display the strength changes across the training period.

6.2.1.2.2 Rate of perceived breathlessness

With an increased heart rate as a result of exercising, it is expected that participants would also have a relatively increased respiration rate. A measure of breathlessness, the Shortness of Breath Modified Borg Dyspnoea Scale, was adopted as an amendment to understand the breathlessness caused by the exercise training program (Wilson and Jones, 1989). This assessment is very similar to the rate of perceived exertion scale (mentioned in section 6.2), though uses a different scale on which participants refer to. Throughout the training sessions, participants were asked how breathlessness they felt on a scale from 0-10, with 0 being nothing at all, 5 being severe and 10 being maximal. This method is non-linear, though is widely used in exercise science and is part of standard laboratory procedure in the University of Leeds exercise science department. As this measure was adopted as an amendment, the data from the first two participants were not obtained. This measure was added following conversation with the supervisory team and ethical governance team, and deemed appropriate, not burdensome to participants, and informative for future works to indicate how taxing the exercise regime may be on a patient's cardiovascular and pulmonary systems.

6.2.1.2.3 Heart rate

The heart-rate of the participants was measured continuously throughout all of the training sessions, using a wireless chest-strap heart rate monitor, to ensure the safety of the participants and to assess the cardiovascular demand of the exercise training program. A mean heart rate was calculated from the heart rate monitor for all participants for each training session. In order for this to be representative of the work performed during the session, the data from the initial three minutes of the training session were removed from analysis. This is because the heart rate naturally accelerates from resting until it meets the heart rate caused by the exercise being performed. The first three minutes being included would reduce the mean heart rate per session, not providing a fair understanding of the cardiovascular demand caused by the exercise training session.

6.2.1.2.4 Delayed onset muscle soreness

Delayed onset muscle soreness (DOMS) (Cheung, Hume and Maxwelf, 2003) was recorded at the start of each training visit, in reference to the muscle soreness felt during the days following the previous training session. Training sessions were separated by at least 2 full days to allow for recovery. This measure was taken as a value of percent of soreness, self-reported by the participant, with 0% being no soreness and 100% being the sorest the participant has felt. This is standard laboratory operating procedure in the exercise sciences and provides an indicator to the researchers as to whether the previous exercise training session was structured at too high of an intensity, or if the intensity could be increased. This would be done in conversation with the participant before the exercise had begun for that session, before changing the target force setting. This was done with attrition in mind, and changes were made following conversation with the participants throughout the training sessions.

6.2.2: Data interpretation

Analyses for this study were performed using SPSS (SPSS Inc. 2016). The author performed the analyses. The data are presented as mean (standard deviation (SD)) unless otherwise indicated. Assessments of normality were performed using Q-Q plots. Paired t-tests were used to assess the differences between data observed at pre-assessment and at post-assessment.

Additional paired t-tests were used to compare the baseline pre-assessment data with data collected at follow up. Significance for all tests was set at $p<0.05$. Comparisons between post-assessment and follow up were not made. This study is a feasibility study, investigating whether if strength changes can be detected in a short, 4-week training program, in an older adult population and if this program of exercise was amenable to older adult subjects.

6.3: Results

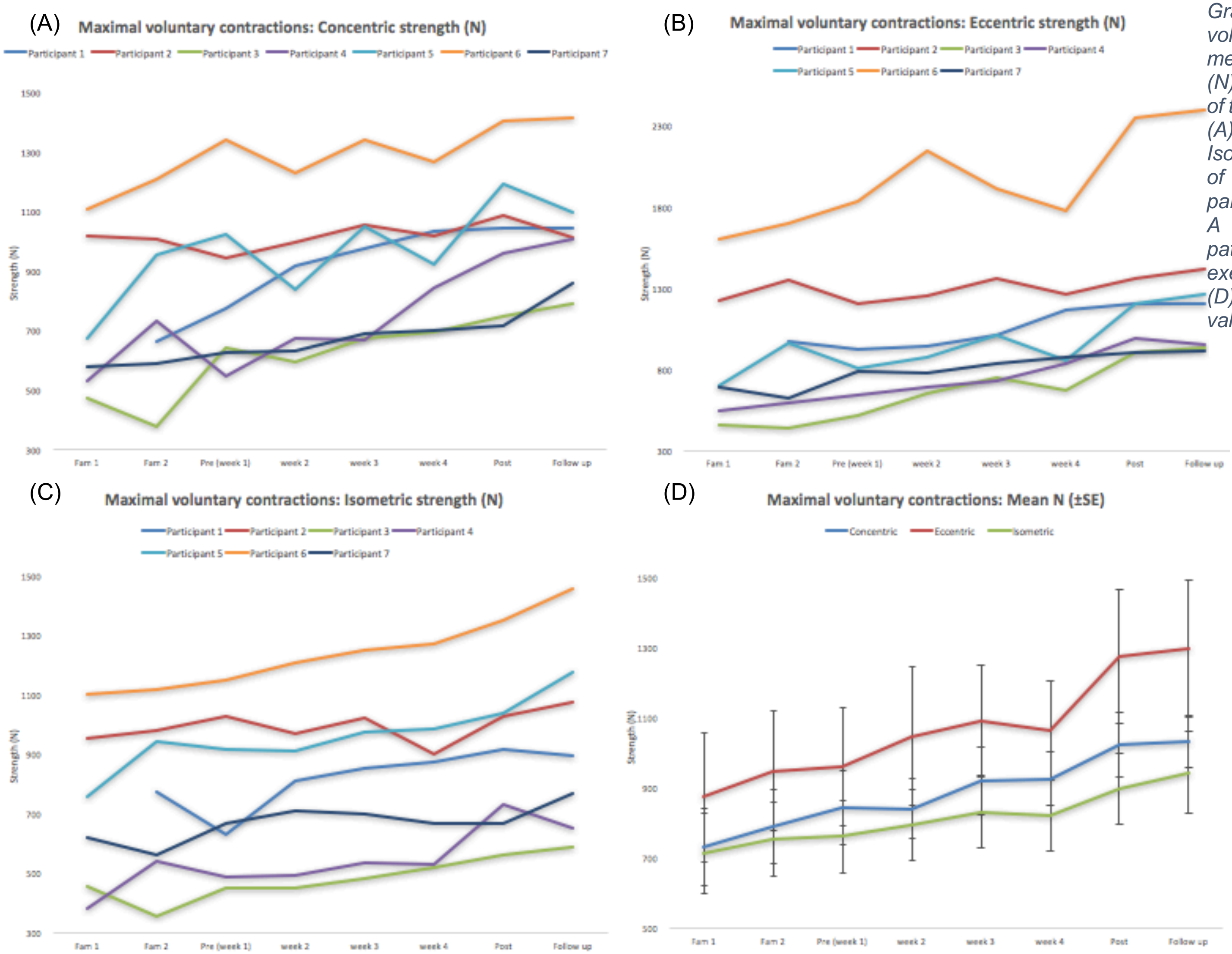
Forty-five potential participants were screened, and ten participants were consented into the study. This number was decided upon as the researchers were resource-limited and could not take additional participants. Eleven potential candidates were not recruited into the study as they were either too active, did not have time or was not in a state of health suitable for the study. Three withdrew before training began and seven participants were recruited in to the study. Of the three who consented but withdrew before training began: one participant withdrew due to falling prior to attending the first pre-assessment session, another withdrew due to not wishing to get clearance from their general practitioner because of high blood pressure. The final participant who withdrew did so due to the difficulty travelling to the laboratory. All seven participants recruited finished the follow-up stage of the study. Baseline information can be seen in Table 32. Five of the seven participants were female. The mean (SD) age was 70 (4.4) years. Mean BMI at the pre-assessment period was 27.2 (3.0) kg/m^2, post-assessment period was 27.1 (3.0) kg/m^2, and 27.3 (3.0) kg/m^2 at follow up. There was no statistical difference in BMI across the study, at either post-assessment (p=0.596) or follow up (p=0.893).

Table 32: Participant characteristics of those recruited into the study. SD: standard deviation, BMI: body mass index, F: female, M male, CV cardiovascular. Cardiovascular risk assessment was defined by the American College of Sports Medicine guidelines.

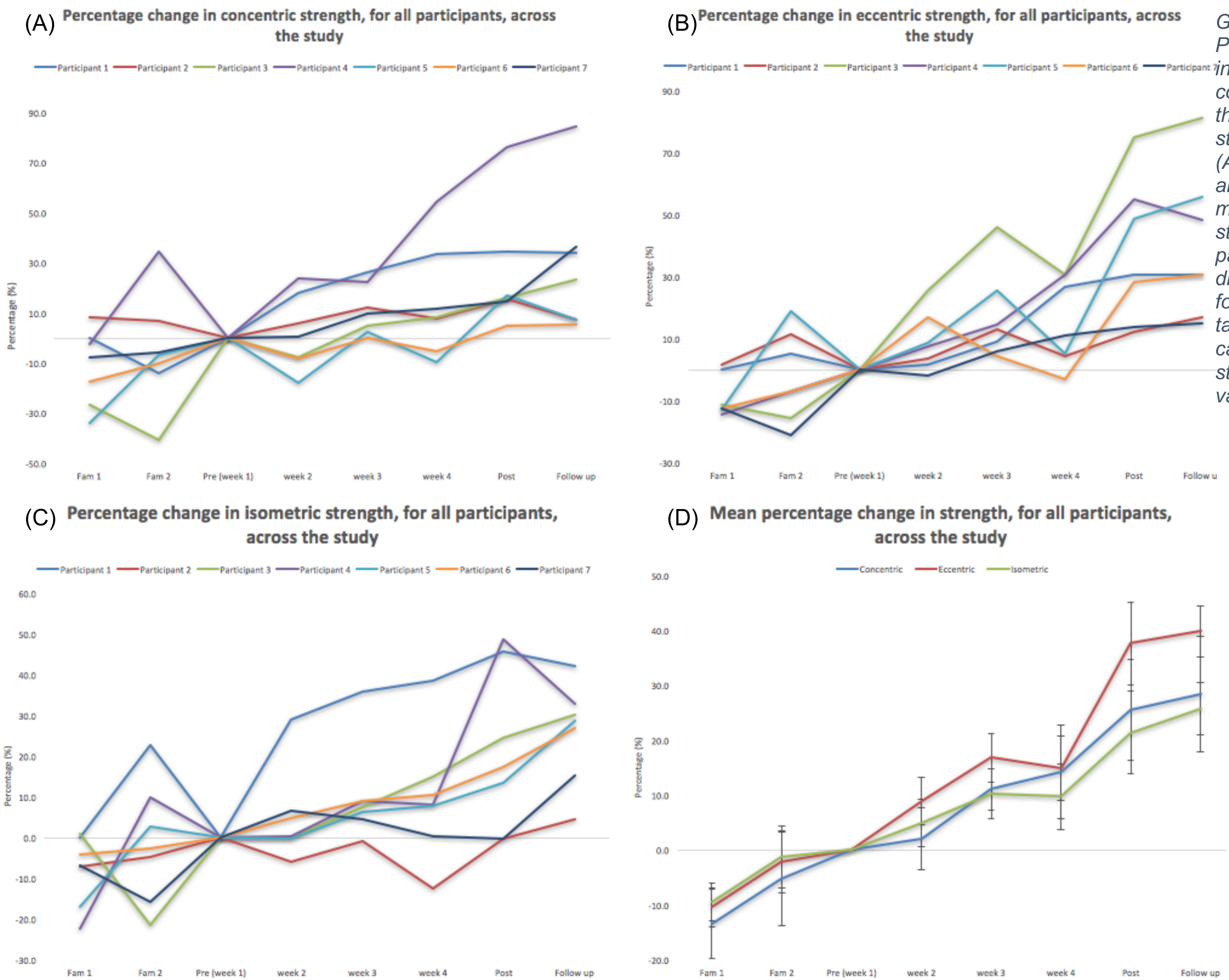
Participant	Sex	Age	BMI (kg/m^2)	CV score
1	F	65	31.5	1
2	M	79	23.1	1
3	F	67	25.8	1
4	F	69	29.2	1
5	F	70	24.7	1
6	M	70	26.6	2
7	F	71	29.6	1
Mean (SD)		70 (4.4)	27.1 (3.0)	1 (0.4)

6.3.1: Strength

The mean maximal voluntary contraction for the three exercise modalities, from familiarisation sessions up until the follow up assessment, can be seen in Graph 12 and Graph 13. The primary aim of this study was to identify a change in strength following four weeks of eccentric exercise training, with a rating of perceived exertion (RPE) to a rating of ‘hard’. All patients were maintained at the set level of RPE. The mean concentric strength at pre-assessment was 843N (standard error (SE) 106). The post-assessment mean concentric strength was 1,024N (SE 92), This increased mean concentric strength was retained at follow up, at 1,032N (SE 75). The mean eccentric strength at pre-assessment was 962N (SE 168). The post-assessment mean eccentric strength was 1,275N (SE 191), This increased mean eccentric strength was retained at follow up, at 1,299N (SE 198). The mean isometric strength at pre-assessment was 762N (SE 103). The post-assessment mean isometric strength was 899N (SE 102), This increased mean isometric strength was retained at follow up, at 945N (SE 118). For all three measures of strength, there was a statistically significant increase from baseline to post-assessment (concentric $p=0.008$, eccentric $p=0.001$, and isometric $p=0.018$). This was retained at follow up (concentric $p=0.013$, eccentric $p=0.001$, and isometric $p=0.003$).



Graph 12: Maximal voluntary contractions, measured in Newtons (N), across the course of the study. Concentric (A), Eccentric (B) and Isometric (C) measures of strength for each participant is displayed. A mean for each patient, taken per exercise, can be seen (D) with standard error values as error bars



Graph 13: Percentage change in maximal voluntary contractions across the course of the study. Concentric (A), Eccentric (B) and Isometric (C) measures of strength for each participant is displayed. A mean for each patient, taken per exercise, can be seen (D) with standard error values as error bar

6.3.2: Frailty

Participants were asked, as part of the frailty phenotype, about their weekly leisure activities, performed a handgrip strength test and a walk speed test. One participant was identified as pre-frail at the point of pre-assessment and became robust at post-assessment and follow up. One participant was robust at the point of pre-assessment, though became pre-frail at the point of post-assessment - this was resolved by the point of follow up. For both participants with a fluctuation in frailty status, this was a result in their handgrip strength changing past the cut-off. There was no difference in frailty status (p=0.621) within the study. There was no change over the duration of the training or follow up in the amount of activity being performed, as determined by the Minnesota Leisure Time Activity section of the Frailty Phenotype assessment (p=0.345).

6.3.3: Sarcopenia

Table 33 identifies the sarcopenia changes in participants from pre-assessment, to post-assessment and follow-up visits. There was no change in hand-grip strength across the study (p=0.565). There was no change in walk speed across the duration of the study (p=0.338). There were two patients identified as a risk of being sarcopenic at pre-assessment, one at post-assessment and one at follow up. All patients recorded a high gait speed, but those who were at risk of being sarcopenic were identified as a result of a poor hand-grip strength. There was no statistically significant change in the risk of being sarcopenic throughout this study by post-assessment (p=0.604) or follow up (p=0.356).

Table 33: Sarcopenia (Sarc), as defined by slow gait speed (gait) and a low grip strength (grip), measured at pre-assessment, post-assessment and at the follow up assessment. F: female, M: male, '+' : value is above threshold, '-' : value is below threshold, Yes: patient is at risk of sarcopenia, No: patient is not at risk of sarcopenia.

		Pre-assessment			Post-assessment			Follow up assessment		
Participant	Sex	Gait	Grip	Sarc	Gait	Grip	Sarc	Gait	Grip	Sarc
1	F	+	-	Yes	+	+	No	+	+	No
2	M	+	+	No	+	+	No	+	+	No
3	F	+	+	No	+	+	No	+	+	No
4	F	+	+	No	+	-	Yes	+	+	No
5	F	+	-	Yes	+	+	No	+	+	No
6	M	+	+	No	+	+	No	+	-	Yes
7	F	+	+	No	+	+	No	+	+	No

6.3.4: Cognitive impairment

The mean pre-training MoCA score was 28.3/30 (1.9), which was 27.8/30 (1.2) at post-assessment and 28.7/30 (0.9) at follow up. There was no cognitive impairment identified at any point of this study or change in cognitive ability ($p=0.335$).

6.3.5: Elderly mobility scale

The EMS is scored out of 20. The mean (SD) score for pre-assessment was 19.3 (1.2), though for both post-assessment and follow-up, all participants achieved maximal scores (20.0 (0.0) for both post-assessment and follow-up). The mean functional reach at baseline was 29.3 (7.1) cm, which was non-significantly increased at the post-assessment (mean 34.9, 6.7, $p=0.134$). The change between mean pre-assessment functional reach and the follow up mean functional reach of 37.0 (5.7) was statistically significant ($p=0.010$).

6.3.6: Incremental shuttle walk time

The IWST was performed on participants 3-7 as this was added into the study in an amendment. The mean (SD) distance walked at pre-assessment was 730 (167) m, which increased to 756m (90) at post-assessment. This was not a statistically significant change (p=0.654). The ISWT was not performed in follow-up, due to time pressures and participant-research burden.

6.3.7: Blood pressure

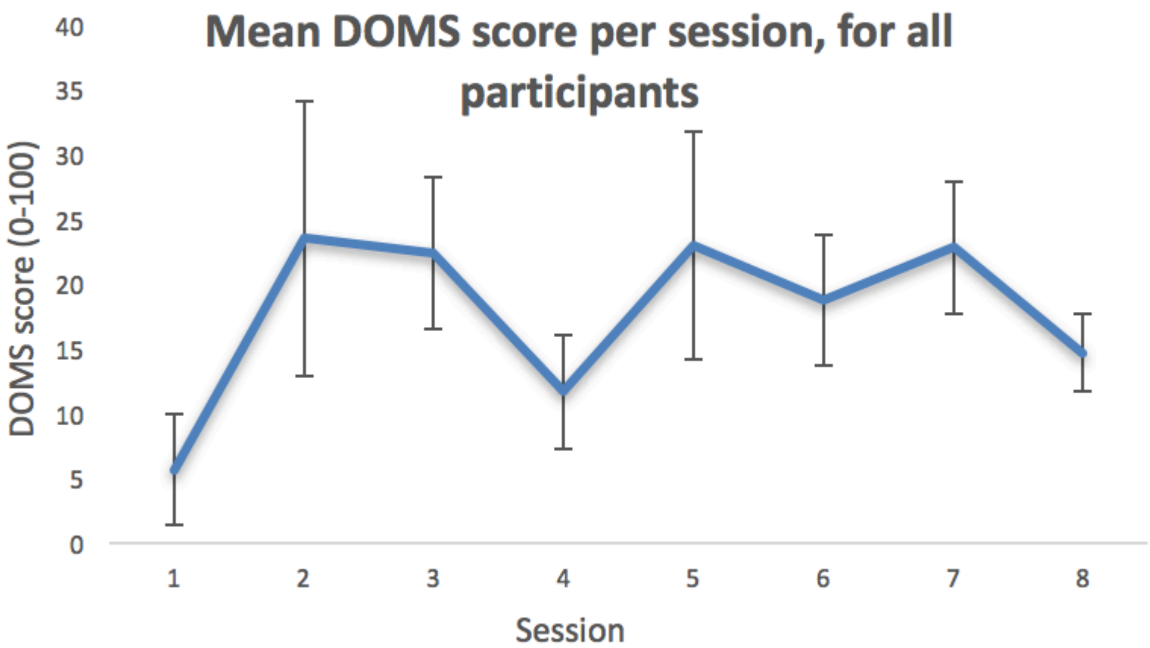
Blood pressures were taken at pre-assessment, post-assessment and at follow-up. The mean pre-assessment blood pressure was 130/79, the post-assessment blood pressure was 123/76 and the follow up assessment blood pressure was 121/75. There was a marginally non-significant change of systolic blood pressure from baseline to post-assessment (p=0.052). There was, however, a significant reduction in systolic blood pressure values from baseline pre-assessment to follow up (p=0.016). There was no statistically significant change in the diastolic blood pressure at either post-assessment (p=0.256) or follow up (p=0.066).

6.3.8: Rate of perceived breathlessness

A measure of breathlessness was added into the feasibility study following the completion of the initial two participants' training. Participants 3-7 were asked about how breathless they felt during their exercise, at the time they were exercising, as defined by the Shortness of Breath Modified Borg Dyspnoea Scale. The mean breathlessness across the entire program was rated 0.83/10 (0.77), which translates to a score between 'extremely slight (just noticeable)' and 'very slight'.

6.3.9: Delayed onset muscle soreness

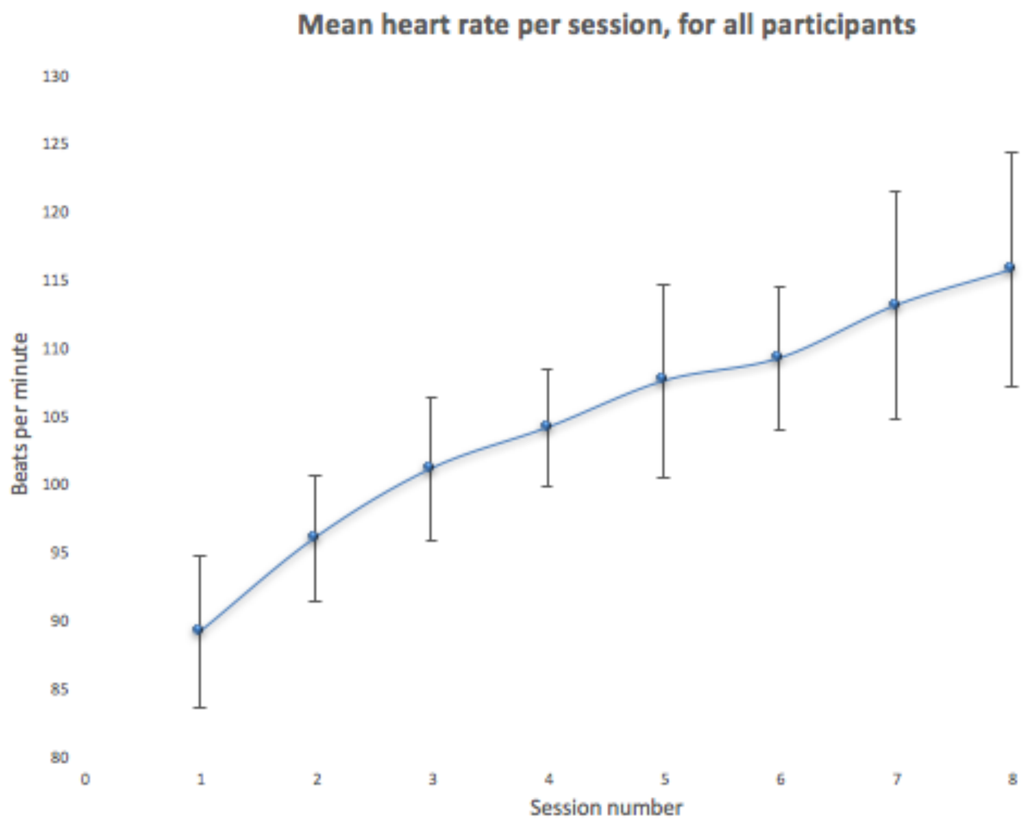
DOMS was recorded at each training session (Graph 14), related to the time period between the previous training session and the current. This was performed on a simple analogue scale from 0-100, with 0 being no pain and 100 being the worst pain they have experienced. The mean DOMS rating was 17.9 (6.6).



Graph 14: Mean delayed onset of muscle soreness (DOMS) per session, for all participants. Error bars are standard error values.

6.3.10: Heart rate

Participants had their heart rate measured throughout each training session in order to explore the taxation of this exercise modality on their cardiovascular system. The mean heart rate on session 1 was 89.0 (SE 5.6), which incrementally increased across the 8 training sessions, reaching a mean of 115.7 (SE 5.4) on the last training session (Graph 15).



Graph 15: Mean heart rate (beats per minute) of all participants, for each session. Error bars are standard error values.

6.3.11: Informal feedback regarding the study and intervention

At the start of each session, participants were informally asked about how they felt their training was going. The general feeling was that there was some slight delayed muscle soreness following the starting sessions of the program, though this stopped occurring after a short period. Participants relayed that they felt more confident and active as a result of the exercise program. Following the exercise study, one participant offered to provide a written quote regarding the research: 'I found the exercise invigorating. I was surprised that I could do it! I was very pleased to have a print out of my progress: it gave me an enormous sense of achievement. I wished it could have been possible to continue with the exercise after the end of the programme; or been directed to someone/somewhere that would have been as encouraging and with a similar machine. My rheumatology doctors were very interested in the exercise programme, and very supportive and encouraging. It was really beneficial to my health and well-being'.

6.4: Discussion

This study shows that it is feasible to recruit healthy older adults into an eccentric exercise programme. This work identified a statistically significant increase in lower limb muscle strength is possible over a 4-week eccentric training programme, which is retained over a 30-day window. This strength increase, of approximately 40%, is only seen in the lower limbs, as opposed to wider systemic developments. This is due to the intervention focusing on the lower limb. The changes in lower limb strength may be beneficial for older adults, in terms of stability and help facilitate activities of daily living (Rocha *et al*. 2016). This is additionally supported by the statistically significant increase in functional reach – a measure that has strong ties to independence, falls and balance, and activities of daily living (Bohannon *et al*. 2018). Work following on from this research project should include patient-centred outcome measures. Lower limb strength is valued for mobility and balance (Rocha *et al*. 2016), meaning an outcome related to functionality (such as the incremental shuttle walk time, or a stair climb assessment) as opposed to crude strength could be beneficial. This exercise intervention was designed to show that demonstrable benefit can be achieved in the preoperative time window - the outcome measures available could be discussed at a patient and public involvement group to work out what measure would be the most appropriate. Unfortunately, looking at patient-reported outcome measures for quality of life in colorectal cancer patients (Public Health England 2015), elderly patients were under-represented. This means that more work needs to be done to look into the patient-reported outcome measures that would be appropriate in an exercise intervention for colorectal surgical patients.

The work in this exercise study shows that eccentric exercise can improve strength over a short-term period. If this was to be used for patients in a preoperative setting, with the surgical procedure taking place shortly after the training, the strength changes may last until after the patient has had surgery. An understanding of how the benefits from eccentric exercise lasts following a surgical procedure would support the implementation of exercise intervention preoperatively, in the hope to encourage a safer, more effective post-operative recovery (Bogdanis 2012; Mcisaac *et al*. 2018; Li *et al*. 2017; Gill *et al*. 2003; Carli *et al*. 2010; Danjoux & Kothmann 2015).

The stepper ergometer, trademarked as the Eccentron^{TM}, was well received by participants after they had become familiarised with the method of eccentric exercise. It is unlikely, without a lot more research performed in the effectiveness of eccentric exercise preoperatively and postoperatively, that hospitals would invest in purchasing this equipment. Following further work clarifying the benefits eccentric exercise has in older adults, a health economic study would provide valuable insight as to the benefit this training modality could bring to those who would benefit from the additional costs this type of exercise program would deliver. Work is required to determine what exercise methods would provide similar changes in strength over a 4-week training window, which could be provided routinely by the NHS in a cost-effective, patient-centred way. This would also likely require the patients to find the exercise intervention more acceptable. Our feasibility data indicate that eccentric exercise is acceptable in healthy elderly patients. It would be appropriate to conduct further research in high-risk populations. High risk patients with a greater burden of comorbidity and limited reserve may gain greatest benefit from an exercise intervention, but would require close supervision and would likely have a higher dropout rate. This calls into question whether it would be ethical, cost-effective and will address whether this intervention can provide more benefits to outweigh the additional risks.

Our study population was not frail and further feasibility work may be needed in frail patients in order to inform the design of a clinical trial. One of the aspects of the frailty assessment is the Minnesota Leisure Time Activity tool, which measures how many calories are expended through activities of daily living and in recreational activity such as walking or gardening. This study identified no change in activity levels from pre-assessment to either post-assessment or follow up, meaning that the success of the exercise intervention was as a result from the exercise programme as opposed to increasing exercise out-with the programme. However, this is a small study and this interpretation is limited by the fact that this is a small population of relatively healthy elderly volunteers, which will possibly differ in an unwell or frail population.

Hand grip strength is a component of the frailty phenotype and the EWGSOP definition of sarcopenia. Hand grip strength did not change as a result of this programme. An exercise intervention that may further support frail or sarcopenic patients should not just address lower limb strength, but also support the patient's overall strength and translate to their independence. However, the improvement of hand grip strength should impact on the patient's life, as opposed to simply increasing the ability to grip a dynamometer - interventions should be balanced between treating conditions and facilitating patients' lives. What is unknown still is: how changes in frailty, or if possible sarcopenia, would benefit a patient's fitness for surgery. Frailty has been described as a scalar syndrome, where it is possible to provide an intervention in order to restore functional ability.

Sarcopenia is thought to be caused by associated inflammatory changes that may be more permanent. It may be possible to arrest, or slow the onset of, sarcopenia (Melton *et al*. 2000; Haran *et al*. 2012; Rolland *et al*. 2008). Sarcopenia is associated with a host of chronic inflammatory and endocrine systemic changes, which may not reverse following exercise (Rolland *et al*. 2008; Fielding *et al*. 2011). It will require further work in this area to resolve this question. It is not yet clear if sarcopenia can be reversed by exercise or other interventions, and whether the reversal of sarcopenia would also be clinically beneficial.

There was no significant change in the ISWT. As lower limb strength increased as a result of the exercise intervention, it could be expected that there would also be an improvement in the ISWT. The reason there was no identifiable difference could be because strength is not synonymous with performance. The non-significant improvement could also be a sign that this study lacked the power to be able to identify a significant change. Further work on the muscle changes induced by of eccentric exercise training would support further understanding of how this training modality could support patients preoperatively and post-operatively.

An interesting finding of this intervention is that there was a statistically significant change in mean blood pressure. This change is also potentially clinically significant, if sustained. The mean systolic pressure of 130 is technically pre-hypertensive. The reduction of systolic pressure to 121 returns the participants to a normal systolic pressure. It may be useful to research the concept of eccentric exercise in the elderly and its impact on the haemodynamics of patients, on a larger sample size, to explore whether this change provides any general health benefits to patients.

There was no difference identified in the participants as to cognitive impairment across the study duration. This is unsurprising, as this study was performed in healthy older adult volunteers. Exercise has been shown to potentially reduce patients' risk of cognitive impairment (Geda *et al.*, 2010). Our study did not have power to suggest any change or significance, though it would be interesting to determine whether eccentric exercise, performed on the Eccentron^{TM}, also supports patients reduce risk of cognitive impairment.

The exercise study identified a gradually increasing heart rate across the eight training sessions. This is highly likely due to the increasing forces the participants were working at, and may indicate a degree of cardiorespiratory training as a result of eccentric exercise (Lastayo *et al*. 2014; Gault *et al*. 2013). The breathlessness remained remarkably minimal. This suggests that eccentric exercise may be of value for patients who find other forms of training challenging. The mean heart rate of the last session (115.7 (SD 22.8)) remained fairly low for an exercise program. The results of this study are consistent with, though do not prove the hypothesis that eccentric exercise increases strength without increased cardiovascular strain. As the mean heart rate increased over the exercise, though the rate of perceived exertion was remaining the same, it may be that this study did support cardiorespiratory training to a degree, though this is not identified in the ISWT. It may be this study is underpowered to identify if this is the case. Further work over a longer duration with additional subjects may uncover more information about the relationship between cardiorespiratory training for older adults undergoing eccentric exercise.

One recruited person who was frail at the point of recruitment withdrew prior to undergoing training, as a result of falling on their way to the laboratory. Some interventional studies occur in hospital, in community centres and at homes – all designed with participant attrition and adherence in mind. This work was performed in a supervised laboratory setting at a University. One of the considerations for future works is whether this is a requirement for an intervention to be effective. Liu and Fielding raise a salient point that should supervision be required for all interventions, this would be costly in terms of resources – a limitation of this study (Liu & Fielding 2015). A recent Cochrane publication provides evidence to suggest, at least with cardiovascular training, that there is a significant improvement in the benefits of training when there is some form of supervision, in comparison to those without supervised exercise training (Fokkenrood *et al*. 2013). This publication does not provide any insight as to whether eccentric exercise has similar challenges; there appears to be limited literature for the comparison of supervised and non-supervised eccentric exercise training modalities and the therapeutic validity of these methods.

This feasibility study highlights the fact that older subjects are able to perform supervised eccentric exercise, that they find it acceptable, and that it may offer physiological and clinical benefit. The next logical step is to perform studies to confirm that frail patients can undertake this type of training. This would provide support for a clinical trial to test the outcome benefit and cost-effectiveness of eccentric training is a frail elderly surgical population.

The results of this study are promising and forms part of the proof of concept of eccentric exercise delivered by the Eccentron^{TM} in pre-operative patients. An example of the route this research would require to take includes transition from where it currently stands through to clinical practice (Figure 19) (Douet *et al.*, 2010). However, this technology is new to the literature and the majority of prehabilitation exercise programmes for surgical patients resides in orthopaedic patients. There are multiple studies that would be beneficial to perform, to ensure this exercise training modality is cost-effective, safe and replicable to colorectal surgical patients.

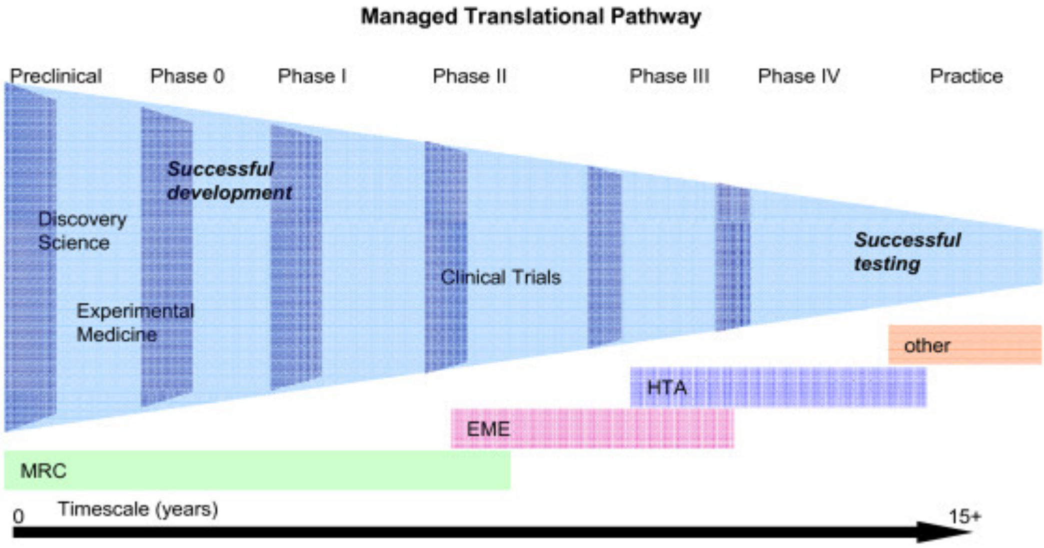


Figure 19: The managed translational pathway, identifying the trajectory of research from conception through to clinical practice. The medical research council (MRC), Efficacy and Mechanisms Evaluation (EME), Health Technology Assessment (HTA) and other blocks are funding streams. The MRC, EME and HTA blocks are fundable sections through the National Institute of Health Research (NIHR (Douet *et al.*, 2010)*).*

6.5: Limitations

Patients were excluded based on their medication use, arthritis, cardiovascular risk score and other clinical presentations. As a result of these exclusion criteria, this study does not investigate the acceptability of this exercise modality in frail surgical patients. The aim of this and future feasibility work is to support the development of a trial of eccentric exercise in frail surgical patients with medical supervision.

My collaborators and I used the Eccentron™ machine to deliver eccentric exercise. This is a large and expensive device. Whilst a valuable tool for delivering and monitoring eccentric exercise, its use is constrained to units with the facilities to host and provide access to the machine. Development of smaller cheaper machines to deliver eccentric exercise would be of value.

6.6: Conclusion

This work highlights that it is possible to improve mean strength by 40% in older adults, through two 15-minute eccentric exercise training sessions per week, over four weeks. This change is preserved after 30-days of not training. Whilst the training in this study used an Eccentron™ machine, it may be that similar and less-costly exercise interventions may also improve strength. Further work is required to demonstrate that frail patients can use the Eccentron™, or other forms of eccentric exercise interventions and to examine the benefits of the intervention in a randomised controlled trial.

Chapter 7: Discussion

7.1: Perceptions regarding frailty

This thesis begins with a description of perceptions surrounding frailty, in the context of colorectal surgery. Our data indicate that the majority of healthcare staff wish to see the assessment of frailty is incorporated into patients' surgical pre-assessment. However, my data suggest that clinical data on frailty may not identify patients at risk of adverse post-operative outcomes. There needs to be clinical benefit to justify implementing frailty identification into busy pre-assessment clinics. This might not necessarily be that the measure identifies patients who do indeed go to suffer adverse post-operative outcomes, but there may be benefit highlighting those patients who already have a poor functional independence at baseline in order to provide some additional peri-operative support.

The work in this chapter is consistent with key publications investigating the perception of frailty in older adults (BritainThinks, AGE UK and Society, 2015). Patients who are frail do not necessarily identify as frail, but do indicate that they may require additional support from others – especially during their time recovering from surgery. Furthermore, those who are frail have the same expectations of recovery that a non-frail patient has, though they do expect to have more support and attention from nursing staff whist recovering in-hospital. Nursing staff on busy wards may not be able to meet these expectations. Surgeons reported that they rely on the nursing staff's intuition and expertise to bring in additional support for patients, whilst they are recovering from their procedures.

7.2: Frailty identification

Frailty and sarcopenia are both constructs with a degree of overlap (Beggs *et al*. 2015; Milte & Crotty 2014; Oakland *et al*. 2016; Sandini *et al*. 2017) but these different conditions are not interchangeable. Frailty may present with a reduction in functional capacity, which can include sarcopenia, cognitive impairment and other conditions (Fried *et al.,* 2001; Morley, 2015; Boyle *et al;* 2011). Our data suggest that there may be some overlap yet sarcopenic patients may not be frail, and not all frail patients are also sarcopenic (Figure 20).

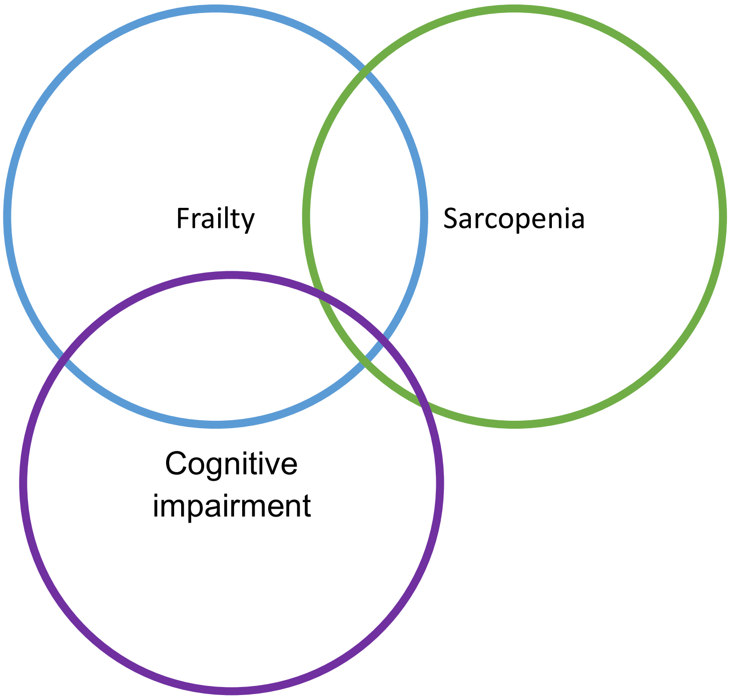


Figure 20: Overlap between frailty, sarcopenia and cognitive impairment

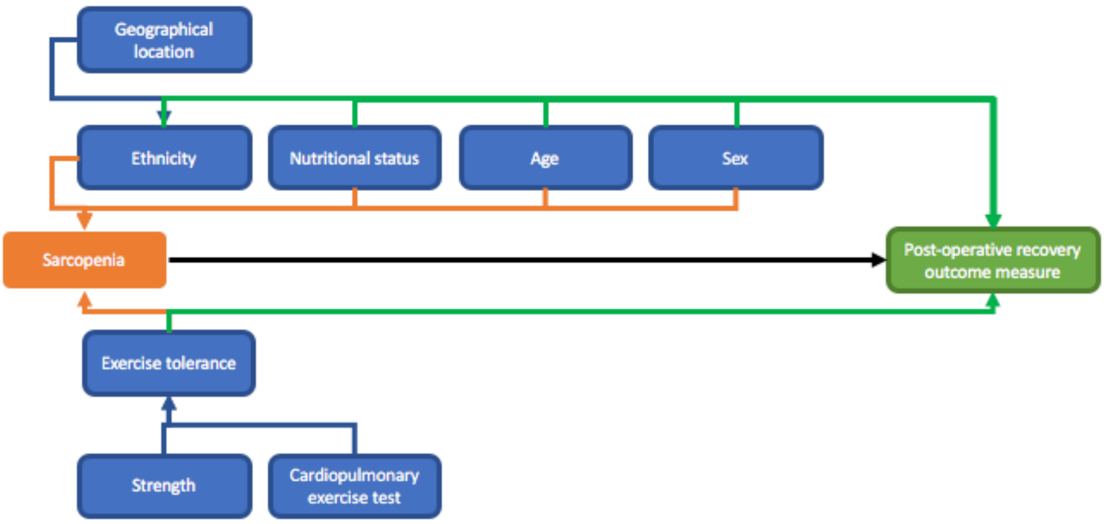
This interaction between frailty, sarcopenia and even cognitive impairment, needs careful consideration when applying these concepts in the clinical setting. Much current work takes a pragmatic approach that facilitates clinical care and research but can undermine scientific rigor through a lack of agreement between case definitions. For example, the clinical frailty scale (CFS) may be appropriate in a general practice setting or for elective surgical patients, but is not fit for purpose in the acute surgical population as it may identify the symptoms of the acute condition as opposed to the state of frailty a person has (The British Geriatrics Society 2014; Cockburn *et al*. 2015). Functional measures of frailty, such as the frailty phenotype (FP) could be used to determine the change in a person's status when investigating the effects of an intervention. In contrast, the accumulation deficit (AD) method, for example, uses a patient's medical history of experience with co-morbidities to ascertain their frailty status, which is unlikely to change as a result of an intervention as their medical history will remain the same. The AD may not be sensitive to change in frailty status and be too sensitive to the patient having previously been identified as frail. In surgical settings, it may be that a combination of measures is beneficial to determine frailty, as long as the method is adopted routinely and the information gathered by that assessment is clinically informative, not only to the assessor at the time but to the healthcare teams that will support that patient in the future. The Edmonton frailty scale (EFS), for example, has been identified as strongly associated with the comprehensive geriatric assessment (Rolfson *et al*. 2006) and has been taken up by Guy's and St. Thomas' Hospital, London, to use in their pre-assessment work-up as a screening tool. This is then used to determine whether a patient will benefit from a comprehensive geriatric assessment.

The electronic frailty index (eFI) is currently being explored as a potential to identify frailty. This measure identifies frailty using health deficits recorded by the GP in the patient's electronic patient record. The eFI algorithm is derived from the accumulation deficit (AD) model of frailty and would be accessible to healthcare professionals with access to the patient's electronic records, meaning the score could be transferrable Trust-wide and the result may not have the confounders of acute clinical presentations (Clegg *et al*. 2016). Electronic frailty index data were not available for inclusion in the studies described in this thesis but access to these data in secondary care is improving. The eFI has limitations. Our data suggest that the AD method of identifying frailty, on which the eFI is based, has poor agreement with other frailty assessments, and is overly sensitive in the colorectal surgical population, identifying approximately 32% of patients as frail. The eFI is dependent on the coding of clinical conditions by the GP. Data gathered from GP interviews have shown that sometimes GPs may not code or identify for a potential condition in a patient for the risk of causing anxiety to the patient by labelling them as having that condition, especially when that patient may be borderline or an intervention is agreed in their consultation. This would lead the eFI to not be as representative as it should be, potentially making the identification of the frailty score inaccurate. Coding for conditions may also have potential limiting factors for the eFI as one condition may have numerous codes and it may be a patient is coded for more than one condition or have a mis-coded condition that has not translated to the eFI. An example was provided by one of the GPs involved in the interviews: patients at risk for a debilitating condition were invited to discuss their risk with their GP. This unfortunately caused anxiety in the recipients of this letter and caused additional strain on the GP practice trying to resolve the concerns the letter had caused. Finally, clinical conditions fluctuate yet the eFI, at the time of writing, does not allow for the removal of codes. The eFI is currently incapable of representing the change in clinical presentation in patients whose clinical condition improves. Frailty may be reversible to some extent, with the potential that interventions may not only limit the progression of functional impairment, but also potentially restore some functional ability to the patient. It may be that that with further development and testing in surgical populations the eFI will become a more robust, accessible tool to aid the preoperative assessment of surgical patients.

In some pre-assessment units, self-reporting in response to a direct question is used to identify cognitive impairment. This has evident flaws. A patient with mild cognitive impairment may not be aware that their cognitive ability is declining. In my study of a single preassessment clinic, I identified a statistically significant difference between the routine pre-assessment identification of cognitive impairment and cognitive impairment measured by the Montreal Cognitive Assessment (MoCA) as part of the research project. This result indicated that those with cognitive impairment are likely being overlooked by the current process. Modifying the surgical pre-assessment process could prove beneficial as, identified in this thesis, the MoCA potentially identifies patients who were more at risk of re-admission to hospital (RR 3.3, 95% CI 0.3-43.38)

7.3: Sarcopenia identification

The results of my work on computed tomography (CT)-derived measurements of sarcopenia studies found relatively poor predictive value for postoperative complications. These results stand in contrast to other studies (Zhuang *et al*. 2016; Lieffers *et al*. 2012; Chen *et al*. 2016; Jones *et al*. 2015; Du *et al*. 2014). Our study may represent a false negative result or may be a true negative with preponderance of positive results in the extant literature reflecting publication bias. The use of internally derived cut-off values may also contribute to the number of studies with positive results. I suggest that further work is needed in this area which addresses the question of whether CT-derived sarcopenia measures contribute useful diagnostic information after confounding factors such as age, ethnicity and sex have been taken into account. Such work rests on having a clear understanding of the relationship between exposures, confounders and outcomes. Developing a directed acyclic graph (DAG), as I have in Graph 16, may be invaluable in understanding these relationships.



Graph 16: An example of a direct acyclic graph, showing potential confounders for sarcopenia in the relationship with post-operative recovery measures. Blue boxes are potential confounders, orange being the variable of interest (sarcopenia) and green being the outcome measure (post-operative recovery). The black arrow indicates the relationship of interest; green arrows highlight the potential relationships known between potential confounders and outcome measure; orange arrows highlight potential relationships between the potential confounders and variable of interest; blue arrows highlight other confounders that may be of relevance that would be adjusted for by adjusting for the confounding variable they are linked with.

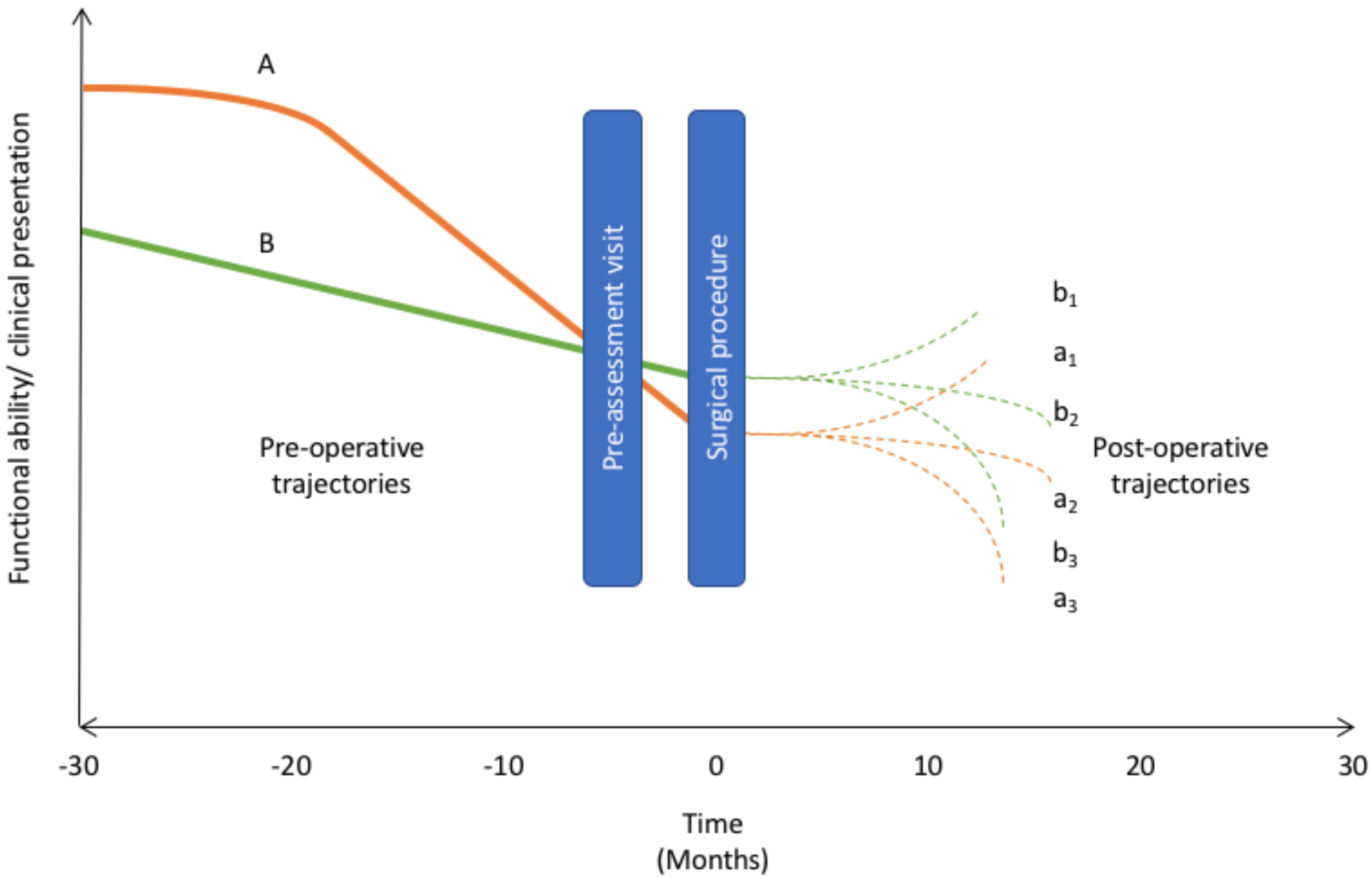
7.4: Relationship between frailty, sarcopenia and post-operative outcomes

Our data suggest that neither frailty or sarcopenia can be used in isolation to identify individual patients likely to experience adverse post-operative outcomes. This stands in contrast to the results published by other groups (Gregorevic *et al*. 2016; Ommundsen, Torgeir B. Wyller, *et al*. 2014; Du *et al*. 2014; Robinson *et al*. 2011). We found relative risks for the associations between frailty and sarcopenia and adverse outcome ranging from 0.9 (95% CI 0.5 - 1.8) to 1.6 (95% CI 0.9 - 2.8) but likelihood ratios close to unity. Many of the publications that suggest that frailty or sarcopenia may be used to predict adverse outcome base this on the finding of a significant association but do not report likelihood ratios, sensitivity and specificity or positive and negative predictive values (Du *et al*. 2014; Keller *et al*. 2014; Revenig *et al*. 2015). That is not to say that frailty or sarcopenia should not be considered clinically informative in a surgical population. A person may be malnourished or socially-isolated, and have become less independent as a result of that, and in turn become frail or sarcopenic. The currently available assessments can be used for the identification of a person at risk of being frail or sarcopenic, and allow screening for patients who may need additional support and tailored interventions.

Our data suggest that the European Working Group of Sarcopenia in Older Persons (EWGSOP) definition of sarcopenia (Cruz-Jentoft *et al*. 2010) is potentially a more useful assessment than CT-derived sarcopenia (Jones *et al*. 2015; Baracos 2010) in a colorectal setting. Our data identified a statistically significant difference between sarcopenia and frailty as measured by gait speed, the frailty phenotype and Gerontopole frailty screening tool. Sarcopenia, as identified by the EWGSOP definition had the strongest association with a patient requiring an increased degree of post-operative care, such as high-dependency or intensive care (risk ratio (RR) 10.1, 95% confidence interval (CI) 5.1-20.0, likelihood ratio 3.4). This was substantially different to the frailty assessment. Studies comparing these assessments directly are required to confirm our observations. The positive and negative predictive values of sarcopenia were the best out of the pre-operative assessments used, though indicated that sarcopenia could be further improved.

Pre-operative frailty assessments are performed at the initial phase of a patient's surgical journey and provide minimal understanding of the clinical trajectory a patient prior to their presenting for surgical assessment. The progression of frailty from the onset of their illness to the time of the surgical assessment may differ between patients. It may be that some have been declining physiologically for longer, but slowly, and others may rapidly be deteriorating. This information is difficult to ascertain from frailty identification in pre-assessment. It could be that patients who are deteriorating rapidly pre-operatively are more likely to suffer an increased risk of adverse recovery than people who measured the same degree of frailty pre-operatively, yet had a longer, more gradual decline in their functional ability. This concept is explored by Needham and colleagues with regards to cognitive impairment pre-operatively, and the trajectories of cognition post-operatively (Needham *et al*. 2017). Graph 17 is based on the model proposed by these authors. Patients may have different initial pre-operative trajectories in terms of their frailty or sarcopenia severity; they present with the same degree of impairment at pre-assessment. Following surgery, they may follow one of a number of trajectories. It may be that their clinical deterioration was as a result of their surgical condition, and following surgery the patient recovers some degree of function. Another possibility is that following surgery, a condition stabilises and a patient establishes their functional ability at the time of surgery as their new baseline. A third possibility is that following surgery the patient continues to decline in how robust they are, as the surgical condition was not the primary cause of their frailty or sarcopenia. Holistic and individualised care treats the management of a surgical condition as one event, for a patient's overall health trajectory for their lifetime. Clinicians and healthcare systems strive to deliver this ideal. Much remains to be done, both in terms of research and integrating primary and secondary care. However, changes in health policy and initiatives such as the results of the eFI derived in primary care being made available in secondary care, point to the work that is being done.

Graph 17: Conceptual graph representing two possible frail surgical patient pre-operative trajectories (A and B) with possible recovery trajectories for those declining rapidly (a1, a2, and a3), and for those declining gradually (b1, b2 and b3).



7.5: Exercise interventions for older adults

Our data indicate that it is possible to increase muscle strength in older adults by 40% with eccentric exercise training. Ours was a small feasibility study in older volunteers. These people were not necessarily frail, although people who were sarcopenic at the baseline assessment were not sarcopenic following the training or at follow up. The extent to which sarcopenia can be reversed is unclear given the endocrine and inflammatory aspects within this condition (Beggs *et al*. 2015), though work in this area addressing muscle protein loss, muscle protein synthesis and anabolic resistance suggests that it is possible to offer effective interventions in sarcopenic patients (Lynch 2011). Studies are required with participants who are frail or sarcopenic at baseline as defined by agreed criteria such as that produced by EWGSOP.

7.6: The impact of this work and doctoral thesis

Throughout this Doctorate, research efforts have aimed to identify those who are frail or sarcopenic, explore the likelihood of these conditions to result in adverse post-operative outcomes, and to start working towards interventions. Aspects of this work have been presented at regional, national and international clinical and scientific meetings. Dissemination helps the progression of this work and supports the critiquing of the scientific rigour, yet the more valuable part of this body of work is determining how it may impact clinical practice. As a result of this work, surgical pre-assessment in the local trust are considering including frailty assessments into their routine practice. An acute frailty-surgical ward round has been developed as a result of a quality improvement project (detailed in **Error! Reference source not found.**), designed by *TDM* to measure the impact of implementing frailty assessments into the acute pre-operative period, involving a colorectal nurse specialist, geriatrician and a colorectal surgeon. This work has fostered scientific collaborations, as well as clinical. The development of the exercise intervention resulted from a collaboration built from the progress made by these research aims, and through exploring research potential, other collaborations are developing with psychologists, nutritionists, physiotherapists, exercise scientists and data scientists.

Frailty and sarcopenia are both constructs which can be approached through many different foci, and it is only with additional drive and inclusive collaboration between specialists that both clinicians and researchers can be clear that they are correctly and collectively identifying strategies to intervene on these conditions. In the future it may be possible to identify both sarcopenia and frailty in the one assessment, given the overlapping domains of both physical frailty and sarcopenia. However, the relationship between the two constructs would need further definition before this would be appropriate. A cohesive multi-factorial assessment may benefit from also considering cognitive impairment, nutrition or exercise tolerance more closely, should it provide additional clinical value.

Chapter 8: Frailty implementation

Interventions into frailty are becoming more of interest, especially in a surgical setting. The work described in the thesis was performed at St. James' Hospital, Leeds. As noted in Section 7.6, following on from this work, consideration is being given to frailty screening in the Trust pre-assessment processes. This would only capture patients who are being assessed for elective surgery. Acute surgical patients would not be screened for frailty as a result of these changes.

As a result of my work in the elective setting, I considered what support could be offered to surgical patients admitted acutely (data not reported elsewhere in this thesis). I led a quality improvement study that tested a frailty identification tool in the acute setting, introduced these tools to the medical and nursing staff on the acute surgical wards, and trialled some simple interventions.

In Leeds, an acute surgical patient presents predominantly through the surgical assessment unit (SAU), after either going through the emergency department, coming from their GP or being transported directly to SAU by paramedics. It is at SAU that patients are triaged to determine if they should be admitted to a surgical ward, or if they are medical patients. Here, nurses begin the admission proforma, a physician will assess the medical needs of the patient prior to their admission, and healthcare assistants will complete observations, draw bloods and provide other support as needed. When an acute patient is admitted to hospital, they will go from SAU to the ward where appropriate, should a bed be available. The patient may go directly to surgery, depending on how emergent the condition is. On the wards, patients may have between a couple of hours to approximately a day until they undergo surgery, depending on the case, availability of the surgeons and whether they consent for the surgical intervention. It may be feasible to assess for frailty on the ward, pre-operatively. This could provide an opportunity for the staff on the ward to optimise the patient pre-operatively with the window of time between admission and surgery.

Quality improvement (QI) methodologies are widely used and accepted as a process to change current practice, and implement change. QI uses improvement science to translate scientific research into clinical practice. QI projects are widespread in the NHS, with these projects being part of the development and training of junior doctors. The primary researcher in this thesis undertook a QI training program, with the aim of developing a QI project for implementing a frailty identification and support process into the acute surgical pathway at St James' Hospital.

QI projects are typically designed with driver diagrams, indicating what the aim of the project is, what components are involved and highlighting the intricacies involved within each component to support a holistic view of change. A 'dream' driver diagram was created, to map out what would be involved in the ideal situation, and subsequently a first, second and third driver diagram were developed as different stages of implementing frailty assessment. The aim of the first part of the process would be to implement frailty identification into the ward or SAU (Figure 21). The second would be that patients who were identified as frail would be targeted for of intervention based on existing components of hospital care (Figure 22). The third part of the process would be to measure the impact the interventions had on the recovery of frail patients following acute colorectal surgery (Figure 23). These three drivers would support the progression of the acute pathway to a routine identification process, towards the dream driver diagram (Figure 24).

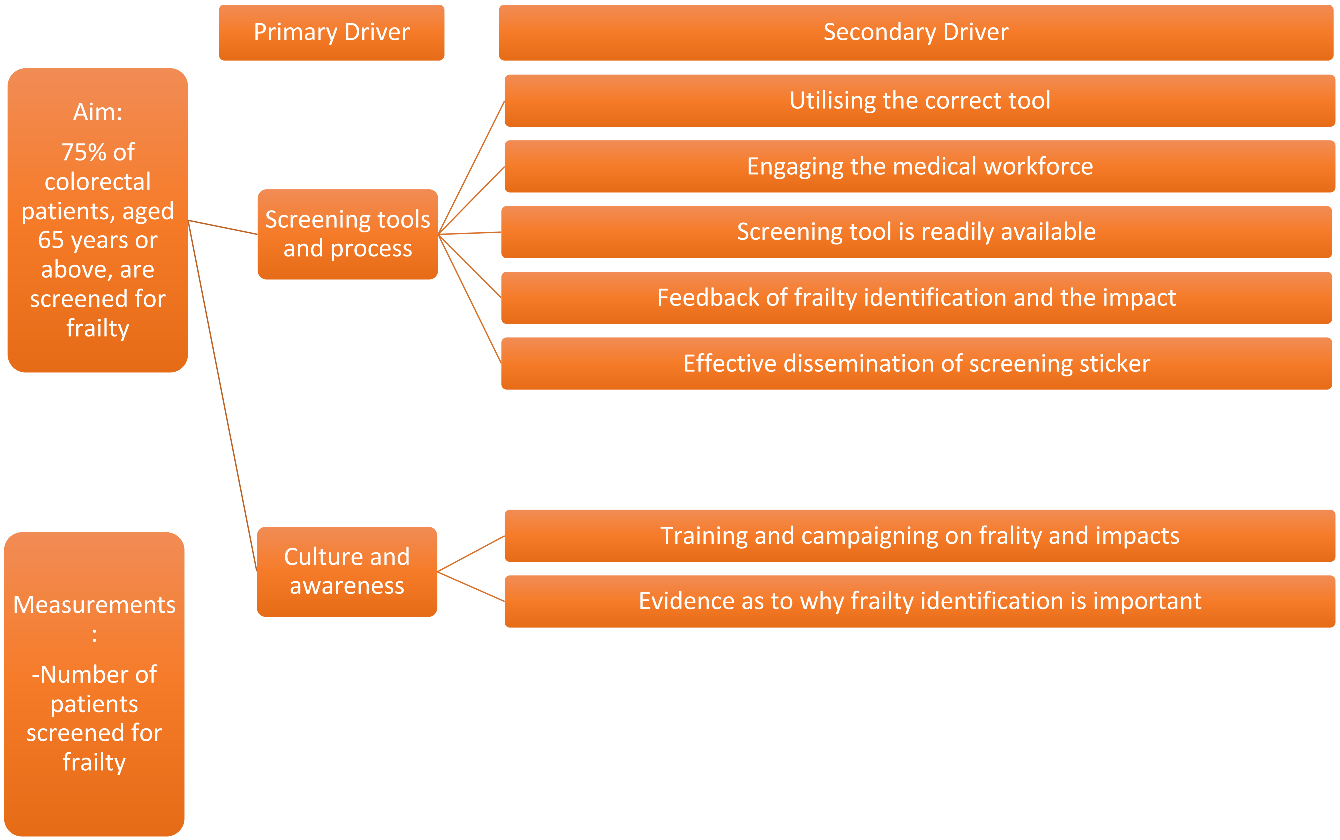


Figure 21: First driver diagram, to support the implementation of frailty identification into an acute surgical pathway

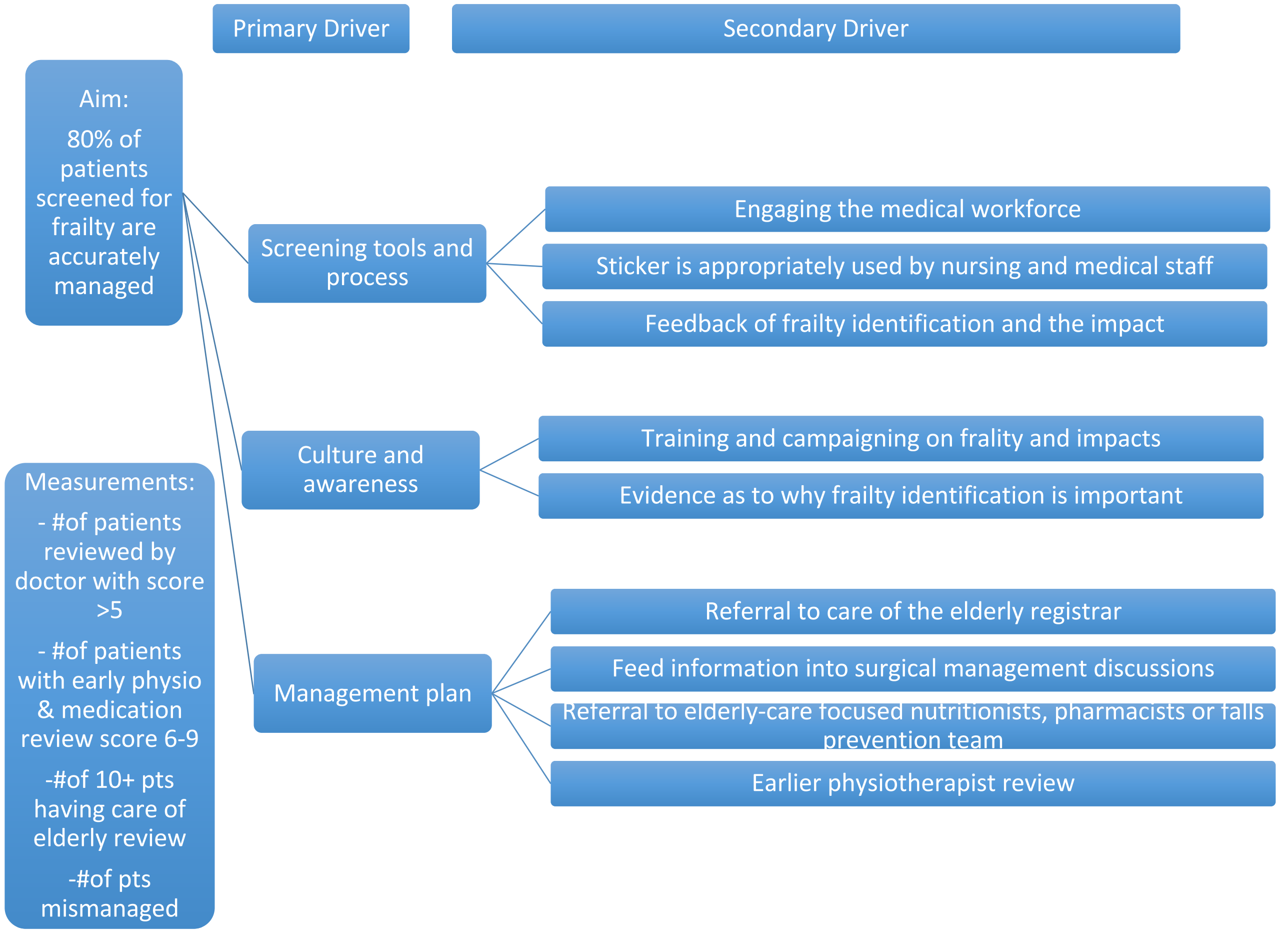


Figure 22: Second driver diagram, supporting frail patients pre-operatively with a review of medication, support by physiotherapy and input from a care of the elderly physician

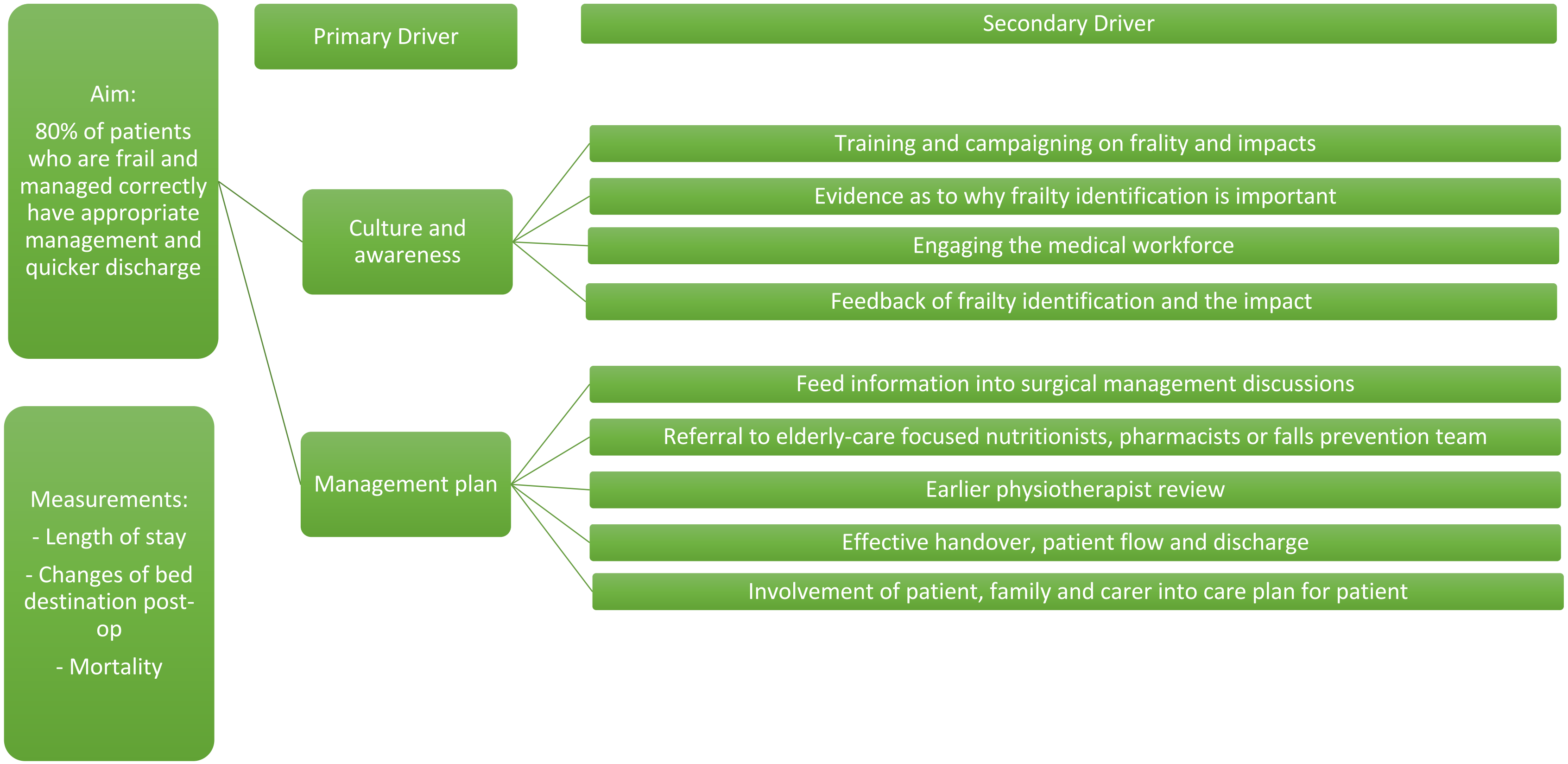
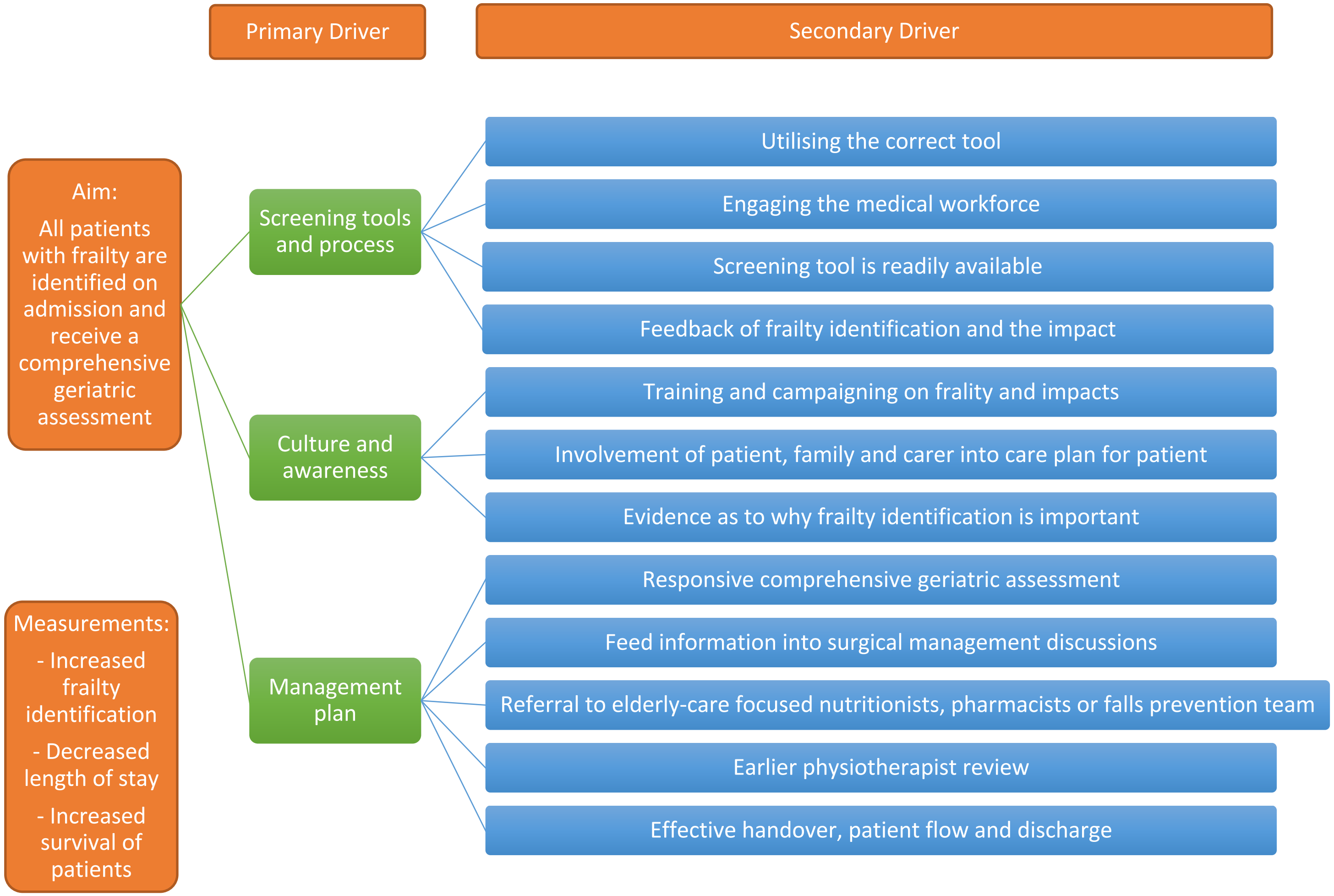


Figure 23: Third driver diagram, assessing the effectiveness of the quality improvement project through changes in post-operative recovery in frail acute surgical patients

Figure 24: 'Dream' driver diagram, for patients being supported for frailty on an acute colorectal surgical ward



This work was undertaken in St James' Hospital as a quality improvement programme, was approved as such by the Trust, and received University ethical approval (MREC16-098).

We used the Edmonton Frailty Scale (EFS) to identify admitted patients as frail. This has been used in other hospitals such as Guy's and St. Thomas' Hospital, which was determined to be a selling point to the nursing staff being asked to perform the assessments. It was hoped by highlighting the use of the assessment elsewhere in the country, but highlighting the novelty of this assessment in the local county, that staff would further engage with the project. The EFS has also been validated to be indicative of the comprehensive geriatric assessment (Rolfson *et al*. 2006), as well as having few questions that are typically already known to the nursing staff admitting patients. This was added to the acceptability of the assessment, which was intended to take only a short time to complete. The EFS was also shared with a local Clinical Nurse Specialist, who was a reliable and well-known member of staff looking after patients in several wards, who provided guidance on structuring the assessment to be performed in a way to make more logical flow for our setting.

The EFS was condensed into one-side of A4 paper, in order to facilitate the appearance of the assessment to be short and manageable. When the nursing staff had completed the admission documentation for the patient, they would complete the frailty assessment, and affix a frailty sticker (Figure 25) into the patient's notes. This would then highlight to allied healthcare professionals that this patient was screened for frailty and indicate what is required for that patient. We included recommendations for physiotherapists, pharmacists, and care of the elderly physicians that were provided from collaborations built within the hospital in those respective fields. This was done and written with their support so that allied healthcare professionals were able to engage with the recommendations, even if they were unaware of the project or if they were new to the ward. Training and conversations were also had with the doctors and allied healthcare professionals working with colorectal patients to ensure that they were aware of the project, had any concerns addressed and were made aware that this project was a widely-agreed and bought into development, with the hopes this would be more engaging.

A frailty sticker was developed, and distributed amongst the surgical wards and SAU. Following several rounds of feedback, the decision was to roll out the frailty sticker (Figure 25). Patients who were 65 years old or over were identified upon admission by the assessing nursing staff. They would then, when working up the admittance documentation, screen the patient for frailty. The nurse would affix the sticker into the notes for that patient which would be picked up by the ward staff. The allied healthcare professionals would then be able to identify whether the patient was frail, and as a result, likely to benefit from being reviewed from a prompt review, relevant to their area of expertise. For example, pharmacists were encouraged to access a host of online resources that the local trust Care of the Elderly pharmacist specialists provide to their juniors, and provided a bullet point list of things to consider for individual patients. For physiotherapists, this would involve reviewing the patient's balance and falls risk, and to perform a physiotherapy assessment for the patient early on. Nursing staff were also asked to include patients who were identified as frail onto their morning safety huddles, to ensure the frail patients were handed over between shifts in a way that continually reminded ward staff not only of the patients who are frail and their care needs, but also of the project itself.

The leading team for the quality improvement project accessed the ward records to identify patients who were eligible to be screened for frailty and requested the medical records for these patients. These records were then reviewed as a team, including a Care of the Elderly physician and a Clinical Nurse Specialist, to determine what interventions were performed and to judge whether the intervention would have been beneficial, if it had not been performed. the data collected from the patient notes were:

- Had the sticker been used appropriately
- Had the frailty assessment been performed, and what that score was
- Had the patient received:

    - Pharmacy review
    - Physiotherapy review
- Surgical plan and medical interventions
- Expected length of stay and true length of stay
- Current medication use
- Care level required when in hospital
- Current living situation and support structure

Nurse review:
65+ yr ☐ **If yes, continue**

Edmonton Frail Scale

Not frail	score 0-5	☐
Pre frail	score 6-7	☐
Mildly frail	score 8-9	☐
Moderately frail	score 10-11	☐
Severely frail	score 12-17	☐

If score is >5, pass to F2 doctor or above
Date______/______/______ Time:__________
Nurse name_______________________

Please stick this & frailty sheet into Admission Booklet

Frailty treatment:
If Edmonton score is 6-9:
Pharmacist to review of medication ☐
Call for earlier physio review ☐
Add patient to safety huddles ☐
If Edmonton score is 10+, do above
and discuss with care of elderly reg ☐
Date______/______/______ Time:__________
Doctor/AHP name_____________________ Grade_________
Please ensure this information is handed over to surgical team.
AHP guidance is on the back of the EFS assessment.

Figure 25: Frailty sticker distributed to colorectal surgical wards and surgical assessment unit. AHP - allied healthcare professional. F2: foundation doctor. EFS: Edmonton frailty scale

This work looked at 63 patients over 17 weeks of trailing the sticker and the EFS. Fifty-one of these patients had case notes available for reviewing, and all were 65 or over. Of these 51 case notes available, 38 (74.5%) of patients were surgical and only 2 (4%) had a frailty assessment. Patients were deemed as surgical if the consultant responsible for the patients' care was a surgeon.

Twenty (39%) patients were reviewed by a pharmacist as a part of their in-hospital stay - though the two patients who had been assessed for frailty did not receive a pharmacy review. Eighteen (35%) had a physiotherapy review whilst in hospital. Three (6%) were seen by care of the elderly. Nine (18%) were escalated to a high dependency unit, and 2 (4%) were escalated to intensive care. Thirty-two (63%) had an extended length of stay of three or more days longer than what would be typically expected for their surgical procedure. This was assessed in the same way as in Chapter 5, where BUPA guidelines were followed, and adjusted by surgical recommendations where available.

Twenty-nine (57%) patients had surgery, and the remaining surgical patients were treated without operative intervention. Of these 29, 15 (52%) had post-operative complications, including acute kidney infection, hospital acquired pneumonia, delirium, anastomotic leak, infection, hypoglycaemia and hyperglycaemia, and one developed a stone which required removal. When reviewing these notes, a nurse specialist, care of the elderly physician and frailty researcher discussed cases to determine whether the frailty assessment would have benefited the patient. It was identified that 26 (51%) of the total number of patients reviewed would have benefitted from a frailty assessment and the interventions that were aimed to be delivered as a result of this project.

This project was not successful, in terms of how many patients had stickers in their notes. The work did lead to the establishment of a frailty ward round in the surgical department. A care of the elderly registrar, along with a nurse specialist, now assesses acute elderly surgical patients admitted for emergency laparotomy. This is in accordance with National Emergency Laparotomy Audit recommendations, where patients over the age of 70 admitted for an emergency laparotomy are reviewed by a care of the elderly doctor. There are limitations to this work, in that other acute surgical admissions are not being reviewed and frailty is not being identified but being treated for, which reduces the metrics available for analysis to make sure a positive difference is being made. However, QI processes are is designed in a way to accept the flexibility of development if an improvement is being made, as progress towards the end-goal is often more beneficial than ‘getting the numbers right’. It is hoped that with the development of this frailty ward round, a business case can be developed to begin a well-founded, service-wide frailty ward round, to support acute surgical frail patients in the peri-operative window.

Chapter 9: Conclusion

This work described in this thesis aimed to compare frailty measures, sarcopenia measures, their interactions, and their association with recovery in colorectal surgical populations. The work spanned the use of frailty and sarcopenia assessments, a qualitative study of staff and patient views of frailty and its assessment, an examination of outcomes, and pilot work on an intervention. The key learning from this work is that sarcopenia and frailty are separate entities and our data highlight that some measures are not predictive of adverse outcomes in a colorectal surgical population in their current form. Frailty can be identified through different methods, and whilst they may disagree with each other, it may be that frailty is most accurately identified through a series of screening and functional assessments. We need to consider the choice of frailty identification measure for use in the clinical setting carefully, taking into account the intended outcome from the use of the tool. If frailty is to be assessed in the surgical setting, there must be clinical value. The use of frailty as a predictor to post-operative outcomes is not necessarily the only justification. Frailty should be identified routinely not because of any possible association with post-operative outcomes, but because patients who are frail require additional support throughout their surgical treatment and beyond. It is only with the identification of those individuals living with frailty that we can target interventions to support them.

The assessment of sarcopenia in surgical patients needs further research, to clarify what the optimal cut-off points are for the components making up the sarcopenia criteria. Sarcopenia, as identified by the EWGSOP criteria, can indicate patients who have a greater risk of adverse outcomes, though to use it for outcome prediction would be premature without further work. This work would need to be performed on large datasets to determine if knowledge of sarcopenia adds value to the information gleaned from other risk factors.

Our data indicate that older adults can improve their lower limb strength through an eccentric exercise regime, though this information is in a community-dwelling population in a feasibility study. Studies are required to determine if the impressive results of the short four-week training program we tested in volunteers can be reproduced in frail and clinical subjects.

There are limitations to the work in this thesis, in that it was performed in a single-centre and was restricted by statistical power, cost and resources. The data collected identifies a weaker signal between frailty, sarcopenia and surgical outcomes, in comparison to what current literature suggests. This work raises salient questions as to what truly is the optimal frailty measure to use in colorectal surgical patients and what interventional support may be suitable for them. This series of pilot studies provides a strong platform on which future research can develop, looking in depth at the relationships this broad thesis explores.

Geriatric conditions are becoming more prevalent with our both-chronologically and biologically ageing population. This thesis identifies the need for assessments and interventions in the frail elderly to be translated from research to routine clinical practice and provides a baseline against which improvement methodologies can be tested. There are many challenges in this field of research, however an incredible potential to make a substantial difference.

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Chapter 11: Appendices

11.1: Appendix 1: Elective Pathway

With developments in technology, surgical procedures, support throughout the surgical pathway and better identification of conditions (such as through the national bowel cancer screening programme), there is an increasing number of patients attending for surgical resection. The majority of these patients are older adults. Colorectal cancer is the third most common cancer in the UK, for example, and typically is identified through the bowel cancer screening programme in patients over the age of 60. Due to the developments seen in the healthcare service delivery for the older adult, more operations are occurring on those who are chronologically older. Whilst the availability of surgical treatment for older patients with cancer may be positive, there needs to be consideration as to the impact that the biological age or physiological reserves a patient has and how this will impact on the patient throughout their time on the surgical pathway.

When a patient is identified as a potential surgical candidate, this predominantly occurs at a surgical outpatient clinic. Some patients may have had an acute episode, treated conservatively and require an elective procedure later on, or may be identified from their general practitioner and referred to a surgeon for their clinical evaluation of the patient. Regardless of the initial journey for having an elective procedure, almost every elective patient who undergoes an elective procedure will attend surgical outpatients for the surgical consult. It is at this consult that the patient will discuss with the surgeon the options for their treatment, should intervention be an option. For example, someone who has a right-sided colonic tumour may want to have an elective resection of their bowel, in order to have a curative procedure. There may be other options for that treatment, such as chemotherapy or radiotherapy, which will be discussed if appropriate, as well as what would happen should treatment not occur. It is at this surgical outpatient appointment where the patient and surgeon make an informed decision together to determine whether an elective procedure is the right course of action for the patient.

Following the outpatient appointment, the patient will either receive an appointment or will attend a drop-in session at a surgical pre-assessment clinic. At this clinic, in St James' Hospital, the patient will complete a pre-assessment proforma detailing lifestyle, health and wellbeing questions in the waiting room prior to being called in to see one of the pre-assessment nurses. The questions within the proforma are then discussed in further details with the pre-assessment nursing staff to explore if there are any co-morbidities or risks that the patient may have that could be detrimental to their health, especially throughout the surgical pathway. This assessment with the nurse will then instigate certain interventions or packages of care for the patient. One package of care, for example, is if a patient is a falls risk. Should a patient indicate that they have fallen twice or more within the last year, have a fear of falling, or have a walking aid or impairment, the patient is referred to a falls clinic. This is vital for not only patient safety in hospital, to ensure a full risk assessment is provided for the patient and their healthcare team for when the patient is in hospital, but also to support the mobility of that patient prior to the patient being admitted. The patient at risk of falls may have their gait examined, be given advice to support their mobility or provided a different walking aid that may be better suited to them. Another example is that if a patient is overweight, the pre-assessment nurse will perform a STOP BANG assessment on the patient, which is not noted on the proforma but part of the nursing skillset, which identifies if a patient is at risk of sleep apnoea or obstructive pulmonary/sleep disorder. A positive STOP BANG assessment indicates that if a patient is supine, there may be a risk of respiratory distress due to obstruction caused by their body mass. This is a critical consideration for the surgical procedure because if the patient is under a general anaesthetic, the airway would be harder to manage should the patient suffer from respiratory obstruction due to their body mass. If the patient is under a spinal anaesthetic, the patient could potentially struggle to maintain their airway whilst under the anaesthetic and could experience a degree of obstruction. This, in itself, may cause the oxygen saturation of the blood to deplete, causing a degree of hypoxia and increase the risk of adverse events throughout and following the surgery. It is the nursing staff's responsibility to identify risks following the patients' responses on the surgical pre-assessment proforma and to initiate any further investigations or interventions, should they be required. Pre-assessment nurses have only 40 minutes to review each question on this substantial proforma, explore the patients' histories and make their referrals, before their next patient is due.

Following on from the nurse's assessment of the patient, the patient will then visit a healthcare assistant. With the healthcare assistant, the patient will have a Methicillin-resistant *Staphylococcus aureus* swab, have bloods and urine samples taken and an echocardiogram performed if indicated by the pre-assessment nurse. The healthcare assistant will also take the height and weight of the patient, and provide the literature available on surgery to the patient.

Previously, discussing healthcare with the nurse and having routine assessments with the healthcare assistant were the only members of staff the patient would encounter as part of the surgical pre-assessment pathway if robust enough for surgery as deemed by their clinical reviews. Recently at St James' Hospital, however, patients on blood thinners now attend a 'bridging' clinic, to help control their prothrombin time for blood clotting so that risk of excessive bleeding is minimised for their upcoming procedure. There is also a diabetes-specialist based within the clinic that will see patients who attend surgical pre-assessment to help the patient better manage their diabetes, with the aim to support the patient both throughout their time on the surgical pathway and also following discharge.

Between the pre-assessment clinic appointment and the surgical procedure, there is an unknown window of time. For cancer patients, the government have implemented the six-week 'time-to-treat' gap, meaning that those patients who are diagnosed with cancer should receive treatment within six weeks of their diagnosis. Clarification of what is defined by 'treatment' may be required, as there is a potential debate around whether patient optimisation pre-operatively classifies as treatment, however currently St James' Hospital surgical performances indicate that the six-week 'time-to-treat' refers to the timescale between diagnosis and surgical procedure. For non-cancer patients, this window is much more variable, with some patients requiring another surgical pre-assessment clinic appointment for re-assessment after three months. This is to ensure that the information the patient and the surgical team have is an accurate, up-to-date representation of the patient. Over this extended window, the patient may or may not be provided information on how to better their health pre-operatively. This also provides healthcare teams the opportunity to investigate conditions that may impact the surgical recovery of that patient, such as if they are a falls risk or have sleep apnoea, and provide risk assessments and interventions for the patient. Some patients, over this duration, may either remove themselves from the elective surgical pathway or present acutely to the emergency department and treated acutely, depending on their clinical condition.

When the date of surgery is provided, regardless of how long the patient has been waiting since their previous pre-assessment appointment, the patient may either come in during the day preceding or day of the surgery. Should a patient attend the day prior to the surgery, it is likely that these patients require an infusion pre-operatively in order to boost their iron levels. A recent clinical trial (preoperative intravenous iron to treat anaemia in major surgery - PREVENTT) being delivered at St James' Hospital was investigating the efficacy of preoperative iron infusions in comparison to a placebo, for example, in order to optimise patients preoperatively. The patient will have their procedure and the pre-operative care plan will be followed, unless an adverse event occurred and additional provisions are required. If an adverse event occurs, some patients may require support from the high-dependency unit (HDU) or intensive care unit (ICU), depending on the severity of the patient's condition, or return to a ward to recover. Whilst recovering in any setting in hospital, the patient will be monitored by nurses regularly throughout the day and provided meals by catering staff, and potentially be reviewed by a physiotherapist and pharmacist. If a patient is a falls risk, this is highlighted upon admission using the pre-assessment proforma and the falls clinic work pre-operatively, and the physiotherapists would attend to the patient whilst in hospital, in co-ordination with the nursing staff, to ensure the patient has a bed visible from the nurse's station, has clear access to the toilet and the mobility aids they require to mobilise as independently as is safe to do so. The surgical staff will also perform a ward round in the morning, which provides the consultant information on the progress of the patient, which highlights any further medical or surgical considerations for the patient and indicates if other care is required.

Patients will remain in hospital until they are both deemed medically fit for discharge and also have the social care in place to return to the intended place of origin. These two dates may not necessarily be the same; a patient may be medically fit for discharge from the hospital, but could still be waiting a care in the community (CIC) bed as they are too unwell to return home. Unfortunately, the patients who are more likely to require additional packages of care post-operatively, following discharge, are the frail elderly who have been unattractively coined 'bed-blockers' by media as there can at times be a substantial gap between those patients who are medically fit for discharge from a hospital setting but require rehabilitation prior to returning to their intended post-operative destination.

Approximately four to six weeks after discharge, surgical patients are invited to attend a surgical outpatient appointment for the operating surgeon or colleague to review the progression the patient is making in terms of their recovery. Following their discharge and from here-on-in, patients are also returned to the care of the general practitioner (GP). At the post-operative outpatient appointment, it is discussed if there is any remaining treatment, any expectations to have following discharge or any indicators for the patient to be aware of that further related health-deterioration may occur, so the patient can self-monitor their recovery. If the patient has had a complication at home, they are likely to be re-admitted to hospital acutely, and are treated accordingly.

Patients preoperatively and postoperatively, whilst out of hospital, are also in the care of their GP. Often, referrals are made from the general practitioner to the surgical staff for their consult of the patient. The GP, when referring, will have discussed with the patient that surgery may be one of the potential treatment options available, or there may be medical alternatives should they have a preference or if one is more appropriate. GP practices are currently exploring the adoption of frailty identification, in the form of the electronic frailty index (eFI). This frailty tool is automatically generated by the codes inputted into SystemOne (a GP healthcare database for that patient) using the philosophy that frailty is derived from the accumulation of healthcare comorbidities.

When the patient is discharged from hospital the GP will be notified at some point, in the form of a discharge note written by a foundation doctor, informing the GP of the surgical procedure that was performed and what events occurred in the hospital, if it is relevant to do so. As discharge notes are not automatically generated at St James' Hospital, there is variance in the depth and scope of information provided to the GP about the patient's health status following discharge. The patient will refer themselves to the GP should they require further medical input, such as medication changes. Sometimes the GP, if they are aware of specific healthcare needs a patient has, may call or visit the patient post-operatively in order to provide further support. This, however, is unfortunately not a frequent occurrence due to the unrelenting schedule a GP has.

Frailty in surgical patients is rife, and can influence the entire journey from being referred to the surgical outpatient appointment, through to the post-operative recovery of the patient. Frailty is not identified as part of the surgical pathway in St. James' Hospital for colorectal patients, regardless of the presenting cause of surgical review. Considering frailty is associated with adverse post-operative complications, similar to falls and sleep apnoea, the identification of frailty could potentially be clinically-informative, providing patients and healthcare staff more of an understanding of potential treatment options and potential side-effects that may be experienced as a result of the different treatment modalities. Patients need to make informed decisions about how what action to take following their understanding all of the options available to them. There is an ethical argument to be made, in that without the identification of frailty - a syndrome associated with increased care requirements, especially during surgical interventions - we are not empowering patients with all of the necessary information that would aid them in their treatment decision.

Identification of frailty could occur at any point throughout the elective surgical pathway, however if done during or following surgery, there would be little possibility of supporting the patient. Should frailty be identified in the elective pathway pre-operatively, there are two possible areas for this to occur: in the surgical outpatient appointment when presenting for the surgical consultation, or in the surgical pre-assessment work up. The surgical outpatient clinics are incredibly brief and will often require re-establishing a verbal history of the patient, a physical examination should it be pertinent to decision making, explaining possible surgical treatments, discussing expectations and providing information as to ‘what’s next’ for the patient. Within this time, the patient may have also received a cancer diagnosis, which can be distressing, meaning that identification of frailty in this clinical setting may not be the most appropriate. Alternatively, using frailty as a measure of risk similar to sleep apnoea or falls, the implementation of frailty identification is the logical choice. This assessment would also then be able to risk stratify the frailer patient, highlighting areas that the patient could undergo optimisation for their upcoming surgery, and pass this information to the surgical team, so that the appropriate preparations could be made.

The impact frailty has on patients is under-explored, as well as the opinion of the surgical and nursing staff, and the GPs with regards to how they understand and perceive frailty in their day-to-day work. The concept of frailty identification occurring at pre-assessment would directly impact onto the surgical pre-assessment clinical staff, meaning that an appreciation as to the impact frailty identification would have in this clinic is vital for the success of its adoption. If frailty was to be identified routinely, it would be valuable to understand the patient perspective of frailty and those with frailty differ, if at all, in their experience during the surgical pathway. As the surgeons are operating on the patients and support the co-ordination of post-operative support such as the destination of the patient to HDU or ICU following surgery, perceptions of surgeons on frailty is also valuable. Finally, considering how patients are referred and discharged to the care of the GP, and may sometimes not come back to the outpatient appointments or would see the GP prior to returning to the outpatient appointments, understanding the perceptions GPs have on frailty could provide more information as to what more could be done in hospitals to ensure adequate support is available for the frailer older adult following surgical discharge.

11.2: Appendix 2: Patient, Surgical, Pre-assessment and General Practitioner background

11.2.1: Patients

Frailty, to some, is considered a ‘dirty word’. Some people regard it as referring to ‘end-of-life’, dependent on external help or being helpless and is potentially an emotionally-charged word. For others, it may mean that someone required additional support and vulnerable, but without the emotional inference. However, a considerable amount of research effort investigates the quantification of frailty, using different frailty identification tools, and has created almost a race in its application. An area that is much less understood is the qualitative value frailty has, in the way people experience frailty and what it means to them. There is reasonable premise that frailty needs further qualitative exploration in order to determine the less quantifiable aspects surrounding frailty, such as in-depth emotional responses to being identified as frail, or about the aspects of frailty which patients may already understand and what aspects are less well known.

Qualitative methodologies are utilised for many different purposes. For instance, when first approaching a research topic, the National Institute of Health Research (NIHR) recommends Patient and Public Involvement (PPI) groups are approached to ascertain the impact that the research would have on patients and look to see whether the work is ‘palatable’ for patients to be involved in. This work can adopt a loose qualitative approach to understand the emotions people have around a research topic and utilise this information to aid the study design. Other uses for qualitative research is to explore experiences of patients within a context, such as surgery or cancer treatments, to investigate either a breadth or depth of information that can inform future treatment options and research programmes. For this study, a broad qualitative research design has been adopted to provide preliminary data, exploring the range of feelings patients may have about their time on the surgical pathway. This can then lead to more targeted mixed-methodology studies investigating the impact frailty has directly on patients during the surgical journey and their recovery post-operatively.

With frailty being a contested topic by many, and one of a sensitive nature, the focus groups involving participants are designed to not discuss frailty directly, but to discuss the expectations patients had prior to undergoing surgery and their experiences throughout the surgical journey through to recovery. This study compares the themes identified by the participants in a robust population and allows comparison to a frail population, as defined by the work outlined in the larger study. The aims of these focus groups are to explore whether patients who are frail have different expectations and experiences throughout the colorectal surgical pathway, in comparison to their robust counterparts.

11.2.2: Surgeons

Consultant surgeons have ultimate responsibility of surgical patients admitted to the hospital, regardless of whether the patients are admitted acutely or electively. Within the scope of this responsibility, decision-making regarding what treatment options are available for the patient is fundamentally rests with the surgeon and the patient. Whilst patients are given every effort to be empowered to make informed decisions, there are times when this may not be overly feasible. For example, if an unresponsive patient is admitted acutely with a perforated bowel, it is likely that the surgeon will be required to operate on the patient in order to prevent the patient from further deterioration or from dying. It is therefore unlikely that this patient can make an informed decision on their treatment options. Another example is if a patient does not have the capacity to make an informed decision due to other health conditions, such as dementia. Those who are cognitively frail, who have dementia or other conditions affecting cognitive ability, can impair patients in making decisions relating to their health. It is in these instances where the surgeon has overall responsibility as to whether or not surgery is in the best interest of the patient. One factor that may inform surgical decision-making is the presence of frailty.

Frailty has been shown to be associated with hindered recovery following surgery, such as an extended length of stay, re-admission and not restoring to pre-operative baseline activity levels. Controversially, little work has been done to investigate the perceptions of surgeons on frailty, on how frailty is identified and treated, and how it may or may not impact surgical decision-making. This information would be incredibly tenuous to capture quantitatively, and not provide enough information through probing questions in a reliable way to receive an understanding of the surgical perspective. Open-ended interviews were utilised to answer the following question: how, if at all, does the patient's frailty status change your surgical planning?

11.2.3: Pre-assessment clinical staff

Frailty does not only need further exploration through quantitative methods, but there is a lack of understanding as to the perceptions around frailty. With the decision to undergo surgery, a patient will require a pre-operative assessment. This assessment will identify the risks a patient may face throughout their time on the surgical pathway, and what requirements they may have both immediately post-operative and after discharge. During pre-assessment, nurses examine the history and current presentation of the patient, addressing the holistic view of the patient. It is here, following these assessments, that interventions and care packages are put into place to support the patient for their surgery and to support both the patient and the surgical team to make more informed decisions about the options of care available for the patient and what the outcomes of each treatment option may be. Currently, in St James' Hospital, frailty is not identified in the elective surgical pathway however would be ideally placed at pre-assessment. This could enable the delivery of a package of care for frail patients, with the aim to optimise health prior to surgery. A body of literature already exists in the perioperative optimisation of patients presenting for surgery (POPS), with the specific goal of supporting frail older adults survive surgery. The POPS programme was trialled at the St James' pre-assessment service, though unsuccessfully. Whilst the research available shows that perioperative optimisations can have a marked effect on patients' progressions throughout recovery, uptake of the service was minimal and not enough for a sustainable pathway to form.

The POPS service supports the identification and treatment of frailty, using the comprehensive geriatric assessment (CGA). The CGA takes time to perform, involves either a specifically trained nurse or geriatrician to co-ordinate a multidisciplinary team approach to supporting the patient, and adapts following the clinical changes in the patient throughout their time within and following discharge from hospital. Unfortunately, it is unfeasible to train the pre-assessment nurses to be able to perform this assessment within the short 40-minute time window a nurse has with a patient, as well as performing the routine assessments currently in place. This would be timely, expensive and with the current high-turnover of staff within St James' pre-assessment, unfeasible to train the nursing staff to perform this in-depth assessment. An alternative measure of frailty identification is required to be able to pick up on those patients who are potentially at risk of an adverse event during their time on the surgical pathway, and hopefully allow the healthcare team to provide methods of optimising health care for that patient in preparation.

Pre-assessment clinic, in our Trust, is under significant pressures due to a high staff turnover, low morale and an increasing number of patients who are either requiring surgical pre-assessment or re-assessment if patients have been waiting an extended period of time between their initial assessment and their planned surgical date.

In order for the pre-assessment staff to adopt a frailty assessment into their workload, the barriers of implementation and the perceptions of frailty within the pre-assessment setting at the moment is vital to explore. Without the awareness of these perceptions, frailty identification may either not be accepted into the pre-assessment methods or the adoption of frailty identification at pre-assessment may not provide the intended aims to support tailor patient care planning.

A focus group was held with pre-assessment staff, including nurses, healthcare assistants and senior charge nurses. The aim of this focus group was to identify barriers of implementing frailty identification tools into the current pre-assessment work stream and to identify the current perceptions of frailty held by the pre-assessment staff.

11.2.4: General practitioners

Arguable, a general practitioner (GP) will have a better insight into a patient's health status than a physician in a secondary care centre, unless the patient has been treated within the hospital for a period of time. For elective patients, or patients on a cancer screening pathway, they will have likely been identified through an appointment with their GP. The GP may refer for additional tests or for a surgical consult, and following the patient undergoing surgery, the patient is discharged back into their care. The GP has a substantial role to play in the identification of potential conditions a patient may have and the individual support requirements the patient has in order to retain independence and to intervene on health deterioration. Patients post-operatively may present to the GP with questions about recovery or about any complications or adverse event they may have concerns about or are experiencing.

GPs are currently integrating the eFI into general practice, following a change to the GP contracts. An initiative by the Improvement Academy has supported the adoption of the eFI for practices with SystemOne support to identify frailty, based on the accumulation deficit approach. Frailty identification using the eFI is based on 36 health deficits, similar to the 36-point accumulation deficit model, though uses a variety of codes for each deficit that a GP may use to demarcate a health condition on the patient's electronic record. There is more work needed on the eFI, such as the ability to have the eFI be more adaptive to the patients' current clinical presentation, as frailty is a scalar syndrome which can both deteriorate and improve over time. Also, the applicability of this method of frailty identification is not completely validated. One issue this thesis identifies is that in an elective population, the 36-point accumulation deficit model is the least associated with post-operative outcomes in comparison with the frailty phenotype and the clinical frailty scale. The understanding of not only how a GP perceives frailty but also the clinical value of a frailty status being available is critical to the success of the successful adoption of frailty identification and its use throughout clinical practice. The interviews conducted within this thesis aim to address the research questions: how should we identify for frailty, how should we treat for frailty and how should frailty information relating to surgical patients be shared between clinical practice and the surgical setting?

11.3: Appendix 3: Topic guides for interviews

11.3.1: Patient topic guide

Table 34: Patient topic guide

Introduction	• Name, job and where I'm from. Name of the research study: Introduction of research participants are involved in (with information as to funding, the design of the study, types of data collected and what the hoped outcomes would be) • Explain; confidentiality, length of interview nature of discussion • Ask if there are any questions for the research team • Consent those who wish to continue. Those who do not consent will be asked to leave.	10 minutes **Information Sheets** **Consent forms**
Frailty: Background and expectations	Key question: What did you hope to get out of surgery? Prompt questions: • How has your medication use changed? • How has your ability to do everyday tasks changed? • What were your expectations of your time being an in-patient? • Did reality differ from your expectations? • What morecould be done to better support you?	

Post-operative evaluation	Key question: What did you think about the way you were prepared for surgery? Prompt questions: • Did you feel prepared for your surgery? • How did you prepare for your surgery? • How better could you have been supported in getting prepared for your operation? • Did you notice any side effects from your surgery? • Would any of these side effects be attributed, in your perception, to frailty? • What were the negative aspects of surgery? • Did you find that you were reliant on the healthcare staff during recovery in hospital? What happened during this time? • Did you find that you were reliant on your family and friends during your recovery? Were you expecting this? • What was your wait time from the point of the clinic where surgery was discussed to the operation? Was this what you were expecting? • Were you advised to do anything between the time of the out-patient clinic and the operation, in order to prepare for the operation? By who? • If you were advised to do anything prior to surgery, how much did you follow these? • Upon reflection, do you think you would have done anything different in this time?	
Changes to your daily activities	Key question: Looking back, would you still have had the surgery? Prompt questions:	

	• Have you had changes to your medications? What effects have these changes had? • How are your day-to-day activities different to before? • If you often felt tired before your surgery, has this changed? If you didn't, again, has this changed? • Have you noticed any changes in your physical strength or activity levels? • Are you now happier than you were before? • Have you previously experienced any falls? Are you worried about falling? Is this more or less now? • Have you noticed any mental health changes over the surgical journey? • Have you noticed any changes to your independence since the surgery? What does this mean for you?	
Conclusions	• Reiterate how information is to be used • Thank them for participation • ?Feedback of the interview • Where to find the results of the study	

11.3.2: Surgeon topic guide

Table 35: Surgeon topic guide

Introduction	• Name, job and where I'm from. Name of the research study: Introduction of research participants are involved in (with information as to funding, the design of the study, types of data collected and what the hoped outcomes would be) • Explain; confidentiality, length of interview nature of discussion • Ask if there are any questions for the research team • Consent those who wish to continue. Those who do not consent will be asked to leave.	10 minutes **Information Sheets** **Consent forms**
Frailty	"Frailty is a syndrome that is typically associated with an increased risk of falls, and health complications. In the medical field, frailty is being explored to a reasonable degree, however what one thing means to healthcare professionals, does not necessarily mean the same to a patient. We are looking to see what your opinions, as a surgeon, are on frailty." Key question: How does frailty change your surgical planning of a patient? Prompt questions: • How many patients aged 65 or older do you see? • What other factors change the surgical plan? • Do you identify frailty as part of the surgical pathway at the moment? • If frailty isn't identified already, would you change surgical planning if you knew a patient was frail?	

Expectations	Key question: Can you tell me a time where the expectations of the patient and yourself didn’t align? - Can you tell be about a time where the patient felt that surgery was not appropriate for them, where you believed it was? - Can you tell me a time where the patient felt that surgery was appropriate for them, but you felt it didn’t? Prompt questions: • What would a typical 65 yro patient expect from their surgery? • How do you think this would change if the patient was frail? • Would your expectations of the patient’s recovery change? • What, pre-surgery, should be done to optimise the frail patient? • What would you recommend during the in-patient recovery for frail surgical patients? • What would you recommend to the patient during recovery following discharge? • What would you recommend to a frail patient to do prior to their surgery? • In your perspective, what are the barriers patients would face following this advice?	
Treatment	Prompt questions: • How would you treat a 65 yro patient differently from normal? • How would you treat a frail patient differently from that? • Do you think frailty is treated intuitively? Is there any specific group of people who do this for surgical planning? • How would you support a patient who is too frail for surgery? • Whose responsibility should it be to identify frailty? • Whose responsibility should it be to treat frailty?	
Conclusions	• Reiterate how information is to be used • Thank them for participation	

	• ?Feedback of the interview • Where to find the results of the study	

11.3.3: Pre-assessment clinic topic guide

Table 36: Pre-assessment clinic topic guide

<table>
<tr><td>Introduction</td><td>Name, job and where I'm from
Name of the research study: Introduction of research participants are involved in (with information as to funding, the design of the study, types of data collected and what the hoped outcomes would be)
Explain; confidentiality, length of interview nature of discussion
"What is discussed in the context of this focus group will be solely used for research purposes and opinions shared in this focus group will remain within this body of work. The aim is to see if frailty has a place in the pre-assessment clinic, as an idea of improving the ability to identify high-risk patients pre-operatively."
Ask if there are any questions for the research team
Consent those who wish to continue. Those who do not consent will be asked to leave.</td><td>10 minutes

Information Sheets

Consent forms</td></tr>
<tr><td>Pre-assessment</td><td>"Currently, patients enter at allotted times, or attend drop-in slots, and during their wait, complete the pre-assessment form. During a 40-minute window, a nurse will review the pre-assessment booklet, identifying risk factors and whether certain tests are required. Following this, the healthcare assistants will perform some tests (bloods, urine samples, ECGs etc) and the patient then leaves to undergo further tests or to await surgery."

Key question:
What is the function of pre-assessment?</td><td></td></tr>
</table>

	Prompt questions: • What are your opinions on the current process of which pre-assessment works at the moment? • How are the questions in the booklet used in pre-assessment? • How are the questions in the booklet used out of pre-assessment? • How, if at all, are the elderly cared for differently? • How do you prepare an elderly person for surgery? What advice do you currently provide?	
Frailty	"Frailty is a syndrome that is typically associated with an increased risk of falls, and health complications. In the medical field, frailty is being explored to a reasonable degree, however what one thing means to healthcare professionals, does not necessarily mean the same to a patient. We are looking to see what your opinions, as staff, are on frailty." Key question: How should high-risk patients be identified at pre-assessment? Prompt questions: • What does frailty mean to you? • What do you know about frailty at the moment? • What do you think frailty means to your patients?	

	• What can a frail patient expect from their upcoming surgery? • What differences will the degree of frailty cause on the patients' time on the surgical pathway? • How do you think pre-assessment identifies the frail patient? • If you know someone is frail, what should be done for them? • When should frailty be identified? By who and where? • What should a frailty assessment need to look like to be included in to pre-assessment?	
Impact	Key question: What benefits do you think would come with frailty identification occurring in pre-assessment? Prompt questions: • If frailty assessments were included in the pre-assessment process, what would be the barriers? • What benefit would you imagine this introduction of frailty assessments would be? • What impact would pre-operative frailty identification have on recovery post-operatively? • What sensitivities would you envisage around adding frailty identification to pre-assessment?	
Conclusions	• Reiterate how information is to be used • Thank them for participation • ?Feedback of the interview • Where to find the results of the study	

11.3.4: General practitioner topic guide

Table 37: General practitioner topic guide

Introduction	• Name, job and where researcher is from. Name of the research study: Introduction of research participants are involved in (with information as to funding, the design of the study, types of data collected and what the hoped outcomes would be) • Explain; confidentiality, length of interview nature of discussion "What is discussed in the context of this focus group will be solely used for research purposes and opinions shared in this focus group will remain within this body of work. The aim is to see if frailty has a place in the pre-assessment clinic, as an idea of improving the ability to identify high-risk patients pre-operatively." • Ask if there are any questions for the research team • Consent those who wish to continue. Those who do not consent will be asked to leave.	10 minutes **Info Sheets** **Consent forms**
Current practice	Key question: Is frailty a problem in your practice? Prompt questions: • How many patients aged 65 or older do you see? What percentage is this? • Do you see much frailty? • How do you identify and record frailty? • Do you forward any frailty information in your referrals?	

Surgery	Key question: How do you think frailty impacts the surgical patient? Prompt questions: • When do you think frailty should be identified? Who should identify this? • What should be done for the frail surgical patient before surgery? • What should be done for the frail surgical patient following surgery? • If frailty identification was performed in hospital, would you want to know? • What would you do with the knowledge that one of your patients is frail? • What could the frail surgical patient expect from their surgical plan? • How do you think frailty impacts patients before surgery? After surgery, as an in-patient? After surgery, following discharge? • Do you think frailty is observed/ treated already in GP practices? In hospitals?	

Frailty	"Frailty is a syndrome that is typically associated with an increased risk of falls, and health complications. In the medical field, frailty is being explored to a reasonable degree, however what one thing means to healthcare professionals, does not necessarily mean the same to a patient. We are looking to see what your opinions, as staff, are on frailty." Key question: How should we treat frailty? Prompt questions: • What impact does frailty have on your patients? • What impact does frailty have on your practice? • How do you teat the elderly? How does this change if they are frail? • Do you believe we treat frailty intuitively? If so, how? • What more could be done to treat frailty? • What barriers are there in the identification of frailty? In GP practices? In hospitals? • What barriers are there in the treatment of frailty? In GP practices specifically?	
Conclusions	• Reiterate how information is to be used • Thank them for participation • ?Feedback of the interview • Where to find the results of the study	

11.4: Appendix 4: Pilot frailty assessments, referring to the clinical frailty scale, accumulation deficit and frailty phenotype

17/02/15 Version 2 Date: Consent Check :
Patient NHS Number: Researcher:

According to the Clinical Frail Scale, how does the patient present?

1 2 3 4 5 6 7 8 9 Time: Mins/ Secs

Does the patient have any of the following?

- A long-term disability or handicap
- Restriction of activities
- Need of help preparing meals
- Need of help shopping for necessities
- Need of help for house work
- Need of help for heavy household chores
- Need of help for personal care
- Need help moving about inside the home
- Rheumatism or arthritis
- High blood pressure
- Chronic bronchitis or emphysema
- Diabetes mellitus
- Heart disease
- Cancer
- Stomach or intestinal ulcers
- Suffers from the effect of a stroke
- Suffers from urinary incontinence
- Migraine headache

- Cataracts
- Glaucoma
- Other medical conditions
- No regular physical exercise
- Vision problems
- Hearing problems
- Feeling hopeless
- Dexterity problems
- Emotional problems
- Memory problems
- Bodily pain
- Speech problems
- Is taking 5 or more medications
- Difficulty carrying or lifting light loads
- Mobility problems
- Limited kind or amount of activity
- Constantly tired
- Weight loss

Score: / 36 Time: Mins/ Secs

In terms of weight loss, have you lost more than 10 pounds unintentionally in the past year?

Yes No

I have felt that everything I did was an effort:

Not at all/ rarely Some of the time A moderate amount of the time Most of the time

How often in the last week did you feel this way?

<1 day 1-2 days 3-4 days >4 days

Walk time for 15 feet:

Gender = M / F

Height = cm

Time = s

Grip Strength:

Weight = Kg

BMI = Kg/m^2

Grip Strength = Kg

Physical activity:

How many minutes do you spend on the following activities per week?

- Walking ____________ (3.5)
- Chores (moderately strenuous) ____________ (4.5)
- Mowing the lawn ____________ (4.5)
- Raking ____________ (4.0)
- Gardening ____________ (4.5)
- Hiking ____________ (6.0)
- Jogging ____________ (6.0)
- Biking ____________ (4.0)
- Dancing ____________ (5.5)
- Aerobics ____________ (6.0)
- Bowling ____________ (3.0)
- Golf ____________ (3.5)
- Singles tennis ____________ (8.0)
- Doubles tennis ____________ (6.0)
- Racquetball ____________ (7.0)
- Swimming ____________ (6.0)
- Other (define below) ____________ (NK)

____

Kcal expenditure per week = Kcal

Time: Mins/ Secs

Clinical Frailty Scale

1 Very Fit – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.

2 Well – People who have no active disease symptoms but are less fit than category 1. Often, they exercise or are very active occasionally, e.g. seasonally.

3 Managing Well – People whose medical problems are well controlled, but are not regularly active beyond routine walking.

4 Vulnerable – While not dependent on others for daily help, often symptoms limit activities. A common complaint is being "slowed up", and/or being tired during the day.

5 Mildly Frail – These people often have more evident slowing, and need help in high order IADLs (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.

6 Moderately Frail – People need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing and might need minimal assistance (cuing, standby) with dressing.

7 Severely Frail – Completely dependent for personal care, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).

8 Very Severely Frail – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.

9 Terminally Ill – Approaching the end of life. This category applies to people with a life expectancy <6 months, who are not otherwise evidently frail.

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common **symptoms in mild dementia** include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In **moderate dementia,** recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In **severe dementia,** they cannot do personal care without help.

36 Deficit model: non-frail ≤ 0.08; 0.08 > pre-frail <0.25; frail ≥ 0.25

Phenotype model: non-frail = 0, pre-frail = 1 or 2, frail = 3+

Weight loss: "In the last year, have you lost more than 10 pounds unintentionally (i.e., not due to dieting or exercise)?" If yes, then frail for weight loss criterion. At follow-up, weight loss was calculated as: (Weight in previous year – current measured weight)/(weight in previous year) ? K. If K ≥ 0.05 and the subject does not report that he/she was trying to lose weight (i.e., unintentional weight loss of at least 5% of previous year's body weight), then frail for weight loss = Yes.

Exhaustion: Using the CES–D Depression Scale, the following two statements are read. (a) I felt that everything I did was an effort; (b) I could not get going. The question is asked "How often in the last week did you feel this way?" 0 = rarely or none of the time (<1 day), 1 = some or a little of the time (1–2 days), 2 = a moderate amount of the time (3–4 days), or 3 = most of the time. Subjects answering "2" or "3" to either of these questions are categorized as frail by the exhaustion criterion.

Physical Activity: Based on the short version of the Minnesota Leisure Time Activity questionnaire, asking about walking, chores (moderately strenuous), mowing the lawn, raking, gardening, hiking, jogging, biking, exercise cycling, dancing, aerobics, bowling, golf, singles tennis, doubles tennis, racquetball, home exercise, swimming. Kcals per week expended are calculated using standardized algorithm. This variable is stratified by gender.

Men: Those with Kcals of physical activity per week <383 are frail.

Women: Those with Kcals per week <270 are frail.

- **Walk Time**, stratified by gender and height (gender-specific cutoff a medium height).

Men	*Cutoff for Time to Walk 15 feet criterion for frailty*
Height ≤ 173 cm	≥7 seconds
Height > 173 cm	≥6 seconds
Women	
Height ≤ 159 cm	≥7 seconds
Height > 159 cm	≥6 seconds

- **Grip Strength**, stratified by gender and body mass index (BMI) quartiles:

Men	*Cutoff for grip strength (Kg) criterion for frailty*
BMI ≤ 24	≤29
BMI 24.1–26	≤30
BMI 26.1–28	≤30
BMI > 28	≤32
Women	
BMI ≤ 23	≤17
BMI 23.1–26	≤17.3
BMI 26.1–29	≤18
BMI > 29	≤21

11.5: Appendix 5: Sarcopenia Standard Operating Procedure (SOP)

Title: Measurement of sarcopenia through computed tomography (CT) analysis, derived by the Picture Archiving and Communication System (PACS)			
Scope: Procedure for identifying sarcopenia on CT scans for the frailty and sarcopenia trials (FAST) unit.			
Document Number: SOP_version 1.0; 01/05/2016			
Replaces: N/A			
Effective Date: 1st May 2016			
Author: Thomas Dale MacLaine			
Approved by	**Title**	**Signature**	**Date**
Dermot Burke	Colorectal Surgeon		01/05/2016
Simon Howell	Anaesthetist		01/05/2016

Document Change Control			
Version No.	**Reason For Change**	**Author**	**Date**

Training Implications; ***(Please tick ✓ appropriate box)***	**A**	**B**	**C**	**D**
A = New Users – New procedure requiring documented assessment of competence B = Existing users - Modified procedure requiring documented reassessment of competence C = New Users - Familiarity with new procedure required (no assessment of competence necessary) D = Existing Users - Familiarity with changes required (no assessment of competence necessary)				

1. Introduction

This SOP describes the use of PACS for the diagnosis of sarcopenia.

2. Purpose / Scope

This SOP applies to the PACS machines with diagnostic power. Machines with access to AGFA IMPAX client need to have radiological diagnostic power. Machines that are not for diagnostic purposes are not calibrated for accurate measurements, and as such, do not provide accurate results. These measurements are specific to the analysis of sarcopenia for the FAST unit.

3. Associated Documents

None.

4. Safety Requirements

4.1 All users must comply with St James' Hospital safety regulations.

5. Responsibilities

5.1 Equipment Users:

- All users of the PACS machines should comply with this procedure.

6. Equipment / Procedure

6.1 Operational Use

6.1.1 Ensure the PACS machine is switched on, and is accurate for diagnostic purposes

6.1.2 Open the software called 'AGFA IMPAX client'

6.1.3 Enter patient identification details into the fields at the top of the initial screen. Once patient has been selected, press  to pull a drop down list of previous radiological investigations.

6.1.4 After selecting the scans required for sarcopenia investigations, drag the thumbnail of the transverse view of the abdomen/pelvis. If the scan is a CTC, use the transverse section where the anterior abdominal wall is at the top of the screen, and the posterior region is found at the bottom of the screen.

6.1.5 To set up the measurements required, press F12. Select the tab 'user profile' followed by the subtab 'markup defaults'.

- Check the following boxes and ensure they are selected
  - Area
  - Density (houndfield unit - HU)
- Other boxes in the measurements section are not required
- Use the calibration unit - mm

After selecting these, click 'apply' followed by 'okay'.

6.1.6 To set up the tools required for measurement, press F12. Select the tab 'toolbar' followed by the subtab 'markup'.

- Under 'markup', identify tool called 'markup freeform' similar to . Drag this from the main task bar, into the pop up tool bar.

After this, press 'apply' followed by 'okay', on the main task bar.

6.1.7 To identify the appropriate view of the transverse cross section, hold a left-click and drag down, or scroll downwards, to move inferiorly through the scans. Scrolling up or holding a left-click and dragging upwards will move superiorly. Scroll to the most inferior aspect of the L3 vertebral body.

- Identify the sacrum, using the vertebral column on the bottom of the scans and moving inferiorly.
- Scroll up slowly from the sacrum, counting the transverse processes past L5, L4 to L3. The sacrum has fused transverse

processes however there is a space between the transverse processes of sacrum and L5, between L5 and L4, and between L4 and L3.

- Once having identified the L3 vertebral body, scroll slowly inferiorly to identify the most compact slice of the L3 vertebral body - this will be a dense white oval structure. If possible, avoid scrolling too inferior where the intervertebral disc is partly visible (this can be identified as a darker non-uniform shape on the vertebral body). The average density of compact bone will be approximately 100-200 HU (this figure can be obtained by hovering the mouse curser over the section under investigation, and HU can be identified in the lower right hand side of the screen). The average density of the intervertebral disc is less than approximately 5 HU.

6.1.8 Following the identification of the correct L3 plane, identify the muscles of interest. For this investigation, identify all muscles in the transverse cross section for both left and right sides of the patient:

- Psoas (psoas major and minor are combined in this cross section)
- Erector spinae (measured as one muscle)
- Quadratus lumborum
- Latissimus dorsi
- External oblique, internal oblique and transversus abominis (measured as one muscle)
- Rectus abdominis

6.1.9 For each muscle of interest, select the freeform mark up tool - right-click on the screen, and left-click the freeform mark up tool, then move the cursor away from the tool bar. Identify a boundary of the muscle (muscles have an approximate density of 0-40 HU, and the surrounding fat is approximately -20-0 HU). Left-click once at the border of the muscle. Move the cursor following the muscle border a short distance, and left-click once to draw a straight line between the two points. Ensure the straight line fits with the curvature of the muscle. Continue to click around the muscle until the circumference has been measured. Right-click to complete the measurements, which will join a line between the final left-click and the first point. As such, ensure the final left-click is close to the point of origin (the machine will not allow the final left-click to be on the same pixel as the origin).

6.1.10 Completing the circumference of a muscle will produce the cross-sectional area measurement as well as the average density of the selected area. Note these down on a data entry form/ research database. Do this for every muscle relevant for the investigation.

Appendix 1 - Contact Numbers for FAST Research Team

Mr Thomas Dale MacLaine - 07512835326
Cath Moriarty - Senior Surgical Research Sister: 07909 960597;
Office ext. 64672

Appendix 2 - References for measurements

Full cross sectional area:
Body composition in patients with non–small cell lung cancer: a contemporary view of cancer cachexia with the use of computed tomography image analysis. Baracos *et al.* The American Journal of Clinical Nutrition, 2010.

Psoas cross sectional area:
Simple psoas cross-sectional area measurement is a quick and easy method to assess sarcopenia and predicts major surgical complications. Jones *et al.* Colorectal disease, 2014.

Density-included psoas measurements:
Paper under review - not available for distribution.

11.6: Appendix 6: Combined frailty assessments used in Chapter 5

Pre-Assessment Frailty Screening

Frailty Screening

Date of birth:

According to the Clinical Frail Scale, how does the patient present?

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐ Time: Mins/ Secs

For the below, if markers are not specified, enter 0 for no

Gender Enter M or F		Do you live alone?	
Age > 85 years		Have you noticed an increased difficulty in mobility?	
Do you have health issues that limit activity?		Have you recently noticed you have memory complaints/ difficulty with your memory?	
Do you have health conditions make you stay at home?		In the past year, how many times have you been admitted to a hospital? 0 (0), 1-2 (1) or 3+(2) times?	
Can you count on someone close to you?		How would you describe your general health? 0 for Excellent/very good/ good, 1 for fair, 2 for poor	
Do you need someone to help you regularly?		With how many of the following activities do you require help: meal preparation, shopping, transportation, telephone, housekeeping, laundry, managing money, taking medications? 0-1 (0), 2-4 (1) or 5-8 (2)?	
Do you have a walking aid/ wheelchair?			
Are you taking 5 or more medications?		At times, do you forget to take your prescription medications?	
Do you find walking 400m/ 1300ft difficult?		Do you often feel sad or depressed?	
Do you find climbing stairs difficult?		Do you have a problem with losing control of urine when you don't want to?	

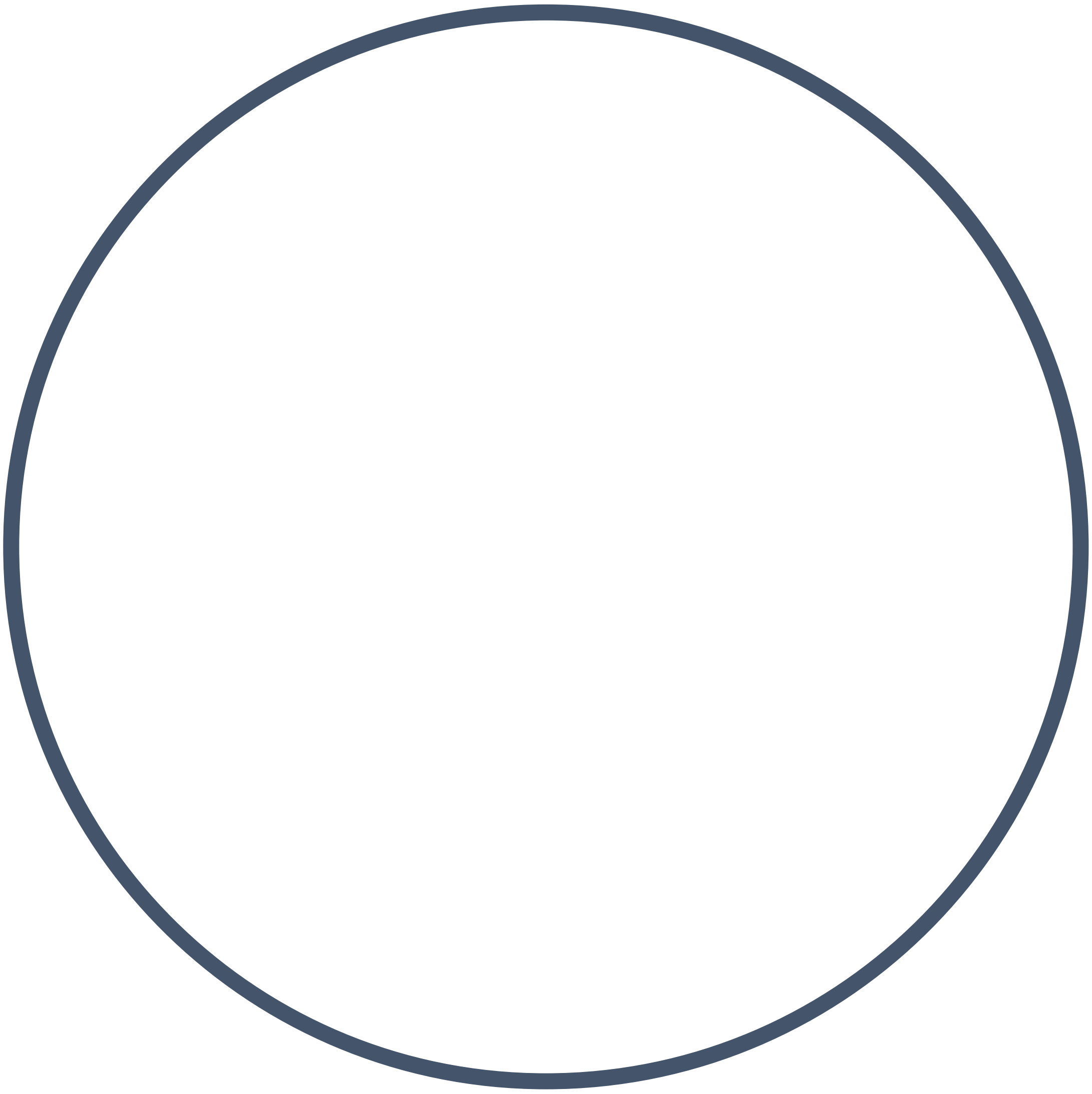
Have you noticed you have recently lost weight? (Above 4.5kg/10lbs)		How many illnesses/ medical conditions do you currently have?	
How often in the last week did you feel everything you did was an effort? (0=≤2 times a week, 1=≥3 or more)		Which is your level of physical activity? (0=2-4 hours, 1=none/sedentary)	

What is the time taken to walk 4 meters? ____________________

What is the time taken to get up out of an arm chair, walk 3 meters away, return to the chair and sit back down? *(Please circle)*	0-10 seconds	11-20 seconds	>20 seconds, patient unwilling or requires assistance

Grip strength:

Please imagine that this pre-drawn circle is a clock. I would like you to place the numbers in the correct positions then place the hands to indicate a time of ‘ten after eleven’



No errors	Minor spacing errors	Other errors
0	1	2

(please circle)

Frailty identification: 36-point accumulation deficit

Does the patient have any of the following:

☐A long-term disability or handicap
☐Restriction of activities
☐Need of help preparing meals
☐Need of help shopping for necessities
☐Need of help for house work
☐Need of help for heavy household chores
☐Need of help for personal care
☐Need help moving about inside the home
☐Rheumatism or arthritis
☐High blood pressure
☐Chronic bronchitis or emphysema
☐Diabetes mellitus
☐Heart disease
☐Cancer
☐Stomach or intestinal ulcers
☐Suffers from the effect of a stroke
☐Suffers from urinary incontinence
☐Migraine headache
☐Cataracts
☐Glaucoma
☐Other medical conditions
☐No regular physical exercise
☐Vision problems
☐Hearing problems
☐Feeling hopeless
☐Dexterity problems
☐Emotional problems
☐Memory problems
☐Bodily pain
☐Speech problems
☐Is taking 5 or more medications
☐Difficulty carrying or lifting light loads
☐Mobility problems
☐Limited kind or amount of activity
☐Constantly tired
☐Weight loss

Score / 36

Patient assessment complete

To complete from pre-assessment pack:

What is the:

Patient's height cm

Patient's weight Kg

Patient's gender **M / F** *(circle as appropriate)*

To complete from pre-assessment pack:

Day case (0) or inpatient (1) procedure? ☐

What anaesthesia is required? (0=L/A, 1=Regional/spinal, 2=sed ☐
3=G/A)

What bed is required? (0=ward, 1=HUD, 2=ICU) ☐

What is the indended procedure: ______________________________
____

Admission date: ☐☐ ☐☐ ☐☐

Operation Date: ☐☐ ☐☐ ☐☐

Estimated operation duration: ☐☐ Hours ☐☐ Minutes

Suitable for ERAS (0=no, 1=yes) ☐

Estimated length of stay: ☐☐ Hours/ Days

Suffered 2 or more falls in past 12 months? (0=no, 1=yes) ☐

Difficulty walking or balance? (0=no, 1=yes) ☐

Fear of falling? (0=no, 1=yes) ☐

Cognitive impairment present? (0=no, 1=yes) ☐

11.7: Appendix 7: Statistical Summary

This thesis employs a host of statistical tests. Below is a summary of the statistics used:

- The significance level was set as $p<0.05$ for all tests involved in this thesis, unless otherwise mentioned.
- Normality was assessed for continuous variables, using Shapiro-Wilk analyses and Q-Q plots to provide both numerical and visual judgements of normality.
- T-tests were used to determine a difference between the means of two variables.
    - Paired T-tests were used to analyse differences in the same participant (such as time to measure frailty by different measures). If the data were non-parametric, a Wilcoxon signed-rank test was used.
    - Independent T-tests were used to determine differences between different measures across populations. If the data were non-parametric, a Mann-Whitney U test was used.
- Correlations were used to investigate trends between two continuous variables.
- Unweighted Cohen's Kappa statistic was used to measure the agreement between measures, aiming to identify the same construct, in the same patient.
- Contingency tables were constructed throughout this thesis, testing the relationship between the presence of a condition and presence of an adverse outcome. These provide sensitivity, specificity, positive and negative predictive values, odds, relative risk and likelihood ratios. Sensitivity and specificity were used to assess the reliability of measures and their relationship with outcomes. Positive and negative predictive values were used to explore the reliability of measures at predicting adverse outcomes. Likelihood values were calculated from the sensitivity and specificity, and used to identify how likely a frail patient is to suffer an adverse outcome.

- Receiver Operating Characteristic curves were used determine the characteristics of association and identify cut-off points. Associated tables are provided next to the curves.