Economic Evaluation of Multidisciplinary Rehabilitation Following Hip Fracture

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SUMMARY

Hip fracture is a major contributor to morbidity and mortality in Australia and worldwide. In addition, healthcare spending for individuals spikes following a hip fracture due to increased needs for medical and supportive care. Many patients with hip fractures are malnourished upon admission to hospital, which impacts upon the recovery and rehabilitation potential of patients, and is also a significant independent predictor of increases in healthcare costs. There is increasing scrutiny on healthcare spending and a need for approaches which demonstrate a return on investment. Therefore, finding effective strategies to improve recovery following a hip fracture is important. However rehabilitation following hip fracture is an expensive complex intervention involving multiple components (e.g. medical, nursing, and allied health interventions). Health economics has received increasing focus over the past decades as a way of evaluating not only the benefits from healthcare interventions but also their ‘value for money’. The focus of this thesis was to apply a range of methods of economic evaluation to rehabilitation following hip fracture, especially focusing on nutrition and exercise therapy. The intent was to demonstrate the strengths and potential weaknesses of various approaches.

Initially, a systematic review of the literature for economic evaluations of nutrition interventions for treatment or prevention of malnutrition was conducted (Chapter 2). Malnutrition is known to be common among patients with hip fractures, and therefore effective treatment strategies are useful in multidisciplinary rehabilitation

strategies. Only 20 articles meeting the selection criteria were identified (with an intervention increasing protein and energy intake via the oral route). Studied interventions included the provision of fortified diets but most used commercial Oral Nutritional Supplements (ONS). Seven studies included a multidisciplinary intervention with malnutrition screening and assessment, physical activity interventions, or consultations from other health professionals. The systematic review identified that there were only few high quality cost-utility studies (the preferred method of economic evaluation for regulatory bodies in Australia and around the world), but three indicated likely cost-effectiveness of their interventions in populations of hospitalised and community dwelling adults. While there is promising initial evidence for the cost-effectiveness of nutritional strategies in treating and preventing malnutrition, further studies utilizing preferred methods of economic evaluation are needed to provide more rigorous evidence to inform decision makers, especially in populations of frail older adults.

To add to the evidence for providing nutrition therapy in frail, older adults at risk of malnutrition, an economic evaluation was undertaken of a multidisciplinary rehabilitation strategy including an individualised program of nutrition and exercise therapy provided for six months following a hip fracture (Chapter 3). The study followed a cost-utility methodology, and therefore quality adjusted life years (QALY) were used to assess the benefits of the intervention. The incremental cost effectiveness ratio (ICER) calculated was $AUD28,350 which although large was below the implied cost effectiveness ratio of $50,000 for Australia. Therefore, it is likely that this intervention of multidisciplinary rehabilitation would be considered cost-effective in Australia.

In addition to applying economic evaluation methods to healthcare interventions, this thesis also looked further into methodological issues surrounding cost-utility studies as they are applied to multidisciplinary rehabilitation strategies in frail older adults, namely the measurement of quality of life for calculation of QALY gain. A subsequent study applied two different instruments for measuring quality of life and QALY to a population of older adults following hip fracture to compare their performance (Chapter 4). It was found that the ICECAP-O, a relatively new instrument designed specifically for use in older adults, was highly correlated ($r=0.529$, $p=0.000$) with the EQ-5D-3L, a traditional instrument used worldwide for the measurement of quality of life. However, there were some systematic differences between the two instruments with the mean utility score generated from the ICECAP-O almost 0.01 higher than the score generated from the EQ-5D-3L, and this reached statistical significance ($z=-3.613$ $p=0.000$). Further work is needed to compare the performance of the new ICECAP-O instrument against more traditional instruments, especially overtime and in the generation of benefits for use in cost-utility studies.

In a final study (Chapter 5), patients' preferences for different configurations of rehabilitation programs were elicited utilising an economic technique known as a discrete choice experiment (DCE). In this study, patients were averse to rehabilitation programs involving very high levels of therapy and severe levels of pain, but not to lower levels of therapy and moderate levels of pain. The mobility outcome achieved from rehabilitation therapy following a hip fracture was found to be the most important determinant of rehabilitation program preference, in our sample of frail older adults. Importantly included in this study were two groups usually excluded from studies of this nature, those with cognitive impairment and from a nursing home. The study also highlighted the ability of discrete choice experiment techniques to be used to elicit preferences of frail older adults for multidisciplinary rehabilitation interventions.

In summary this thesis has identified that a number of economic methods can be successfully applied to the evaluation of rehabilitation approaches in older adults, and it is recommended that methods of economic analysis should be more widely applied to evaluate nutritional and rehabilitation strategies in the future to improve the evidence-base for practice in this area.

LIST OF PUBLICATIONS AND ABSTRACTS ARISING FROM THIS THESIS

Publications

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture?A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Milte R, Ratcliffe J, Miller M,& Crotty M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence', *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

Milte R, Ratcliffe J, Chen G, Lancsar E, Miller M, & Crotty M 2014, ‘Cognitive overload? An exploration of the potential impact of cognitive functioning in discrete choice experiments with older people in health care’, *Value in Health*, vol. 17, no. 5, pp.655-9.

Conference Presentations

Milte R, Crotty M, Miller M, Flynn T, Norman R, & Ratcliffe J 2014, ‘Quality of life of frail older people following hip fracture.An empirical comparison of the ICECAP-O and EQ-5D 3L’, 3rd ICECAP users’ workshop 27th February, Birmingham, UK.

Milte R, Crotty M, Miller M, Whitehead C, & Ratcliffe J 2013, ‘Quality of life in older adults following a hip fracture: an empirical comparison of the ICECAP-O and the EQ-5D instruments', Top 15 Poster Oral Presentations, 2nd Fragility Fracture Network Global Congress, 29-31 August, Berlin, Germany.

Milte R, Ratcliffe J, Miller M, & Crotty M 2012, 'Economic evaluations for protein and energy supplementation: Where is the evidence?', 16th International Congress of Dietetics 5 - 8 September, Sydney, Australia.

Milte R, Ratcliffe J, Miller M, & Crotty M 2012, 'Cost effectiveness for nutritional interventions in older adults', Australasian Society of Parenteral and Enteral Nutrition 38th Annual Scientific Meeting 17-19 October, Adelaide, Australia

MilteR,Chen G, Lancsar E, Miller M, Crotty M, & Ratcliffe J 2012, 'Cognitive overload? An exploration of the potential impact of cognitive functioning in discrete choice experiments with older people in health care', 34th Australian Conference of Health Economists 27-28th September, Darwin, Australia.

Conference Posters

Milte R, Miller, M, Crotty, M, Cameron, I, Whitehead, C, Kurrle, S, Mackintosh, S Thomas, S, & Ratcliffe, J 2013, 'Economic evaluation of an individualised nutrition and exercise program for rehabilitation following hip fracture', 2nd Fragility Fracture Network Global Congress, 29-31 August, Berlin, Germany.

Milte R, Crotty M, Miller M, Whitehead C, & Ratcliffe J 2013, 'Quality of life in older adults following a hip fracture: an empirical comparison of the ICECAP-O and

the EQ-5D instruments', 2nd Fragility Fracture Network Global Congress, 29-31 August, Berlin, Germany.

Ratcliffe J, Milte R, Crotty M, Cameron I, Miller M & Whitehead C 2010,'What are frail older people prepared to endure to achieve improved mobility following a hip fracture? A discrete choice experiment'.Australian & New Zealand Society for Geriatric Medicine Annual Scientific Meeting. 5-7 May, Coolum, Australia.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university, and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

When I commenced my candidature, the INTERACTIVE randomised controlled trial had been designed and commenced collecting data. I was involved in the recruitment of participants, baseline assessments and administering the nutritional intervention and control visits to the participants for the remaining duration of trial in conjunction with the other staff working on the trial. Six month outcome assessments were conducted by outcome assessors to maintain their blinded nature. I conducted the analysis of the economic and quality of life data collected for the trial. I was also involved in the recruitment of participants, outcome assessments, and administration of the nutritional intervention for the ATLANTIC trial, and used quality of life data from this trial as part of the cost-utility study contained in this thesis.

For the discrete choice experiment and quality of life studies reported I conducted the recruitment of participants, and administered the questionnaires with the assistance of one other staff member. Design of the discrete choice experiment was conducted prior to my candidature commencing.

While both nutrition and exercise therapy will be considered in reference to multidisciplinary rehabilitation strategies, special focus will be given to the impact of nutrition as it is within the expertise of my discipline.

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ABBREVIATIONS

AQOL	Assessment of quality of life instrument
AUD	Australian dollars
BMD	Bone mineral density
BMI	Body mass index
CAD	Canadian dollars
CBA	Cost benefit analysis
CCA	Cost consequences analysis
CEA	Cost effectiveness analysis
CI	Confidence intervals
CMA	Cost minimisation analysis
COPD	Chronic obstructive pulmonary disease
CUA	Cost utility analysis
DCE	Discrete choice experiment
DOHA	Department of Health and Ageing
DRG	Diagnostic related group

DVA	Department of Veterans Affairs
GI	Gastrointestinal
HEHP	High energy high protein diet
HLC	High level care
HRQoL	Health related quality of life
HUI	Health utilities index
ICER	Incremental cost effectiveness ratio
LLC	Low level care
LOS	Length of stay
MAC	Mid arm circumference
MAUI	Multi-attribute utility instrument
MNA	Mini nutritional assessment
NFS	Not further specified
NHCDC	National Hospital Cost Data Collection
NSW	New South Wales
PA	Physical activity
PBAC	Pharmaceutical Benefits Advisory Committee

PEG	Percutaneous endoscopic gastrostomy
PSA	Probabilistic sensitivity analysis
QALY	Quality adjusted life year
QOL	Quality of life
RR	Risk ratio
SD	Standard deviation
SE	Standard error
SGA	Subjective global assessment
ONS	Oral nutritional supplement
OR	Odds ratio
TCP	Transitional care program
TSF	Triceps skin fold

1 INTRODUCTION AND RATIONALE FOR THESIS

This chapter contains material from:

Milte, RK, Ratcliffe, J, Miller, MD & Crotty, M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence'*European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

1.1 Impact of hip fracture

1.1.1 Incidence

Hip fracture is a major cause of morbidity and mortality both internationally and in Australia. Worldwide there were an estimated 5.2 million non-traumatic fractures in 2010, of which 2.8 million were of the hip or spine (Wade et al. 2012). Internationally there has been an increase in hip fracture rates in western populations over the last 50 years, fractures traditionally associated with osteoporosis in older adults(Cooper et al. 2011; Lyritis et al. 2013). However there is evidence of a stabilising or decline in age-adjusted hip fracture rates in some western populations more recently, which could be as a result of public health campaigns focusing on prevention (Alves et al. 2013; Cooper et al. 2011; Omsland et al. 2012; Turkington et al. 2012). Overall, any reduction in age-adjusted rates appears to be overtaken by the increasing proportion of the population over 50 years, resulting in an overall increase in the absolute number of hip fractures recorded (Icks et al. 2013; Omsland et al. 2012; Turkington et al. 2012). Worldwide fracture incidence appears to be geographically influenced with hip fracture rates highest in Scandinavian countries (ranging from 15.5 to 16.8 per 10,000 population for women aged 60-69 years) and lower in southern European, Asian, African and Latin American populations, although the rate appears to be increasing in some Asian populations (Cheng et al. 2011; Cooper et al. 2011; Kanis et al. 2012; Sakuma et al. 2013; Wade et al. 2012). The lifetime risk of a hip fracture varies from as low as 1.8% in males in Turkey to 28.5% in Swedish women (Kanis et al. 2002). Lifetime risk in Australia has been calculated as 6.3% for men and 17.7% in women (Kanis et al. 2002).

Within Australia the incidence of hip fracture appears to follow similar patterns to those identified in other western populations, with an increase in age-adjusted rates throughout the last century, and a stabilisation or decline in rates in the past few decades (Cassell & Clapperton 2012; Crisp et al. 2012; Pasco et al. 2011; Sanders et al. 1999; Vu et al. 2012). The age-adjusted incidence appears to vary from between 295 to 520 per 100,000 in Australian women and between 200 to 493 per 100,000 population in men over the past 5 years (Cassell & Clapperton 2012; Crisp et al. 2012; Pasco et al. 2011; Vu et al. 2012) while the absolute number of fractures is increasing (Cassell & Clapperton 2012; Crisp et al. 2012; Sanders et al. 1999). In 2006/2007 the total number of hip fractures increased by 11% compared to 1997/1998, to a total of 16,412 ($p<0.001$) (Crisp et al. 2012). Therefore, while there has been commentary on declining age-adjusted rates of hip fractures in western populations including Australia, it appears likely that the overall number of hip fractures worldwide is likely to continue increasing due to demographic changes in populations and due to increasing incidence in countries with previously low incidence. Therefore, the effective treatment of hip and other osteoporotic fractures is likely to remain a key concern of health professionals, and government health departments for the foreseeable future.

1.1.2 Mortality

The majority of hip fractures require surgical treatment, unless surgery is contraindicated for palliative or other medical reasons. It has been estimated that without surgical treatment, 90% of patients die within the first year following fracture (Parker et al. 1992). Even with surgical treatment, risk of mortality is increased following a hip fracture. Previous studies have identified rates of mortality following a hip fracture of between 2.3-13.9% during hospitalization and between 5.9-50% one year following fracture (Abrahamsen et al. 2009; Bliuc et al. 2009; Haleem et al. 2008). Most of the excess mortality is clustered around the period of hospitalisation with over half the deaths occurring within the six months following fracture (Abrahamsen et al. 2009). While men make up less of the hip fracture population, they are highly represented in the deaths following fracture with studies indicating a risk of mortality double that for women (Abrahamsen et al. 2009; Bliuc et al. 2009). Within Australia, mortality following hip fracture shows a similar pattern. Harris et al. (2012) tracked the mortality rate following common surgical procedures in NSW from 2000 to 2009, and found a 30-day mortality rate of 8.6% and 25% within one year following hip fracture surgery, which was higher than for any of the other procedures listed including emergency cardiac and gastroenterological surgery and craniotomy. Frost et al. (2013) found that relative survival was greater in women than in men until five years following the fracture, after which the rates converge.

1.1.3 Function

In addition to their effects on mortality, hip fractures exhibit a devastating effect on function which can go on to cause life-long disability. A recent review identified 42% of patients with hip fractures have not regained their pre-fracture mobility levels at one year following fracture, and almost half report ongoing pain (Bertram et al. 2011). Twenty percent identify they are unable to shop independently, and 29% will go on to experience a life-long disability (Bertram et al. 2011). All of these functional limitations impact upon independence and often result in patients entering a more dependent state of living (Bertram et al. 2011). A hip fracture is recognised as a risk factor for admission to a residential aged care facility or requiring supportive services to stay at home (Bertram et al. 2011; Iorio et al. 2004; Leibson et al. 2002; Pretto et al. 2010). Leibson et al. (2002) compared admission to nursing home facilities between hip fracture cases and age and sex matched general population controls and found the risk of admission to a nursing home at five years following the hip fracture to be double that of the controls. This long term morbidity and limitations to function has also been shown to have a dramatic effect on quality of life (Beaupre et al. 2012). Therefore, the morbidity and limitations to function following a hip fracture have a significant and long term effect.

1.1.4 Risk factors

Identifying risk factors for hip and other osteoporotic fractures can assist in identifying individuals and population groups highly likely to experience a fracture and possible target points for interventions to reduce fracture risk. A number of clinical, lifestyle, and social factors that influence risk of hip fracture have been identified, some of the main factors are outlined in Table 1.1.

Table 1.1 Factors influencing hip fracture risk (Adapted from Marks 2010)

Age
Gender
Race
Cognitive impairment
Physical factors • Falls • Prior fracture • Bone mass
Health Behaviours • Inactivity • Diet • Smoking • Excess alcohol • Vitamin D deficiency • Hormone Therapy
Socioeconomic factors
Clinical conditions

Risk factors tend to either influence bone metabolism and strength, or risk of falls, or both. As many as 95% of hip fractures occur as a result of a fall, and therefore avoiding falls forms the basis of many prevention strategies (Marks 2010; Rolland et al. 2008). In addition, there are risk-factors for osteoporotic fracture which are non-modifiable. Age is a well-known modifier of hip fracture risk with BMD reducing with greater age and hip fracture incidence increasing exponentially (Chen et al. 2009; Curran et al. 2010; Jean et al. 2013; Kanis et al. 2009; Marks 2010; Wade et al. 2012). Gender also influences hip fracture risk with women experiencing roughly double the risk of a hip fracture compared to men (Cummings-Vaughn & Gammack 2011; Curran et al. 2010; Kanis et al. 2009; Marks 2010). In addition to the non-modifiable, there are many risk factors which could be a possible point of intervention to reduce the burden of osteoporotic fractures.

Osteoporosis (defined as a bone mineral density (BMD) at the femoral neck of 2.5 standard deviations (SD) or more below the young adult mean, otherwise known as a T-score less than or equal to −2.5) is a major risk factor for hip fractures (Kanis et al. 2009; Marks 2010). Studies have shown up to 48% of hip fractures occur in patients with osteoporosis (Schott et al. 1998). However, the absence of osteoporosis should not be taken as a guarantee that fractures will not occur. Up to 46% of hip fractures occur in patients with osteopenia, defined as a T-score between -1 and -2.5, while 6.5% occur in patients with bone mineral density within the normal range (Schott et al. 1998). Recent estimations of incidence of hip fracture per 1000 women-years found the highest rate in those with osteoporosis (16.4 95% CI: 16.4-16.5) but a higher rate in those with osteopenia (5.4 95% CI: 5.3-5.5) than those with normal BMD (1.1 95% CI; 1.0-1.2) (Curran et al. 2010). In addition, a previous osteoporotic fracture or a family history of osteoporotic fracture have both been identified as risk factors for experiencing a hip fracture or other osteoporotic fracture (Chen et al. 2009; Cummings-Vaughn & Gammack 2011; Kanis et al. 2009). In an Australian study, the relative risk of experiencing a subsequent fracture after an initial low-trauma fracture was 1.95 (95% CI 1.70-2.25) in women or 3.47 (95% CI 2.68-4.48) in men (Center et al. 2007). By 10 years after the initial fracture, 40% of surviving women and 60% of surviving men had experienced a subsequent fracture (Center et al. 2007). Therefore, an osteoporotic fracture is not an isolated event, but often the precursor to further fractures and could be a potential point for intervention to prevent further decline in BMD and increase in falls risk.

In addition, aspects of physical health and function have been shown to impact on the risk of osteoporotic fracture. Low body weight (often an indicator of the overall nutritional status of the patient) is a risk factor, both through its effect on BMD and muscle strength and mass influencing the number of falls and absorption of the impact of falls (Chen et al. 2009; Cummings-Vaughn & Gammack 2011; Marks 2010; Nguyen et al. 1998). Risk is associated with both low body weight ratio for height in general (as measured by BMI) and greater than 10% loss of maximal body weight, especially in those from a residential care background (Cummings-Vaughn & Gammack 2011; Marks 2010; Nguyen et al. 1998). Nutritional deficiencies, such as vitamins D and B, have been shown to affect muscle strength and BMD(Lai et al. 2013; Marks 2010). Other modifiable risk factors for hip fracture include a low physical activity level, decreased muscle mass and strength, and poor balance leading to increased falls (Cummings-Vaughn & Gammack 2011; Lai et al. 2013; Marks 2010; Nguyen et al. 1998). Therefore, modifying physical activity and improving nutritional intake could be a point of intervention to reduce hip fracture risk.

In addition, living in a residential care facility is associated with a higher risk of experiencing a hip fracture (Kanis et al. 2009; Marks 2010; Rolland et al. 2008). Interestingly, in those from a low level care or hostel-accommodation type background a poorer standing balance has been associated with a higher risk of hip fracture, while in a nursing-home background a better standing balance has been identified as a risk for hip fracture (Chen et al. 2009). This is likely due to those with poorer balance in the nursing-home group being immobile and requiring nursing assistance for all transfers, reducing the risk of hip fracture (Chen et al. 2009). Dementia or cognitive impairment is another risk factor for falls and subsequent hip fractures (Chen et al. 2009; Cummings-Vaughn & Gammack 2011; Guo et al. 1998; Marks 2010; Scandol et al. 2013; Seitz et al. 2011). Finally, many chronic clinical conditions and medications can raise the risk of experiencing a hip fracture either through affecting bone metabolism, or impairing muscular function or both (Cummings-Vaughn & Gammack 2011; Kanis et al. 2009; Marks 2010).

1.2 Importance of multidisciplinary rehabilitation following hip fracture

Given the large risks for poor recovery, rehabilitation has been increasingly considered an integral part of treatment for osteoporotic fractures, such as hip fracture. Rehabilitation is defined as healthcare provided with the specific aim to improve function in the patient e.g. improve mobility or ability to perform daily tasks (Halbert et al. 2007). Guidelines for the treatment of hip fractures recommend rehabilitation provided either as part of a hospital stay or within a patient's home for the majority of patients (Mak et al. 2010b; National Clinical Guideline Centre 2011; Scottish Intercollegiate Guidelines Network 2009). In addition, multidisciplinary rehabilitation care has received increasing focus in healthcare, especially for chronic conditions affecting function and has shown to improve patient function, independence, quality of life, length of hospital stay and participation in healthcare for a wide range of conditions (Momsen et al. 2012).

Multidisciplinary rehabilitation care focuses on creating a team environment where members communicate regularly about the care of a defined group of patients (Momsen et al. 2012). It involves members sharing information, and developing common goals with patients and working towards achieving those common goals. In 2009 an update of a Cochrane review of multidisciplinary rehabilitation for older people following hip fracture was published (Handoll et al. 2009). This review focused on the randomised controlled trials evaluating provision of multidisciplinary rehabilitation either in a stand-alone specialist unit or as an additional programme to current ward strategies, and involved increased communication and goal setting between team members and patients, and/or more frequent involvement of a wider range of health professionals (such as geriatricians, physiotherapist, occupational therapists, social worker, and therapy aids). Control could be either usual care (usually involving some input from the listed professionals, but on an *adhoc* basis) or provision of a lower level of multidisciplinary care. The authors combined mortality data with data on increased dependency in the community or admission to residential care as 'poor outcome', and found a small trend in favour of the intervention at long term follow up, albeit not statistically significant (RR 0.89, 95% confidence intervals 0.78 to 1.01), and at hospital discharge (RR 0.87, 95% confidence intervals 0.75-1.00) which reached the borderline for significance. There was also some evidence of functional gains, and reduced medical complications in the intervention group compared to the control group, but the effect on length of stay and costs was less clear. An earlier meta-analysis by Halbert et al. (2007) also found a reduction in "poor outcome" in the intervention group (RR 0.84, 95% CI 0.73-0.96), as well as trends towards improved chance of returning home, reduced length of hospital stay, readmission, and improvements in physical function. In addition, studies have identified cost saving or only small additional costs to provide multidisciplinary care compared to usual care (Cameron et al. 1994; Fordham et al. 1986; Galvard & Samuelsson 1995; Huusko et al. 2002).

Further to recommendations for multidisciplinary rehabilitation has been a growing focus on coordinating care across the continuum of acute and rehabilitation services, and the use of orthogeriatric models of care (Australian and New Zealand Hip Fracture Registry Steering Group 2013). In Australia, the Australian Hip Fracture Registry has been established, aiming to improve outcomes for frail older people with hip fracture by developing comprehensive guidelines, standards and measurable quality indicators which can be used to evaluate current services being provided, and to ultimately lead to improved outcomes for patients and health services (Australian and New Zealand Hip Fracture Registry Steering Group 2013). Recently released guidelines provide an overview of the care of patients from the pre-operative right through to the rehabilitation phase, and emphasise the need for coordinated orthogeriatric models of care (Australian and New Zealand Hip Fracture Registry Steering Group 2013). Orthogeriatric models involve collaborative specialist care of older patients with hip fractures, shared between aged care and orthopaedics services (The Agency for Clinical Innovation Orthogeriatric Model of Care Collaborative Group 2010). Orthogeriatric care is team based (with medical, nursing and allied health involvement) to achieve improved outcomes for patients with complex multidimensional medical problems, and has been shown to reduce mortality, complications, and readmissions in comparison to patients treated under standard models of care (usually ad-hoc involvement of geriatric specialists and allied health providers) (Australian and New Zealand Hip Fracture Registry Steering Group 2013). The rise of orthogeriatric care also indicates the movement away from segmented and compartmentalised medical care for these frail older adults, and towards a model overarching the pre-operative, acute, and rehabilitation stages, with concurrent earlier initiation of mobilisation and rehabilitation strategies.

Traditionally, a large part of rehabilitation following hip fracture is the provision of exercise or physical therapy. Given the large effects of hip fracture surgery on mobility, strength, and function, and the slow and often poor recovery of pre-morbid status, rehabilitation goals will often focus around these areas (Feehan et al. 2011). In addition, any previous fragility fracture will increase risk of subsequent fracture, highlighting the importance of rehabilitation as an opportunity to mitigate risk of future fracture through reducing frailty, falls, and maintaining muscular strength and bone density (Center et al. 2007). Physical therapy provided by a physiotherapist was a key aspect in most of the multidisciplinary programmes evaluated in the reviews discussed above, indicating its importance to achieving improved functional outcomes in this group (Halbert et al. 2007). Extended physical therapy provided in the community following discharge has been shown to improve mobility, function, strength, balance, and quality of life compared to standard in-patient provided rehabilitation (Handoll et al. 2011). In addition, it has been shown to encourage higher levels of physical activity in the intervention group, although physical activity levels appear to begin to decline towards pre-intervention levels after the intervention is ceased. While there is evidence to support use of exercise therapy including early mobilisation, aerobic, balance, and strengthening exercises, there is still much debate about which prescriptions produce the best outcomes (Feehan et al. 2011). In addition, very few studies have included an assessment of the economic outcomes associated with interventions, leading to the identification of economic evaluation of different exercise prescriptions as a key area for future research (Feehan et al. 2011; National Clinical Guideline Centre 2011).

1.3 Importance of nutrition in rehabilitation

Nutritional status has long been considered an important part of human health, but has received an increasing amount of attention in the past few decades due to renewed focus on the impact malnutrition can have on patients and the health system (Gallagher-Allred et al. 1996; Sahyoun et al. 2004). Malnutrition describes a state where the body's stores of key nutrients are depleted (DAA Malnutrition Guideline Steering Committee 2009; Hoffer 2014). This could refer to deficiency in macronutrient stores (such as fat or protein) or micronutrients (such as vitamins and minerals) (DAA Malnutrition Guideline Steering Committee 2009). Malnutrition is commonly brought about by starvation, a state where the intake or absorption of dietary energy, and macronutrients is less than the body's own requirements for these components (Romijn 2000; Truswell 2012). Where this imbalance is prolonged, it can result in the body using its own stores of nutrients to meet requirements for metabolic processes, and over time if not replaced stores of these nutrients may run out (Truswell 2012). Often for cases of malnutrition in western hospitalised populations, the deficiency is in protein and energy intake, resulting in what is known as protein-energy malnutrition, although deficiencies in micronutrients are also likely to occur in these cases (Romijn 2000; Truswell 2012). For the rest of this thesis, the term malnutrition refers to protein-energy malnutrition as the predominant form seen in western hospitalised populations.

While there is consensus on the consequences of malnutrition, there remains much debate on how to identify malnutrition, especially in older adults (Miller & Wolfe 2008). A Body Mass Index (which gives an indication of body fatness and is calculated as body weight in kilograms divided by square of height in meters) of less than 20kg/m^2 has been identified as a marker of malnutrition in adults (Miller & Wolfe 2008; Truswell 2012). However, there is evidence that while percentage of body fat for a given BMI will be larger for an older adult than a younger one due to the physiological changes that occur with aging, paradoxically the health risks associated with that body fatness will be less in older adults and indeed may be protective (Miller & Wolfe 2008). Therefore, older adults may be at risk of poor health outcomes at a higher BMI than younger adults, and there is evidence that older adults experience peak in mortality at a higher BMI than younger adults (Harris 2004; Miller & Wolfe 2008). Therefore, this has led to recommendations of the cut off for a low BMI to be at a higher value than for younger adults (24 kg/m^2 for older adults compared to 18.5 kg/m^2 for younger adults), with BMI below this to be considered an indicator of malnutrition (Thomas 2001). Studies have indicated weight loss in older adults, whether planned or unplanned, is predictive of mortality and an indicator of malnutrition (Harris 2004; Miller & Wolfe 2008). In general, loss of five percent of body weight or more is an established indicator of malnutrition (DAA Malnutrition Guideline Steering Committee 2009; Hammond 2004). Other markers of malnutrition include markers of muscle mass such as Mid-Arm Muscle Circumference or Calf Circumference, often interpreted through comparison with general population percentiles, and haematological markers such as albumin or total protein concentration (DAA Malnutrition Guideline Steering Committee 2009; Truswell 2012). In addition, some authors support a combination of these factors for diagnosis of malnutrition or use of validated assessment instruments, such as the Subjective Global Assessment (SGA) which combines information on anthropometrics, gastrointestinal symptoms, dietary intake, and appearance to assess whether a patient is considered malnourished (DAA Malnutrition Guideline Steering Committee 2009; Gary & Fleury 2002). There is still much debate on which method is preferred to diagnose malnutrition, although the method should be validated and clinically relevant for the particular patient group under consideration (DAA Malnutrition Guideline Steering Committee 2009). In Australia there is a standardised definition which is accepted for clinical coding of malnutrition as a diagnosis in the hospital setting, which in adults is weight loss of greater than five per cent, with evidence of suboptimal intake resulting in fat loss and/or muscle loss or BMI less than 18.5 (DAA Malnutrition Guideline Steering Committee 2009).

A number of factors are known to increase the risk of malnutrition, and some examples of these are listed in Table 1.2.

Table 1.2 Factors associated with risk of malnutrition in older adults

Meal and Snack Frequency	
	Inadequate meal and snack frequency
	Skipping one or more meals daily
	Replacement of meals by snacks that are not nutritious
	Exclusion of nutrient-dense foods
Dietary Modifications	
	Self-imposed
	Prescribed
	Poor compliance
	Impact of intake, appetite
Dependency/Disability	
	Problems with daily activities
	Inactivity/immobility
	Lack of manual dexterity
	Need for assistive devices
Acute and Chronic Diseases or Conditions	
	Depression
	Dementias
	Oral health problems
	Pressure ulcers
	Sensory impairments
	Diseases associated with wasting (e.g. cancer, end-stage renal failure, hyperthyroidism)
	Malabsorption (e.g. small bowel syndrome, Inflammatory bowel disease)
	Metabolic stress (e.g. post burns, post surgery, head injury)
	Other medical conditions
Chronic Medication Use	
	Prescribed or self-administered
	Polypharmacy
Advanced Age	
Poverty	
	Income
	Income source and adequacy
Food Expenditures and Resources	
	Housing expenditure
	Medical expenditure
	Food expenditure
Social Isolation	
	Support systems
	Living arrangements
	Cooking and food storage
	Transportation

Adapted from (Hammond 2004; Thomas 2001)

A number of these aspects could be at work in older adults following a hip fracture. Older adults in hospital are likely to have experienced a period of fasting prior to surgery which impacts upon their nutritional state (Thomas 2001). After surgery, while still in hospital, achieving adequate intake may still be difficult due to loss of appetite, nausea, and vomiting (Thomas 2001). In addition, patients may have difficulty moving and accessing food items if not placed within reach or may not have the dexterity or strength to open packaging (Thomas 2001). Dysphagia or poor dentition and oral health can make swallowing or chewing food difficult, painful, or slow, and subsequently reduce intake (Thomas 2001). Older adults with a hip fracture are likely to be frail prior to admission to hospital, and may be on a number of medications which can reduce appetite or result in nausea (Thomas 2001). In addition, in the community difficulty in accessing shops to purchase food, and difficulty storing or cooking food due to functional limitations can reduce intake and lead to older adults resorting to eating nutrient poor snacks in place of nutritionally-dense meals (Hammond 2004). Many older adults will have experienced health problems previously, and may have been recommended a diet for treatment while younger which they are still adhering to that is now inappropriate, or have implemented their own restrictive dietary regime (Hammond 2004). By comparison, Baulderstone et al. (2012) showed a liberalised diet with a higher energy, sodium, total fat, refined sugar, and fibre intake was linked to lower risk of frailty in older adults and no increase in diabetes, hypertension, hyperlipidaemia, or obesity. In addition, older adults are at risk of experiencing financial hardship, and low income coupled with the pressures of increasing medical and pharmaceutical bills could leave little money for the purchase of food (Hammond 2004). Therefore the causes of malnutrition can be multifactorial, often resulting from a number of causes rather than one single factor. Treatment strategies for malnutrition for maximum impact need to be designed to take account of this multifactorial nature and may therefore require input from a number of health practitioners for success (DAA Malnutrition Guideline Steering Committee 2009; Hammond 2004).

1.3.1 Impact of malnutrition

There has been some debate on the effect of nutrition on the healthcare system. A long time has passed since the seminal “Skeleton in the Closet” paper published in the 1970s (Butterworth 1974) highlighted the impact of hospital-acquired malnutrition on survival. Malnutrition impacts upon the older adult in a number of ways. Initially, malnutrition depletes the body’s stores of energy and nutrients – which results in loss of fat mass, muscle mass, and overall weight loss (Truswell 2012). Disorders in homeostasis of extra and intracellular fluid can also occur (Truswell 2012). Changes in body composition and metabolism can go on to have more wide-ranging effects, such as lethargy, loss of muscle strength, immunological changes, depression, and poor wound healing (Harris 2004; Paillaud et al. 2000; Thomas 2001; Truswell 2012). This can subsequently result in increased length of stay and increased rate of complications during hospital admissions, reduced engagement with care, and reduced functional abilities, all of which increase burden on the health system (Harris 2004; Thomas 2001; Truswell 2012).

There is conflicting evidence on the effect of nutrition on hospital costs. Even decades ago, Butterworth highlighted the vast costs to society for the hospitalisation of patients, and called for a focus on nutrition to improve the overall health and reduce the length of stay of admitted patients through reducing complications and unnecessary days in hospital (Butterworth 1974). Recent reports have estimated the additional cost to the public health system in Victoria alone as $AUD10.7 million per year, although the authors believe this is likely to be an underestimation (Rowell & Jackson 2011). Previous reports have already indicated the high cost of malnutrition to the health system in Europe (Elia et al. 2005). In patients with hip fractures, one study (Gabriel et al. 2002) failed to show any effect on hospital costs from BMI, although their sample may have been underpowered and mean BMI of participants was within the recommended normal range. More recently, malnutrition was found to increase hospitalisation cost in a sample of patients with hip fractures more than any other comorbidity studied, and increased length of stay by an average of 2.5 days (95% CI 2.2 to 2.8 days, $p<0.001$) (Nikkel et al. 2012). This was a larger increase than that seen for congestive heart failure (1.1 days 95% CI 1.0 to 1.2) and pulmonary circulation disorders such as a pulmonary embolism or pulmonary hypertension (0.9 day 95% CI 0.6 to 1.1 days). Therefore, malnutrition in hospitalised older adults has a large impact, not only on the patients and their own quality of life, but also on the resources available within the health system.

1.3.2 Malnutrition in hip fracture

Malnutrition is known to be common among patients with hip fractures and acts as a risk factor for fracture(Avenell & Handoll 2010). In addition it is likely to develop and worsen during an acute admission, and increasingly is identified as a continuing problem after patients are discharged to the community (Miller et al. 2006b). Hip and lower limb fracture patients have an intake below requirements for much of their hospital admission, meeting as little as 50% of their energy intake (Dickerson et al. 1979; Eneroth et al. 2005; Miller et al. 2006a; Nematy et al. 2006). Their nutritional status declines during hospital admission, and studies have shown this decline is long lasting and has not reversed by up to four months following surgery; in fact many have not recovered their nutritional status by 12 months following surgery (Miller et al. 2006b; Nematy et al. 2006; Paillaud et al. 2000) In addition to poor nutritional intake, there is evidence of catabolism driven by inflammatory responses to injury and surgery which also deplete body resources of protein and muscle mass independent of nutritional intake (Hedström et al. 2006). It has been suggested that this catabolic state lasts for up to three months post fracture, contributing to the loss of body mass experienced commonly by patients for several months (Hedström et al. 2006). These factors combine to cause decline in the nutritional status of patients during the post-operative phase and beyond and make reversal difficult due to the endogenous as well as nutritional causes.

The incidence of malnutrition in patients with hip fractures has been identified as between 13% and 78%, dependent on the population studied and how malnutrition was defined, as illustrated in Table 1.3. While proportions higher than 70% have been identified in studies using lymphopenia as a criteria (Eneroth et al. 2005; Miller et al. 2001), studies using BMI have commonly stated values of between 15% and 53% (Bachrach-Lindstrom et al. 2000; Bruce et al. 1999; Eneroth et al. 2005; Hommel et al. 2007; Lumbers et al. 2001; Maffulli et al. 1999; Nematy et al. 2006).

Bachrach-Lindstrom, Ek, et al. (2000) found an incidence of 25% based on a BMI less than 20kg/m^2 in their sample which included patients from nursing homes and those with cognitive impairment, known to be two independent risk factors for malnutrition. They also found the vast majority of their admitted patients (71%) were considered at risk of malnutrition with a BMI<$24 kg/m^2$. In Australia, studies have found incidence of malnutrition of between and 31% and 72% similar to findings from other western countries (Miller et al. 2001). Specifically in an Australian population of rehabilitation patients (including patients with hip fractures) the Mini-Nutritional Assessment identified 47% at risk of malnutrition and 6% as already malnourished (Neumann et al. 2005).

Table 1.3 Prevalence of malnutrition in patients with hip fractures

Author, Year, Country	**Subjects and Sample Size**	**Exclusion Criteria**	**Prevalence of Malnutrition**	**Methods Used to Determine Malnutrition**
(Li et al. 2013), Taiwan	n=162 acute hospitalised	<60 years old, Pathological fracture, Chinese Barthel Index score <70 prior to fracture, MMSE<10/30,	60-67%	MNA and Albumin
(Hommel et al. 2007), Sweden	n=420 acute hospitalised	Nil specified	25-33% 16-19%	BMI<20-22kg/m^2 (dependent on age) Albumin
(Nematy et al. 2006), UK	n=25 acute hospitalised	<65 years old, Pathological fracture	At risk of malnutrition=56% 36%	Local screening instrument BMI<20kg/m^2
(Eneroth et al. 2005), Sweden	n=80 acute hospitalised	MMSE<6 Multiple fractures, Pathological fracture, Malignant disease Depression Other diseases precluding treatment with ONS regime	Malnourished=9% 13-28% 44-62% 78%	SGA Anthropometry Serum Proteins Lymphocytes
(Lumbers et al. 2001), UK	n=75 female acute hospitalised	<60 years old, Abbreviated Mental Function Test<7/10	15%	BMI<20kg/m^2
(Miller et al. 2001), Australia	n=183 acute hospitalised	<60 years old, Pathological fracture	31% 72%	Albumin Lymphocytes
(Bachrach-Lindstrom et al. 2000), Sweden	n=142 acute hospitalised	<75 years old, Malignancy, Prolonged Intensive Care Unit stay, Disorder of liver or kidneys	25%	BMI<20kg/m^2
(Paillaud et al. 2000), France	n=40 rehabilitation inpatients	<70 years old, Dementia, Malignancy, Acute disease	32.5%	MAC and TSF

(Bruce et al. 1999), Australia	n=100 acute hospitalised	Residential care, Malignancy	35%	BMI<20kg/m^2
(Koval et al. 1999), USA	n=499 acute hospitalised	<65 years old, Non-ambulant prior to fracture, Cognitive impairment, Residential care	18% 57%	Albumin Lymphocytes
(Maffulli et al. 1999), UK	n=119 acute hospitalised	<65 years old, Pathological fracture	31%	BMI<18kg/m^2

Abbreviations: BMI=body mass index, MAC=Mid arm circumference, SGA=Subjective global assessment, TSF=triceps skin fold (Adapted from Milte 2009)

Malnutrition has also been shown to have a large impact on the outcome for patients with a hip fracture. Neumann, Miller et al. (2005) found malnutrition and risk of malnutrition as determined by the Mini-Nutritional Assessment was associated with a higher risk of admission to HLC in a sample of older adults undergoing rehabilitation, which included orthopaedic patients as well as those post neurological injury and infection (RR 2.29, 95% CI 1.09-4.00, p<0.05). They also found a significant difference in their length of stay between the malnourished and the well-nourished groups of around 4 days (p=0.023), and associations between body composition measured by BMI and corrected arm muscle area and function at 90 days (p<0.05). Koval et al. (1999) linked nutritional status measured by albumin in their study of patients with hip fractures to increased hospital LOS (OR 1.9, 95% CI 1.1-3.4, p=0.03), and poorer functional outcome (OR 3.4 95% CI 1.8-6.5, p<0.001). In addition, they found a link between lymphopenia and increased risk of mortality (OR 2.5, 95% CI 1.3-4.9, p<0.01), although the authors identified that lymphopeniawas less reliable as a measure of malnutrition on its own than some other methods. Similarly, Hershkovitzet al. (2007) also found albumin status to be related to LOS. Chevalier et al. (2008) found hand grip strength to be related to a composite index of nutritional markers including body composition and albumin levels in a sample of ambulatory rehabilitation patients while gait speed was associated with mild malnutrition measured using the mini-nutritional assessment. Koren-Hakim et al. (2012) found a relationship between malnutrition determined by MNA and prefracture comorbidities ($p \leq 0.001$). They also found a relationship with readmissions over a six month time period, with fewer well-nourished patients readmitted (36%) than those deemed at risk of malnutrition or malnourished (64%, $p=0.024$). They also found a similar pattern for mortality with the well-nourished participants having lower mortality rate (22.1%) vs. the malnourished (50.5%, $p=0.001$) and those at risk of malnutrition (40%, $p=0.01$) over a period of three years. Therefore, there is clear evidence of a link between malnutrition and poorer outcomes for hospitalised older adults, including those following hip fracture.

But while the level of malnutrition in patients with hip fractures and the poor outcomes associated with it are well defined in the literature, historically in clinical practice it is under recognised and undertreated (Miller et al. 2001; Nematy et al. 2006), despite evidence that hospital-wide strategies to identify and treat patients can result in reduced rates of malnutrition in the hospital setting (O'Flynn et al. 2005). Therefore, promotion of effective treatment of malnutrition in patients with a hip fracture is important for optimum recovery of function in this group of frail older adults.

1.3.3 Treatment strategies for malnutrition

Treatment for malnutrition can involve a number of strategies and is likely to be dependent upon the cause of malnutrition (DAA Malnutrition Guideline Steering Committee 2009; Volkert 2013). As discussed previously, the causes of malnutrition can be multifactorial and need to be addressed as relevant for the particular patient. For example, providing additional food to a patient without addressing their need for adaptive equipment or assistance to be able to eat is unlikely to improve the nutritional status of the patient (Thomas 2001; Volkert 2013). Treatment strategies for malnutrition usually involve improving nutrient intake to meet requirements (Thomas 2001).

Strategies to improve nutrient intake include consideration of the timing and structure of meals, replacing foods with low nutrient densities with more nutrient dense options, and fortifying foods with additional nutrients (DAA Malnutrition Guideline Steering Committee 2009; Thomas 2001; Volkert 2013). Commonly patients with malnutrition are advised to consume smaller portions of food more often, as they may be overwhelmed by larger portions of food, and to consume energy and protein dense foods first before 'filling up' on other foods e.g. to consume meat portion of lunch meal first before vegetables (DAA Malnutrition Guideline Steering Committee 2009; Thomas 2001). Replacing foods with low nutrient densities with more nutrient dense options forms the basis of the 'high energy high protein diet' commonly prescribed for treatment or prevention of malnutrition in hospital patients (Thomas 2001). The aim of this diet is to increase nutritional density of the diet without increasing the volume. It includes increased energy from full fat dairy products, a focus on protein sources in the diet such as meat or dairy products, and fortifying foods with sauces, gravies, cream, cheese, margarine, butter and ice-cream to add additional energy with minimal volume. In addition, nutrient dense fluids are also encouraged, as a way of meeting fluid requirements but also further increasing energy and protein intake (DAA Malnutrition Guideline Steering Committee 2009). Nutrient dense fluids such as milk-drinks, creamy soups, juice, soft-drink and cordial should be consumed over nutrient-poor options such as tea and coffee and water (Thomas 2001). Consuming nutrient dense fluids and snacks between meals has been shown to improve nutrient intake for the day overall for patients, despite some concern that if they eat between meals they will be unable to consume all their meal (DAA Malnutrition Guideline Steering Committee 2009; Nieuwenhuizen et al. 2010; Thomas 2001).

In addition, many commercial products exist for improving nutrient intake (Thomas 2001). Oral nutritional supplements (ONS) are commercially prepared drinks fortified to contain additional kilojoules and protein as well as other vitamins and minerals or bio-actives. Many come in small tetra-packs, designed to be provided to patients from a mid-meal trolley or with their meal-tray, aiming to bridge the gap between nutrient requirements and intake in those patients with malnutrition. ONS typically costs a few dollars per tetra-pack, dependent on the formula and the brand.

There is still much discussion in the literature on whether dietary strategies can effectively treat malnutrition. There is evidence from a systematic review that protein and energy supplementation in older adults (predominantly from ONS although other dietary methods were also utilised) improves weight status and energy and protein intake (Milne et al. 2009). In addition there is growing evidence it can reduce mortality in patients already malnourished (RR 0.79 95%CI 0.64-0.79), although the effect in patients at risk of malnutrition remains under debate. Benefit for those patients at risk of malnutrition may lie in preventing them from becoming malnourished and therefore at risk of the further complications associated with this (Milne et al. 2009). There is evidence of an effect on reducing risk of complications (RR 0.86 95% CI 0.75-0.99), although the effect on length of stay and function is less clear (Beck et al. 2011; Delmi et al. 1990; Gariballa & Forster 2007; Milne et al. 2009).

In patients with hip fractures, nutritional supplementation has been shown to improve protein and energy intake, indicators of nutrition status, body composition and attenuate loss of bone mineral density(Avenell & Handoll 2010; Hedström et al. 2006).In addition, there is some evidence it can reduce length of stay and improve function (Avenell & Handoll 2010; Delmi et al. 1990; Hedström et al. 2006; Neumann et al. 2004; Tidermark et al. 2004). Meta-analysis showed a reduction in mortality although this did not reach statistical significance (RR 0.52 95% CI 0.25-1.07) (Avenell & Handoll 2010). Compliance with dietary interventions remains an important consideration, as many studies included in the review report poor compliance rates. However most reported studies test one particular ONS in a specified dose for a specified period of time (Avenell & Handoll 2010). In practice, dietitians are more likely to use a variety of methods of increasing protein and energy intake according to the needs and preferences of the patients, which may be more successful in terms of compliance and outcomes. Overall, there is still a need for good quality trials, and especially a need for trials evaluating the economic effectiveness of dietary treatment strategies for malnutrition (Avenell & Handoll 2010; Milne et al. 2009).

1.4 Importance of evaluation of healthcare interventions in an economic framework

Given the large costs associated with healthcare generally, and especially hip fracture, providing effective interventions to improve recovery and independence is increasingly important. Given the finite nature of the resources available to fund the health sector, the importance of demonstrating not only the clinical impact of interventions but also their cost effectiveness has received increasing attention (Drummond et al. 2005). Economic evaluation has been described as a comparative analysis of alternative courses of action in terms of both their costs and consequences (Drummond et al. 2005). To achieve this, the analysis must identify, measure, value, and compare the costs and consequences of alternative healthcare interventions (Drummond et al. 2005; Milte et al. 2013b).

1.4.1 Methods of economic evaluation

There are five commonly accepted types of economic evaluation, as described in Table 1.4(Drummond et al. 2005; Gold et al. 1996; Peterson et al. 2009). Briefly they are cost-minimisation analysis, cost-benefit analysis, cost-consequence analysis, cost-effectiveness analysis, and cost-utility analysis.

Cost-minimisation analysis should only be conducted where there is sound evidence for equivalence in both safety and efficacy of both interventions, and has been overtaken by more advanced methods of analysis which account for differences in these aspects (Commonwealth Department of Health and Ageing 2002). Cost-benefit analysis measures and values the costs and benefits of an intervention in monetary terms only, for example as a reduction in healthcare costs due to a reduction in the length of stay. By comparison, cost-consequence, cost-effectiveness, and cost-utility analysis all work on the assumption that while a new healthcare intervention may cost more than simply continuing to provide old services, that it is also likely to provide new benefits or advantages. Therefore, the aim of cost-consequence, cost-effectiveness, and cost-utility analysis is to present the costs associated with an intervention in addition to the proposed new benefits to patients of this intervention. The implication is that then we determine the 'worthwhileness' of funding a new healthcare intervention by judging whether the benefits provided by the new intervention outweigh the burden of the intervention in terms of cost.

Cost-effectiveness analysis (CEA) directly compares the costs associated with an intervention with a measure of clinical or bio-medical measurement of effectiveness. This allows the calculation of an incremental cost effectiveness ratio (ICER) which gives the additional costs per unit gain in effectiveness e.g. cost per unit improvement body mass index by providing dietary advice. Cost-consequence analysis is a form of economic evaluation where the additional costs and benefits associated with a new intervention are calculated but they are not combined into a ratio. Cost-utility analysis is a special type of CEA where the benefits are measured and valued using 'utility' (Torrance 1987). Utility refers to the preference for or desirability of a particular health state (Torrance 1987). Once measured, the utility of a particular health state can be combined with the quantity or number of years that someone spends in a health state to give a standard measure of benefits known as the Quality Adjusted Life Year (QALY). Cost utility analysis using QALYs is the preferred method of economic evaluation by regulatory bodies in Australia and overseas and is increasingly reported in the academic literature(Commonwealth Department of Health and Ageing 2002; National Institute for Health and Clinical Excellence 2008).

There are many ways of measuring utility for determining QALYs, but a commonly used method is by the application of a multi-attribute utility instrument (MAUI) (Richardson et al. 2004). MAUIs are validated instruments which provide a framework with which to describe different health states (or combinations of response categories), and an off the shelf scoring algorithm for converting individual responses to utility weights, which indicate the preferences of the general population for those health states. These values are usually calculated upon a scale where a value of one is assigned for health states indicating perfect or full health, and zero for death, with other health states falling on a continuum between these two points (Drummond et al. 2005). Negative values indicate a health state worse than death and are possible. It is these utility values that are combined with the length of time that someone spends in a health state to determine the QALY. For example, one year lived in perfect health would equal 1 QALY. Half a year lived in perfect health would equal 0.5 QALY.

Table 1.4 Accepted forms of economic evaluation

Type of Evaluation	*Abbreviation*	*Aim*	*Variables*	*Outcomes*
Cost-utility analysis	CUA	Compares the costs associated with an intervention with a measure of utility which combines the life years gained by an intervention with a measure of the quality of those life years	Resource costs Measure of utility (e.g. Quality Adjusted Life Year (QALY))	Ratio of cost per QALY gained
Cost-effectiveness analysis	CEA	Compares the costs associated with an intervention with a measure of clinical effectiveness	Resource costs Measure of clinical effectiveness	Cost per unit of clinical effectiveness
Cost-consequence analysis	CCA	Compares the costs associated with an intervention with the consequences neither without combining these inputs nor without indicating the relative importance of the consequences.	Resource costs Consequences	List of costs List of possible outcomes Up to the reader to make judgements about the benefits and drawbacks of the intervention
Cost – benefit analysis	CBA	Compares the benefits of the intervention in monetary terms with the costs of the intervention	Resource Costs Benefits of the intervention in money	Net benefit of the intervention expressed in monetary terms
Cost-minimisation analysis	CMA	Determine the least costly intervention where outcomes for two interventions are assumed to be equal	Resource costs	Difference in resource costs between two interventions

A number of MAUI have been developed but some of the most common include the EQ-5D, Short Form 6D, Health Utilities Index, and Quality of Well-Being scale (Brazier et al. 2007; Drummond et al. 2005). In Australia, the Assessment of Quality of Life (AQoL) has been developed as a MAUI (Hawthorne et al. 1999). The instruments each have different advantages and disadvantages, having been developed and validated with different populations, and focusing on different aspects of health, which need to be appropriately matched to the population being studied and the expected effect of the intervention (Richardson et al. 2004). Nevertheless, the main advantage that all of theMAUIs share is that they cover not only the expected clinical effects of the intervention, but also any flow on effects to independence, and other important determinants of quality of life. The MAUI are also able to track the longitudinal effectiveness of healthcare interventions from a broader perspective than more traditional clinical outcomes, and also are able to be applied across different types of healthcare interventions and different populations and still retain their meaning. It is this flexibility and standardisation which has led to the MAUI used with the framework of the CUA to be the preferred method of economic evaluation by many funding bodies in Australia and around the world (Commonwealth Department of Health and Ageing 2002; National Institute for Health and Clinical Excellence 2008).

1.4.2 Costs

In addition to tracking the impact of a hip fracture on mortality, morbidity and function, there has also been increasing consideration of the economic impact of hip fracture. There have been relatively few studies focusing on the cost of hip fracture to Australia. Randell et al. (1995) estimated the direct clinical and welfare costs to Australia for the treatment of all osteoporotic fractures as $AUD779 million per year for the 1993 population of 17.7 million, with over half of that total cost attributable to surgical treatment and hospitalised rehabilitation of hip fracture. Given our aging population and increasing number of hip fractures, total costs to society are also likely to be increasing (Crisp et al. 2012).

In comparison, Harris et al. (1998) estimated the annual direct medical and non-medical costs of treating osteoporosis including treatment of recognised osteoporosis and fractures as $AUD227 million, a much lower estimate. Harris et al. (1998) found hospital treatment to account for a larger percentage of the treatment cost, around three quarters of total cost compared to just under half of the total costs in the Randell et al. (1995) study. Difference in provision of rehabilitation services could also be impacting on the cost of treatment with rehabilitation appearing to be a prevalent aspect of treatment in the Dubbo population of Randell et al. (1995) study, accounting for 49% of the total costs of fractures in patients admitted. On the other hand, Harris et al. included a unit cost of $7,454 per rehabilitation stay at a rate of 23% of the hospitalised hip fracture patient sample, making a much smaller contribution to the total costs of treatment. This is in contrast to current thinking in treatment, where while some patients may be fit enough to return home directly after an acute surgical stay, the majority will require some form of institutional or home-based rehabilitation (Handoll et al. 2009). Current guidelines for treatment of hip fracture encourage practitioners to ensure all patients have access to rehabilitation as part of orthogeriatric care (Mak et al. 2010a; Mak et al. 2010b). Therefore, to apply a cost for institutional rehabilitation of 23% is likely to underestimate the total costs of effective treatment in this frail older group.

In addition, Harris et al. (1998) may have underestimated the cost of community allied health input following hip fracture. They recognised that all patients discharged to the community would need input post discharge from a physiotherapist, however allowed in their estimations of cost for only a single one hour visit to take place. This is in contrast to Australian guidelines which recommend most patients with hip fracture are likely to need ongoing physiotherapy treatment post discharge from hospital to improve function and for secondary prevention purposes (Mak et al. 2010a). In addition, many patients may also require support from other allied health professionals as part of multidisciplinary rehabilitation, such as occupational therapists, and dietitians. Therefore, again the Harris et al. (1998) study could be underestimating the true costs required for effective rehabilitation following hip fracture.

The economic impact of hip fracture can be considered in three main parts: the cost of the acute medical care such as the initial hospitalisation and surgery or medical complications directly related to the fracture, the costs of the rehabilitation period, and the long term costs of providing supportive care for patients with reduced function such as community care services for patients still residing at home, or costs of providing residential care for those unable to return to live independently. The costs of the initial hospital admission for hip fracture can include the costs of any emergency department admission, pre-operative care, any procedures and prosthesis and equipment needed, ward care and in some cases stays in intensive or critical care wards. Studies that have included an estimate of the cost of providing medical care following a hip fracture are shown in Table 1.5 below. Costs have been converted to Australian dollars for ease of comparison. The costs post hip fracture for medical care appear to vary from $1,758 to over $20,000 depending on location and year the study was conducted, and whether the initial admission only is included or subsequent readmissions and medical care as well (Clark et al. 2008; Tarride et al. 2012). The majority of measured values are above the average cost of a hospitalisation in Australia ($4,500) (Australian Institute for Health and Welfare

2013), while for other complex acute admissions such as heart failure the cost of admission has been estimated as $19,714 (Titler et al. 2008). Studies have estimated the medical costs for the year following hip fracture between $8,206 (De Laet et al. 1999) and $27,642 (Ohsfeldt et al. 2006). This is more than other clinical conditions suffered by older people such as systolic heart failure ($8,436 per year) or Parkinson's disease ($13,952 per year excess costs related to the disease) (Kowal et al. 2013; Mejhert et al. 2013) but less than some other complex health conditions such as COPD patients hospitalized with pneumonia ($49,547 per year).

Given the large impact of a hip fracture on function, provision of inpatient or ambulatory community-based rehabilitation also contributes to costs associated with hip fracture. Five studies listed in Table 1.6 gave a cost for rehabilitation and medical care following a hip fracture (Bjornelv et al. 2012; Hollingworth et al. 1995; Shi et al. 2009; Tamulaitiene & Alekna 2012; Woolcott et al. 2012). Costs varied from $3,740 (Tamulaitiene & Alekna 2012) up to $40,560 for a Canadian study (Woolcott et al. 2012).

Further beyond the initial period of admission and rehabilitation, there remain ongoing costs associated with longer-term recovery including general medical and specialist appointments, and drug therapy to prevent further fractures. In addition there are large costs associated with providing care to the majority of previously independent patients who will not regain this status (Drummond et al. 2005). This can include such costs as providing assistance to the community-dwelling such as help with personal care tasks, household tasks, and adaptive equipment (Drummond et al. 2005). Ultimately there are very large costs associated with the admission to residential aged care facilities if patients are unable to be supported in the community. While the hip fracture alone may not be the sole reason for the decision to admit the patient to the facility, it is likely to be a major contributing factor to the decision. Therefore, given the large impact of poor recovery from a hip fracture on healthcare spending, economic evaluation of therapies for improving outcomes following hip fracture rather than just considering clinical effectiveness alone forms an important part of evaluating the effectiveness of therapies. Assisting patients to achieve maximum recovery of function and health following a hip fracture may require input of services around the time of admission including staff time and consumables. But if such an intervention is able to promote independence and recovery of health status of patients it may result in cost savings by preventing or delaying some of the ongoing increased health and social care costs associated with a hip fracture (Drummond et al. 2005).

Table 1.5 Studies estimating the medical costs associated with hip fracture

Reference	Average Cost	$AUD Cost	Method	Timeframe	Included
Sahota et al. 2012	₤9,000	15,930	Cohort study	Hospitalisation	Acute hospitalisation
Tarride et al. 2012	$CAD20,750	21,580	Burden of Illness study. Population level data used	Hospitalisation	Acute Hospitalisation
Clark et al. 2008	$US1,613 – 13,778	1758 - 15018	Cohort study	Hospitalisation	Acute hospitalisation
Johansson et al. 2006	€9,740	14,415	RCT	Hospitalisation	Acute hospitalisation, one outpatient visit
Maravic et al. 2005	€8,570	12,684	Cohort study	Hospitalisation	Acute Hospitalisation
Braithwaite et al. 2003	$US8,900	9,701	Model [1]	Hospitalisation	Acute hospitalisation
Autier et al. 2000	€8,667	12,827	Case control study	Hospitalisation	Acute Hospitalisation
Viswanathan et al. 2012	$US17,923	19,536	Retrospective cohort study	6 months	Hospitalisations
Gutiérrez et al. 2011	€4,391	6,499	Retrospective Cohort study	1 year	Hospitalisations

Ohsfeldt et al. 2006	$US23,266	25,3560	Cohort study	1 year	Hospitalisations
Gabriel et al. 2002	Direct excess cost[2] $US3,884	4,233	Case control study	1 year	Hospitalisation and hip-related readmission
Bessette et al. 2012	$CAD15,000	15,600	Cohort study of health databases	2 years	Hospitalisation

1 Modelled economic data uses likely costs and epidemiologic data gained from academic literature, government reports or agreed estimates and combines these to give an indication of the likely economic outcomes

2Direct excess cost refers to the additional medical cost due to the hip fracture. It is calculated by subtracting the mean pre-fracture medical cost from the mean post-fracture cost

Table 1.6 Studies estimating the cost of hip fracture including rehabilitation

Reference	Average Cost	$AUD Cost	Method	Timeframe	Included
Woolcott et al. 2012	$CAD39,000	40,560	Prospective cohort study	Hospitalisation	Acute hospitalisation, inpatient rehabilitation
Hollingworth et al. 1995	£5,000	8,850	Cohort study	Hospitalisation	Hospitalisation, inpatient rehabilitation costs, hip-related readmissions, outpatient visits
Tamulaitiene et al. 2012	€2,527	3,740	Retrospective cohort study	1 year	Hospitalisation, inpatient rehabilitation, hip-related readmission
Shi et al. 2009	$US25,332	27,612	Case Control study	1 year	Hospitalisation, outpatient costs, physical therapy, medications
Bjornelv et al. 2012	€25,000-28,000	37,000 – 41,440	RCT	2 years	Hospitalisation, rehabilitation, hip-related readmissions

Table 1.7 Studies estimating the cost of hip fracture including social and community care costs

Reference	Average Cost	$AUD Cost	Method	Timeframe	Included
Gutiérrez et al. 2011	€5,336	7,897	Retrospective Cohort study	1 year	Hospitalisation, Outpatient visits, prescription medications
Ohsfeldt et al. 2006	$US26,856	29,273	Cohort study	1 year	Hip-fracture related hospitalisation, readmissions, residential aged care admission, outpatient visits
Autier et al. 2000	€12,245	18,123	Case control study	1 year	Hip-fracture related hospitalisation, rehabilitation, community services, outpatient visits and nursing home costs
De Laet et al. 1999	$US11,172	12,178	Case control study	1 year	Hospitalisation, outpatient visits, medications and nursing home costs
Dolan et al. 1998	£12,124	21,460	Case control study	1 year	Acute hospitalisation, new post-fracture community services, outpatient visit, pharmaceuticals for treatment of osteoporosis, residential aged care
Randell et al. 1995	$AUD15,984	15,984	Cohort study	1 year	Hospitalisation, rehabilitation admissions, outpatient doctor and allied health visits, imaging and pathological analyses, pharmaceuticals commenced post fracture, community services and residential aged care
Braithwaite et al. 2003	$US81,300	88,617	Markov state transition model	Life-time costs	Hip-fracture related hospitalisation, nursing home admission, community services

1.5 Aims

The overall aim of this thesis is to apply a number of methods of economic evaluation to multidisciplinary rehabilitation strategies in older adults following a hip fracture, especially focusing on nutrition and exercise therapy. While both nutrition and exercise therapy will be discussed throughout the thesis, emphasis will be placed on the effect of nutrition therapy as this is within the expertise of my discipline. There are four sub-aims for this thesis:

1. To conduct a systematic review of protein and energy supplementation for treatment and prevention of malnutrition from an economic viewpoint.
2. To determine the economic effectiveness of combined individualised nutrition and exercise therapy for rehabilitation following a hip fracture.
3. To empirically compare the performance of two MAUI instruments in patients following a hip fracture for use in future CUA of healthcare interventions in this group.
4. To determine patient preferences for rehabilitation following a hip fracture for consideration when planning future healthcare interventions.

These sub-aims will be met by four main projects forming the bulk of the thesis. The first project (discussed in chapter two) will outline a systematic review of the available economic evidence for treatment and prevention of malnutrition. Chapter three will present the second project, a CUA of an individualised nutrition and exercise intervention for rehabilitation in older adults following a hip fracture. Chapter four will compare the performance of two MAUI in a group of patients with hip fractures (project three), to provide evidence for their incorporation into economic evaluations of health care interventions such as multidisciplinary rehabilitation in older adults in the future. In chapter five, a different method of economic evaluation known as a Discrete Choice Experiment (DCE) which quantifies not only the value that patients receive from the outcome of a healthcare intervention, but also aspects of providing healthcare, will be applied to determine preferences of patients for rehabilitation following a hip fracture (project four). Chapter six will provide discussion of the key outcomes of the projects, and provide a focus for future research in this area.

2 SYSTEMATIC REVIEW OF THE EVIDENCE FOR PROTEIN AND ENERGY SUPPLEMENTATION AS A TREATMENT STRATEGY FOR MALNUTRITION IN REHABILITATION

This chapter contains material from:

Milte, RK, Ratcliffe, J, Miller, MD & Crotty, M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence' *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

This chapter describes a systematic review conducted to determine the quantity and quality of the economic evidence available for providing protein and energy supplementation for treatment or prevention of malnutrition. Protein and energy supplementation was chosen as the intervention of interest due to its widespread use as a method of preventing and treating malnutrition. As discussed in section 1.3.3, there is now evidence to support the clinical benefits of dietary methods to prevent and treat malnutrition, including improvements in markers of nutritional status, preservation of muscle mass and strength, reduction in complications and mortality (Avenell & Handoll 2010; Milne et al. 2009). However, the economic benefits of dietary treatments have so far received little attention. Therefore, the aim of the review was to identify studies that included an economic evaluation of protein and energy supplementation in adults for treatment or prevention of malnutrition, to provide an assessment of the quality of that literature, and an indication of the likely cost-effectiveness of such strategies based on the available evidence.

2.1 Methods

2.1.1 Search strategy

A search strategy (see Appendix 1: Search strategy used for Medline database) was developed largely replicating that published by Milne et al. in their review of protein and energy supplementation for treatment of malnutrition in older adults, but with additional search terms to identify studies with economic evaluation (Milne et al. 2009). While the review published by Milne et al. originally dealt with only older adults (average age 65 years and above), due to the paucity of economic evidence the search strategy was widened to include all adults (18 years and above) thereby facilitating a broader analysis of the quantity and quality of the economic literature. Inclusion criteria were as follows. The review included hospital, residential aged care and community dwelling populations. The focus was specifically upon economic evaluation studies reported either as stand-alone papers or as components of papers which also included a broader focus upon clinical effectiveness. Interventions of interest were those aiming to increase the energy and protein levels of individuals via oral administration. Interventions which included a mix of interventions such as nutrition screening and assessment, dietary advice, and feeding assistance in addition to protein and energy supplementation were included. Types of studies included were any comparative study, including randomised controlled trials, and non-randomised controlled trials. Studies employing economic modelling methods were also included. Exclusion criteria included trials purely based on patients in critical care or recovering from cancer treatment as these patients typically have highly specialised nutritional needs. Relevant comparators included ‘usual practice’ (i.e. ad hoc dietary care or an alternative nutritional supplement with a different energy and protein content) or a ‘placebo’ (such as a low energy drink).

Databases searched included Cochrane register of Controlled Trials (from 1898 until September 2013), Medline (from 1946 until September 2013), Scopus (from 1823 until September 2013), Web of Knowledge (from 1950 until September 2013), CINAHL (from 1957 until September 2013) and Australasian Medical Index (from 1968 until September 2013).

In addition, any reviews of the topic that were identified through the above methods were checked for additional studies that had not been previously identified. Reference lists of identified articles or reviews of protein and energy supplementation or nutrition therapy were also checked for additional references.

2.1.2 Data collection and analysis

Two reviewers independently identified studies from the search results for further analysis by scanning the title, abstract, and key words of the studies for evidence that they compared a protein and energy supplemented diet with no intervention, a placebo, or an alternative supplement and involved adult participants. If there was any doubt about the eligibility of the article, it was retrieved for further investigation.

All information was extracted independently by the two reviewers. All differences in extraction were clarified with a third reviewer by going back to the original article. Information extracted included: study design, participants, intervention, sample size, follow up period, results, and inclusion of sensitivity analysis (which measures the variability around the base-case results, often through varying imputed data across a likely range of possible values, or through modelling possible alternative results in a technique known as bootstrapping), and discounting of future costs and benefits (where applicable) (Drummond et al. 2005). Discounting refers to the practice of applying a discounting rate to benefits that are gained by consumers one year or more in the future, to account for the well described phenomenon of the consumer valuing benefits they receive earlier higher than those they must wait for (Drummond et al. 2005). The quality of the economic evaluations in the articles was assessed using the 35 point checklist developed by Drummond and colleagues for quality submission of economic evaluations to journals (Drummond et al. 2005). These criteria (see Table 2.1) assess the quality of the economic evaluation in terms of study design, data collection, analysis and interpretation of results, and allow assessment of economic evaluations based on single trial data and combinations of data into economic models. Similarly to the previous review, studies were not excluded based on the nutritional status of the participants, but identified studies were categorised into one of two groups according to whether they had targeted malnourished patients only (according to the criteria within the paper) or did not specify the nutritional status of their participants for entry to the study for ease of interpretation and reporting of results. Costs have been converted to Australian dollars to allow easy comparison.

Table 2.1 Drummond criteria for assessing quality of economic literature

Study Design
1. The research question is stated
2. The economic importance of the research is stated
3. The viewpoint(s) of the analysis are clearly stated and justified
4. The rationale for choosing the alternative programmes or interventions compared is stated
5. The alternatives being compared are clearly described
6. The form of economic evaluation is justified in relation to the questions addressed
7. The choice of form of economic evaluation is justified in relation to the questions addressed
Data collection
8. The source(s) of the effectiveness estimates used are stated
9. Details of the design and results of effectiveness study are given (if based on a single study)
10. Details of the method of synthesis or meta-analysis of estimates are given (if based on an overview of a number of effectiveness studies)
11. The primary outcome measure(s) for the economic evaluation are clearly stated
12. Methods to value health states and other benefits are stated
13. Details of the subjects from who valuation were obtained are given
14. Productivity changes (if included) are reported separately
15. The relevance of productivity changes to the study question is discussed
16. Quantities of resources are reported separately from their unit costs
17. Methods for the estimation of quantities and unit costs are described
18. Currency and price data are recorded
19. Details of currency of price adjustments for inflation or currency conversion are given
20. Details of any model used are given
21. The choice of model used and the key parameters on which it is based are justified
Analysis and interpretation of results
22. Time horizon of costs and benefits is stated
23. The discount rate(s) is stated
24. The choice of rate(s) is justified
25. An explanation is given if costs or benefits are not discounted
26. Details of statistical tests and confidence intervals are given for stochastic data
27. The approach to sensitivity analysis is given
28. The choice of variables for sensitive analysis is justified
29. The ranges over which the variables are varied are stated
30. Relevant alternatives are compared
31. Incremental analysis is reported
32. Major outcomes are presented in a disaggregated as well as aggregated form
33. The answer to the study question is given
34. Conclusions follow from the data reported
35. Conclusions are accompanied by the appropriate cavets

(Taken from Drummond et al. 2005)

2.2 Findings

2.2.1 Results of the search

3,574 titles were identified through the search (Figure 2.1 Flow diagram showing study selection process). Of those titles, the vast majority could be excluded via reading the titles or the abstract (3,451 out of the 3,574), as their focus was not health care but agricultural practices, animal health or manufacturing of food, or did not include an intervention to increase dietary energy or protein.

A total of 123 papers had the full text of the title accessed and of those a further 101 were excluded due to lack of an intervention to increase energy and protein intake via the normal oral route (e.g. included parental nutrition or naso-gastric, naso-enteric, or percutaneous endoscopic gastrostomy (PEG) feeding (n=16), did not include economic outcomes (n=32), did not include a dietary intervention to increase energy or protein (n=47) or were testing supplementation of immunomodulatory components within a protein and energy supplement (n=6). Two papers were protocols for studies not yet published and were therefore excluded. This left 20 papers including an economic evaluation which were analysed in the review.

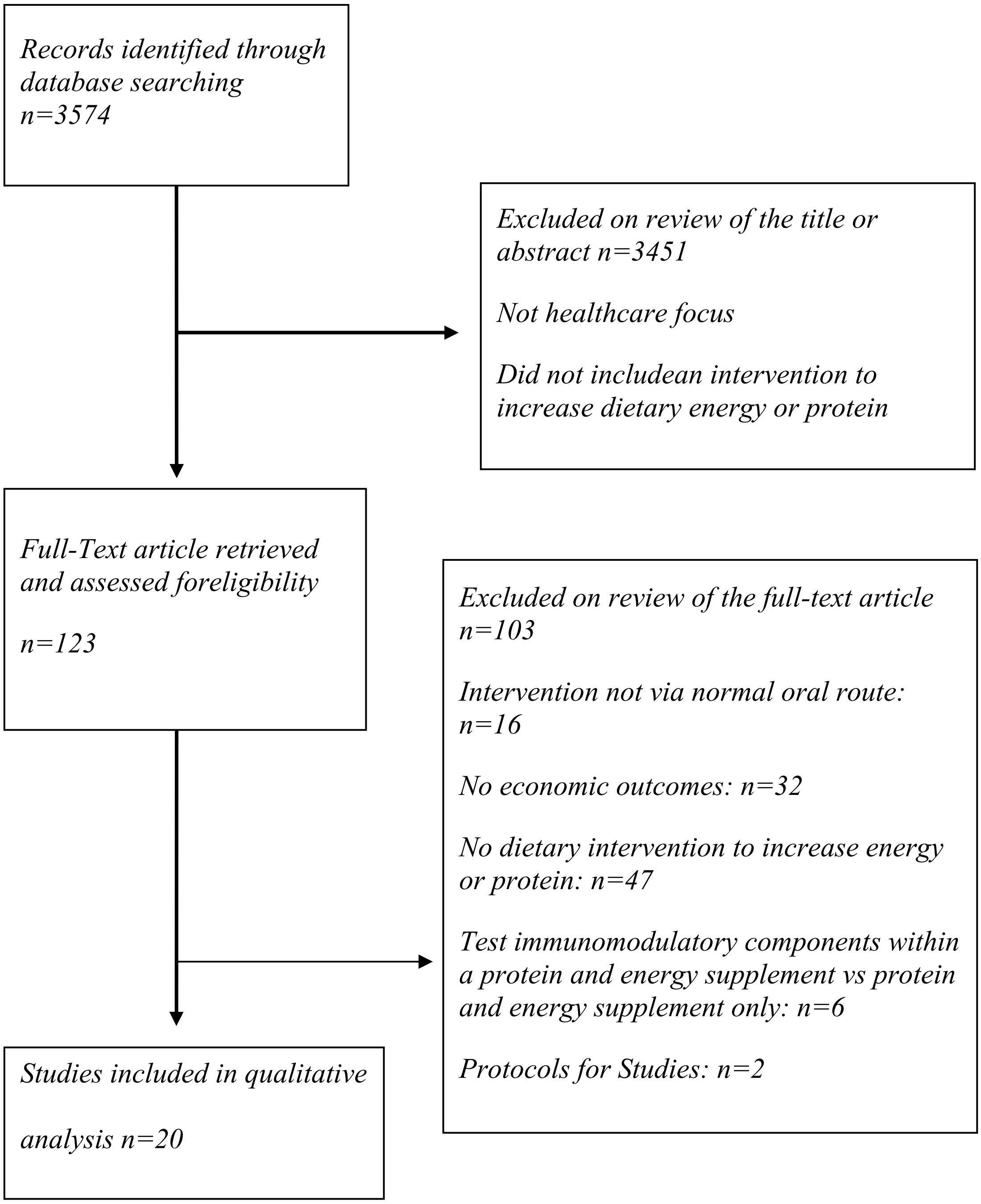

Figure 2.1 Flow diagram showing study selection process

2.2.2 Results of studies where participants were defined as malnourished

Six studies targeted malnourished patients using a variety of identification methods (e.g. Subjective Global Assessment, Mini Nutritional Assessment, BMI, history of unplanned weight loss), listed in Table 2.2. Of those studies three included a cost utility analysis (Neelemaat et al. 2012; Norman et al. 2011; Pham et al. 2011), with the remaining studies including cost benefit analyses (Freijer & Nuijten 2010; Freijer et al. 2012) and a cost consequence analysis respectively (Edington et al. 2004). Two of the studies reporting a cost utility analysis (Neelemaat et al. 2012; Norman et al. 2011) and the cost consequence analysis (Edington et al. 2004) were based on the results of randomised controlled trials both with sample sizes of 100 participants or more while the cost benefit analyses and one cost utility analysis (Freijer & Nuijten 2010; Freijer et al. 2012; Pham et al. 2011) were based on modelled data. All of the studies utilized oral nutritional supplements (ONS) as their intervention, although Norman et al. (2011) also provided dietary counselling to their intervention and control groups. The participants were from different clinical groups with two studies focusing on patients with gastrointestinal disease (Freijer & Nuijten 2010; Norman et al. 2011), two with older adults admitted to hospital (Edington et al. 2004; Neelemaat et al. 2012), one with older adults in residential care facilities (Pham et al. 2011), and one in community dwelling older adults (Freijer et al. 2012). The studies also differed in the costs they included in their analysis. Norman et al. (2011) only included the incremental cost of the intervention in their analysis, excluding any wider effect on the health system, while most other studies took a wider view point including costs of medical treatment and social care in the community (Edington et al. 2004; Freijer et al. 2012; Neelemaat et al. 2012). There was a great variety in outcomes measured as listed in Table 2.2. The cost utility analysis by Norman et al.(2011) found that providing 3 months of ONS to malnourished patients with benign gastrointestinal disease was associated with an ICER between $AU14,056-17,907 per quality-adjusted life year (QALY) gained. Although in Australia no explicit guideline for determining the cost effectiveness of new healthcare technologies has been provided, the Pharmaceutical Advisory Committee appears to consider interventions with cost per QALY below $50,000 as cost effective, and this intervention is well within this threshold indicating relatively high cost effectiveness (Harris et al. 2008). Neelemaat et al.(2012) neared the cost-effectiveness threshold in their CUA providing ONS to older people admitted to hospital as well as routine Vitamin D and Calcium supplementation and telephone support from a dietitian upon discharge after showing a small gain in QALY in the intervention group compared to their control. However, the study showed fewer declines in function in the intervention compared to the control group, which equated to a cost of $915 for a one unit reduction in functional limitations as measured by the Longitudinal Aging Study Amsterdam questionnaire. Cost benefit studies conducted in the Netherlands indicated cost savings of over $300 per patient in abdominal surgery patients receiving 2 cartons of ONS per day during their hospitalisation through a reduced length of stay (Freijer & Nuijten 2010), and reported total budget savings of over $17 million for the provision of ONS for treatment of malnutrition in community dwelling older people (Freijer et al. 2012). Pham, Stern, et al. (2011) found provision of ONS for the treatment of pressure ulcers in malnourished patients of residential care facilities was not cost effective in isolation, but argued that nutrition may play a wider role in supporting other prevention strategies they were unable to model for in their analysis. The remaining study was conducted in a community dwelling sample of older people over a six to 12 month follow up period and failed to demonstrate any cost savings for an eight week intervention in a population of elderly and already malnourished subjects (Edington et al. 2004). In summary therefore although the available economic evidence is scant, the studies which have been undertaken to date do demonstrate the potential for protein and energy supplementation in patients identified as malnourished to provide cost savings to the health system of millions of dollars in addition to improved health outcomes for patients.

Table 2.2 Design and cost outcomes of included studies when participants defined as malnourished

Citation	Design	Intervention	Population	n Subjects	Follow Up	Method	Sensitivity Analysis	Discount	Unit	*Cost per Additional Unit*	*Cost Intervention*	*Cost Comparison*
(Neelemaat et al. 2012)	RCT	ONS (2520kJ and 24g protein) and malnutrition treatment protocol	Hospitalised older adults (Malnourished according to BMI or weight loss)	210	3 months	CUA	Yes	N/A	QALY	€26,962 $AUD39,904	€9,129 (1227)[1,2] $AUD13,511 (1,816)	€8,684 (1,361)[1,2] $AUD 12,852 (2,014)
(Norman et al. 2011)	RCT	ONS 3/12 (2505kJ and 23g protein)	Benign GI disease (Malnourished according to SGA)	120 I=60 C=54	3 months	CUA	Yes	N/A	QALY	€9,497-12,099 $AUD14,056-17,907	€561 (514-609)[3,4] $AUD830 (761-901)	€22 (0-73)[3,4] $AUD 33 (0-108)
(Pham et al. 2011)	Model	ONS (1 carton per day, 8.4kJ/mL formula)	Residential Care (Malnourished according to weight loss)	N/A	3.8 years	CUA	Yes	Yes	QALY	$CAD7,824,747 $AUD8,137,737	-	-
(Freijer et al. 2012)	Model	ONS (2 cartons per day, NFS)	Community dwelling older people	720223	1 year	CBA	Yes	N/A	Total budget savings	€12,986,000 $AUD19,219,280	€262,657,000[5] $AUD 388,732,360	€275643000[5] $AUD 407,951,640
(Freijer & Nuijten 2010)	Model	ONS (2 cartons per day, NFS)	Abdominal surgery	N/A	Per admission	CBA	Yes	N/A	Cost of hospitalisation	-€252 $AUD 373	-	-

(Edington et al. 2004)	RCT	ONS from hospital (2500 – 4200kJ)	Recently hospitalised older adults (Malnourished according to BMI or weight loss)	100 I=51 C=49	6 months	CCA	No	N/A	-	-	£2,989 (4,418)[2,6] $AUD5,291 (7820)	£2,146 (2,238)[2,6] $AUD3,798 (3961)

Abbreviations: BMI=Body Mass Index, C=Control, GI=Gastrointestinal, I=Intervention, N/A=Not applicable, NFS= Not further specified, ONS=Oral nutritional supplements, QALY=Quality adjusted life year, RCT=Randomised controlled trial, SGA=Subjective global assessment

1 Standard Error

2 Costs included for providing medical treatment and social services only

3 Costs included for providing intervention only

4 95% CI

5 Costs included for medical treatment and social services related to treatment of DRM

6 Standard Deviations

2.2.3 Results of studies where nutritional status not specified

Table 2.3presents the results of studies including an intervention to improve nutritional status in a group of participants where their nutritional status was not specified (Allen 2013; Dangour et al. 2011; Hoogendoorn et al. 2010; Kruizenga et al. 2005; Lawson et al. 2003; Lorefält et al. 2011; Philipson et al. 2013; Roulin et al. 2013; Russell 2007; Rypkema et al. 2003; Simmons et al. 2010; Smedley et al. 2004; Tucker & Miguel 1996; Wyers et al. 2013). Although relatively more studies were identified in this category, the studies were very diverse in terms of setting, interventions, and outcomes measured, making any direct comparisons across studies very difficult. In terms of study design, a range of designs were employed including randomised controlled trials (Dangour et al. 2011; Hoogendoorn et al. 2010; Simmons et al. 2010; Smedley et al. 2004; Wyers et al. 2013), a number of non or quasi-randomised designs (Allen 2013; Kruizenga et al. 2005; Lawson et al. 2003; Lorefält et al. 2011; Roulin et al. 2013; Rypkema et al. 2003), observational designs (Philipson et al. 2013), and modelled studies (Russell 2007; Tucker & Miguel 1996). Although sample size varied from less than 100 to over 2000, half of the studies included between 100 and 300 participants. Of the identified studies only two utilized a cost-utility approach (Hoogendoorn et al. 2010; Wyers et al. 2013). Hoogendoorn et al. (2010) assessed a multidisciplinary intervention including exercise and smoking cessation counselling in addition to ONS in community dwelling adults with chronic obstructive pulmonary disease and was found to be near the cost effectiveness threshold at $39,438 per QALY gained. Wyerset al. (2013) assessed the cost-utility of dietetic intervention including ONS in patients with hip fracture and found the cost-utility ICER outside accepted thresholds ($4,000 above the implied threshold of $50,000 per QALY in Australia), however they assessed their intervention as likely to be cost effective based on ICER of $357 per kg weight gained. Both studies used a set volume of ONS provided to patients for a set duration, not dependent on individual patient needs. Four of the studies utilized a cost-effectiveness analysis and reported upon a diverse range of outcome indicators including cost per one day reduction in length of stay, cost per kilocalorie consumed, or cost per kg of weight gained (Dangour et al. 2011; Kruizenga et al. 2005; Rypkema et al. 2003; Simmons et al. 2010). Findings ranged from a cost of $0.01 per kilocalorie additional consumed to cost of $113 per one day reduction in length of stay. Although Dangouret al. (2011) found an ICER of $7 per additional metre walked by their intervention group in a timed walking test, they only included the costs for the physical activity intervention not the nutrition intervention in their estimates, which could lead to an underestimation. All of these included ONS, aiming to provide between 1068kJ and 10g protein to 2500kJ and 28g protein additional per day. Other interventions utilized included mid meal snacks, or fortified foods and five studies included a multifaceted intervention (two of which included an exercise or multidisciplinary intervention, and three which included routine early screening for nutritional status and issues). The studies also focused on different clinical groups such as patients from residential care homes (Lorefält et al. 2011; Simmons et al. 2010), patients with COPD discharged to the community (Hoogendoorn et al. 2010), community dwelling older adults (Dangour et al. 2011), and a large number focusing on patients from various hospital wards (Kruizenga et al. 2005; Lawson et al. 2003; Russell 2007; Rypkema et al. 2003; Smedley et al.

2004; Tucker & Miguel 1996; Wyers et al. 2013). Follow up period was similarly varied across the studies ranging from the duration of hospital stay to a two year period, with the greatest proportion of studies (eight out of 14) centred on the period of hospitalisation. In addition, the costs included in the analysis varied from the incremental costs of providing the intervention only (Dangour et al. 2011; Kruizenga et al. 2005; Simmons et al. 2010), compared to wider viewpoints including the costs of providing the intervention and medical treatment over the follow up time period (Allen 2013; Hoogendoorn et al. 2010; Lawson et al. 2003; Lorefält et al. 2011; Philipson et al. 2013; Roulin et al. 2013; Russell 2007; Rypkema et al. 2003; Smedley et al. 2004; Wyers et al. 2013). One study focused on the changes in hospitalisation costs only (Tucker & Miguel 1996). Overall, while the heterogeneity of the studies makes synthesis of the outcomes difficult, they have indicated beneficial outcomes for the patient or health system, at a relatively low cost.

Table 2.3Design and cost outcomes of included studies where nutritional status not specified

Citation	Design	Intervention	Population	n Subjects	Follow Up	Method	Sensitivity Analysis	Discount	Unit	*Cost per Additional Unit*	*Cost Intervention*	*Cost Comparison*
(Wyers et al. 2013)	RCT	ONS (2 cartons per day)	Hip fracture	152 I=73 C=79	6 months	CUA	Yes	N/A	QALY	€36,943 $AUD54,676	€23,353 (16,124)[1,2] $AUD34,562 (23,864)	€22,896 (16,834)[1,2] $AUD33,886 (24,914)
(Hoogendoorn et al. 2010)	RCT	ONS 4/12 (2351kJ and 28g protein) plus multi-disciplinary intervention	COPD	199 I=102 C=97	2 years	CUA	Yes	No	QALY	€32,425 $AUD47,989	€13,565[3] $AUD20,076	€10,814[3] $AUD16,005
(Dangour et al. 2011)	Randomised factorial trial	ONS (1068kJ and 10g protein) and/or physical activity	Community-dwelling older adults	1669 ONS = 414, ONS+PA=452 PA=403 C=400	2 years	CEA	Yes	Yes	Meter walked in 6 minute walking test	$US4.84[4] $AUD5.28	Nutrition intervention $US91[5] $AUD99	-
(Simmons et al. 2010)	RCT	Snacks or ONS (NFS)	Residential Care	63 ONS=18 Snacks=24 C=19	6 weeks	CEA	Yes	N/A	kCal consumed	$US0.01 $AUD0.01	ONS $US2.13 (0.37)[1,5] $AUD2.32 (0.40)	-

(Kruizenga et al. 2005)	Historical controlled trial	Malnutrition treatment protocol including high energy and protein meals (2500kJ and 12g protein additional)	Mixed ward patients	588 I=297 (HEHP =98) C[d]=291	Per admission	CEA	Yes	N/A	One day reduction in LOS	€35 (-1239-109)[6] $AUD52 (-2230-161)	€37 (15-58)[5,6] $AUD55 (22-86)	-
(Rypkema et al. 2003)	Quasi-randomised controlled trial	Malnutrition protocol including treatment with high energy diet or ONS (NFS)	Geriatric ward patients	298 I=140 C = 158	Per admission	CEA	Yes	N/A	Kg gained	-€392 -$AUD580	€7516[7] $AUD11,124	€7908[7] $AUD11,704
(Russell 2007)	Model	ONS (NFS)	Surgical patients	N/A	Per admission	CBA	No	N/A	Cost of hospitalisation	-£849 -$AUD1503	-	-
(Smedley et al. 2004)	RCT	ONS (6.3kJ and 0.05g protein per ml drink ad libitum) before and after surgery (SSgroup) vs ONS before (SC group) vs ONS after (CS group) vs control (CC group)	Surgical patients	152 CC=44 SS=32 CS=35 SC=41	Up to 96 days	CBA	Yes	N/A	Cost of hospitalisation	-£300 -$AUD531	SS £2,289 (2034-2717)[1,7] $AUD4,051 (3,600-4,809)	£2,618 (2,272-3,181)[1,7] $AUD4,634 (4,021-5,630)

(Lawson et al. 2003)	Prospective controlled trial	ONS (2500kJ and 20g protein)	Emergency and elective orthopaedic surgery	181 I=84 C=97	Per admission	CBA	No	N/A	Cost of hospitalisation	-£16 -$AUD28	£2,069[7] $AUD3,662	£2,199[7] $AUD3,892
(Philipson et al. 2013)	Case-control study	ONS (NFS)	Hospital patients	1160088	Per admission	CCA	No	N/A	Cost of hospitalisation	-$US4,734 -$AUD5,160	-	-
(Lorefält et al. 2011)	Non-randomised controlled trial	Malnutrition protocol including high energy high protein meal options (NFS) for 3 months	Residential Care	109 I=42 C=37	1 year	CCA	No	N/A	-	-	€1,005[7] $AUD1,487	€921[7] $AUD1,363
(Tucker & Miguel 1996)	Model	ONS (NFS)	Hospital patients	2485	Per admission	CCA	No	N/A	Cost of hospitalisation per year	-$US8,294 -$AUD9,041	-	-
(Roulin et al. 2013)	Non-randomised controlled trial	Post surgery protocol including ONS (2 x cartons per day)	Colorectal surgery patients	100 I=50 C=50	Per admission	CMA	Yes	N/A	Cost of hospitalisation	-€1,651 -$AUD2,444	€25,319[7] $AUD37,472	€26,970[7] $AUD39,916
(Allen 2013)	Pre/post quasi-experimental design	Multidisciplinary treatment protocol including ONS (405kJ and 18g protein upto 894kJ and 44g protein per day)	Older adults hospitalised with pressure ulcer	100 I=50 C=50	Per admission	Simple cost analysis	No	N/A	_	_	$US727,245[8] $AUD792,697	$US702,065[8] $AUD765,251

Abbreviations: C=Control, COPD=Chronic obstructive pulmonary disease, GI=Gastrointestinal, HEHP=High energy high protein diet, I=Intervention, LOS=Length of stay, N/A=Not applicable, NFS=Not further specified, ONS=Oral nutritional supplements, PA=Physical activity, QALY=Quality adjusted life year,

1 Standard deviations
2 Costs included for providing intervention plus medical treatment and social services only
3 Costs included for providing intervention plus medical treatment and loss of income for participant
4 Costs included for providing physical activity intervention only
5 Costs included for providing intervention only
6 95% Confidence intervals
7 Costs included for providing intervention and medical treatment
8 Total group costs included providing intervention and medical treatment

2.2.4 Quality assessment of published studies

Overall when assessing the quality of the published studies according to the widely recognised Drummond criteria the quality ranges greatly between studies, (see Figure 2.2, Figure 2.3, and Figure 2.4). Bars indicate the number of studies for which the quality criteria was met (black bar), not met (white bar), or not applicable for this study (grey bar). Studies were of varying quality, with the number of 'yes' responses to the criteria ranging from a minimum of three to 28 out of a possible 35.

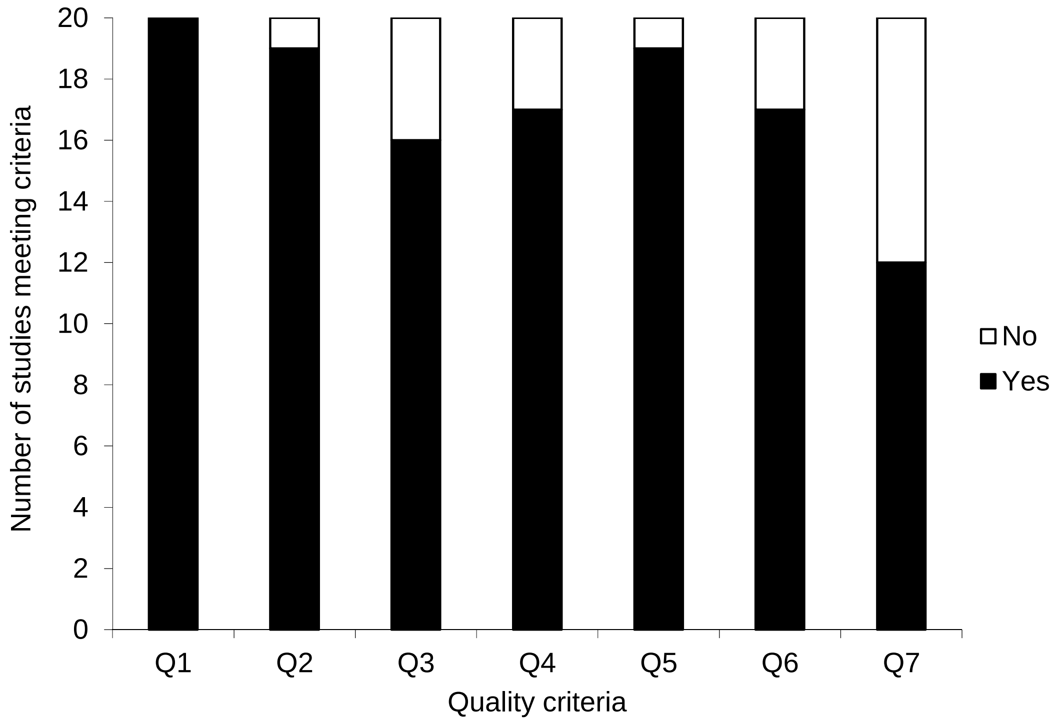

Figure 2.2 Number of studies meeting the Drummond criteria for the design of the studies

Criteria questions are as follows: Q1, the research question is stated; Q2, the economic importance of the research is stated; Q3, the viewpoint(s) of the analysis are clearly stated and justified; Q4, the rationale for choosing the alternative programmes or interventions compared is stated; Q5, the alternatives being compared are clearly described; Q6, the form of economic evaluation used is stated; Q7, the choice of form of economic evaluation is justified in relation to the questions addressed

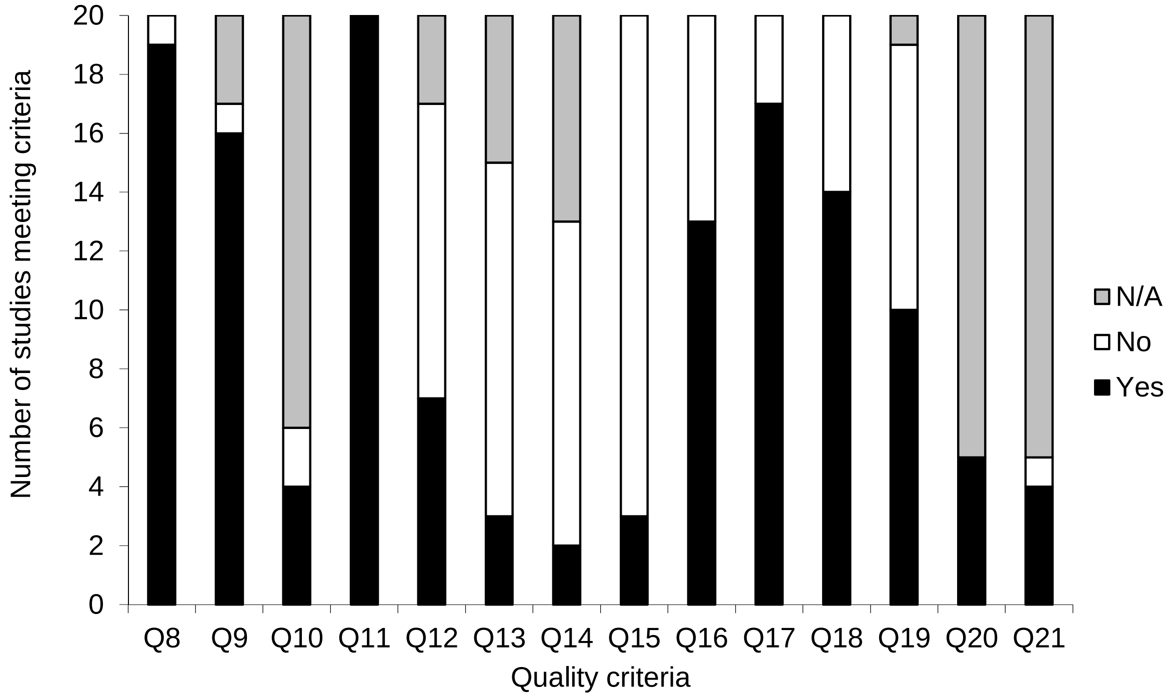

Figure 2.3 Number of studies meeting the Drummond criteria for data collection

Q8, the source(s) of effectiveness estimates used are stated; Q9, details of the design and results of the effectiveness study are given (if based on a single study); Q10, details of the method of synthesis or meta-analysis of estimates are given (if based on an overview of a number of effectiveness studies); Q11, the primary outcome measure(s) for the economic evaluation are clearly stated; Q12, methods to value health states and other benefits are stated; Q13, details of the subjects from whom valuations were obtained are given; Q14, productivity changes (if included) are reported separately; Q15, the relevance of productivity changes to the study question is discussed; Q16, quantities of resources are reported separately from their unit costs; Q17, methods for the estimation of quantities and unit costs are described; Q18, currency and price data are recorded; Q19, details of currency of price adjustments for inflation or currency conversion are given; Q20, details of any model used are given;Q21, the choice of model used and the key parameters on which it is based are justified.

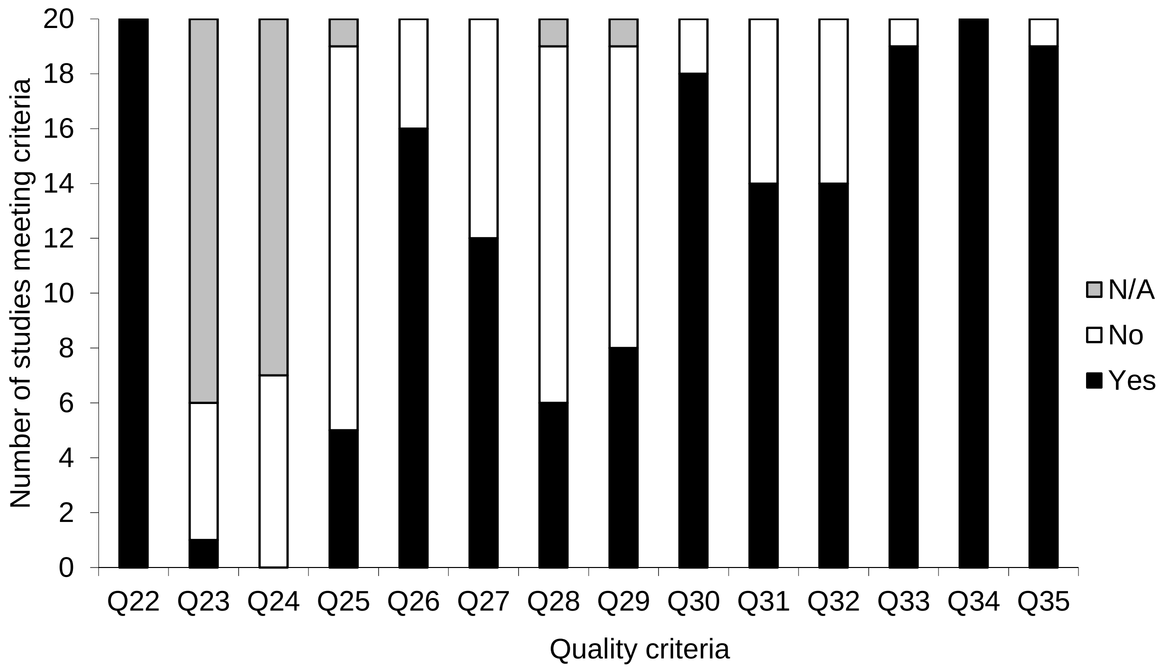

Figure 2.4 Number of studies meeting the Drummond criteria for analysis and interpretation of data

Q22, time horizon of costs and benefits is stated; Q23, the discount rate(s) is stated; Q24, the discount rate(s) is justified; Q25, an explanation is given if costs or benefits are not discounted; Q26, details of statistical tests and confidence intervals are given for stochastic data; Q27, the approach to sensitivity analysis is given; Q28, the choice of variables for sensitivity analysis is justified; Q29, the ranges over which the variables are varied are stated; Q30, relevant alternatives are compared; Q31 incremental analysis is reported; Q32, major outcomes are presented in a disaggregated as well as aggregated form; Q33, the answer to the study question is given; Q34, conclusions follow form the data reported; Q35, conclusions are accompanied by the appropriate caveats.

Generally, the studies scored well on question 1 (“the research question is stated”), 5 (“the alternatives being compared are clearly described”), 22 (“time horizon of costs and benefits is stated”), and 32 (“conclusions follow from the data reported”). Questions completed less well included 14 (“productivity changes if included are reported separately”), 15 (“the relevance of productivity changes to the study question is discussed”), 23 (“the discount rate is stated”), and 24 (“the choice of rate is specified”).

The paper which had the highest number of ‘yes’ responses to the criteria (n=28) was Phamet al. (2011), a recently published CUA of ONS in Residential Care patients closely followed by Normanet al. (2011) (n=27) a cost utility study of ONS in malnourished patients with benign GI disease. This study found that ONS was cost effective. In general, it was found that the more recently published Cost Utility (Hoogendoorn et al. 2010; Neelemaat et al. 2012; Norman et al. 2011) and Cost Effectiveness studies (Dangour et al. 2011; Kruizenga et al. 2005; Rypkema et al. 2003; Simmons et al. 2010) were of a higher quality than older published studies in terms of their adherence to the Drummond criteria. Figure 2.5 shows the number of criteria met by studies according to the year of publication. There did not appear to be a relationship between the adherence of the studies to the Drummond criteria and their likelihood of showing economic benefits.

A few studies included only a partial report of healthcare costs such as general practitioner or health service visits (Edington et al. 2004; Lorefält et al. 2011; Tucker & Miguel 1996). However, these studies fail to provide a direct comparison between the costs and benefits provided by the interventions, and they therefore fail to take into consideration the value for money of the interventions from an economic perspective (Brown 2005).

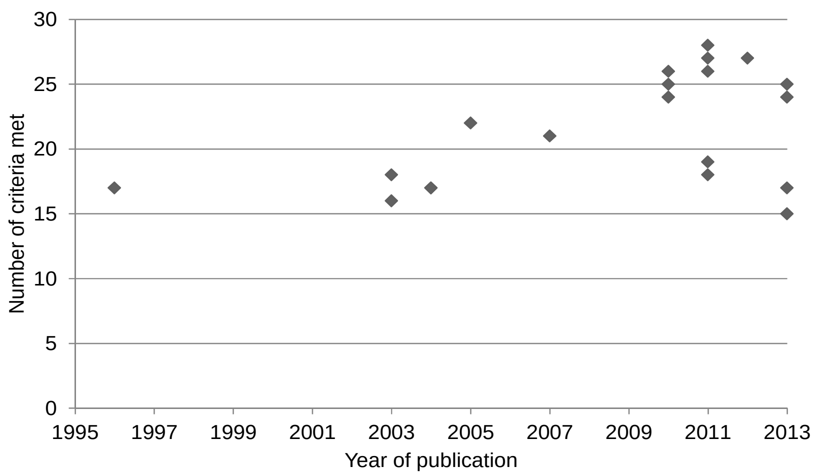

Figure 2.5 Comparison of the number of Drummond criteria met and year of study publication

2.3 Discussion

In a comprehensive review of the published literature, twenty papers were identified which included analysis of providing protein and energy supplementation for prevention or treatment of malnutrition from an economic view point. Of these, only five studies(Hoogendoorn et al. 2010; Neelemaat et al. 2012; Norman et al. 2011; Pham et al. 2011; Wyers et al. 2013) utilised cost-utility analysis, which is currently recommended as the preferred method of economic evaluation for new health care interventions by the Pharmaceutical Benefits Advisory Committee and Medical Services Advisory Committee in Australia, and the National Institute for Health and Clinical Excellence in the UK as well as many other regulatory bodies around the world (Commonwealth Department of Health and Ageing 2002; National Institute for Health and Clinical Excellence 2008).

Wyerset al. (2013) found that the use of ONS and nutritional counselling in patients with hip fractures was just above accepted cost effectiveness thresholds based on QALY (approx. $AUD 54,000 just above the $50,000 published threshold for determining cost effectiveness of healthcare interventions in Australia (Harris et al. 2008)) but that it was likely to be considered cost effective based on a cost per kg of weight gained of $357. This study represents the first cost-utility analysis of nutrition support in the nutritionally vulnerable hip fracture population.

Two of the cost-utility studies identified by the review concluded that the interventions under consideration (ONS for 3 months in patients with benign gastrointestinal disease who were also malnourished and ONS for 2 years in adults with Chronic obstructive pulmonary disease) were cost effective (Hoogendoorn et al.

2010; Norman et al. 2011). In both studies, the incremental cost per QALY ratios were below threshold values for determining cost effectiveness (Harris et al. 2008).In another CUA, Neelemaat et al. (2012) neared the cost-effectiveness threshold for their intervention of ONS in malnourished hospitalised older adults, while Pham et al. (2011) did not show cost effectiveness in prevention of pressure ulcers in malnourished older people living in residential care facilities.

Studies identified in this review indicate an incremental cost of between -$AUD580 to $52 for health outcomes such as a reduction in one day length of stay, additional metre walked, additional calories ingested, or per kg of weight gained (Dangour et al. 2011; Kruizenga et al. 2005; Lawson et al. 2003; Lorefält et al. 2011; Russell 2007; Rypkema et al. 2003; Simmons et al. 2010; Smedley et al. 2004; Tucker & Miguel 1996).However, while these indicators appear broadly favourable, it is difficult to synthesise these outcomes due to their heterogeneous nature (Darmon et al. 2008). The utilization of the QALY, a generic measure of health outcome, for application within cost-utility analysis can be helpful in this regard in demonstrating the ‘value for money’ of nutrition therapy in a world of competition for scarce health budget resources (Darmon et al. 2008). The paucity of economic evidence has also been proposed as the main reason for the failure for uptake of national and international evidence based guidelines in the clinical setting (Darmon et al. 2008). Within this context, the lack of economic evaluations of protein and energy supplementation for malnutrition treatment coupled with the lack of utility-based outcomes for facilitating comparison across interventions and disease areas for decision-making is therefore a serious concern.

In addition, there were a small number of published studies evaluating the economic benefits of protein and energy supplementation in older adults. However, this target group has received more attention recently, with three cost utility studies published within the last two years (Freijer et al. 2012; Neelemaat et al. 2012; Pham et al. 2011; Wyers et al. 2013). Of three cost effectiveness studies identified that targeted older participants, one failed to include the cost of the nutrition therapy itself in their estimation of cost effectiveness (which involved a physical function measure) (Dangour et al. 2011).

Many identified studies have a short follow up time of one year or less. This presents a challenge for clinicians aiming to demonstrate the benefits of nutrition support, as the short follow up time may not be long enough to allow the benefits to become apparent. When one study in community living elderly over a six to 12 month follow up period did not show cost savings in the intervention group compared to the control group, the authors hypothesised that their eight week intervention was not sufficient to show improvement in their elderly and already malnourished population (Edington et al. 2004). In addition, previous studies in frail older adults with lower limb fractures (including hip fracture) have also listed short term provision of intervention as a reason for their intervention being limited in effect (Miller et al. 2006b).

The potential economic benefits of protein and energy supplementation for the prevention and treatment of malnutrition could be generated via a number of effects on the individual and at a wider societal level. In the acute setting, providing adequate protein and energy could help reduce the risk of malnutrition or treat existing malnutrition. Through preventing and treating malnutrition, protein and energy supplementation could reduce the risk of developing complications following surgery, and improve recovery time, reducing expenditure of hospital resources in treating infections and complications and providing costly medical care releasing hospital resources to be used by another patient (Milne et al. 2009). The economic benefits seen in Freijer&Nuijten (2010), Russell (2007), Smedley et al. (2004) and Lawson et al. (2003) were based on reductions in complications or length of stay during hospital admission with the provision of protein and energy supplementation. On the other hand, the improvement could be broader, in assisting the optimum health of older adults in the community, protecting against the development of frailty and associated loss in physical and functional abilities (Avenell&Handoll 2010; Delmi et al. 1990, Hedström et al. 2006; Neumann et al. 2004; Tidermark et al. 2004). If this allowed the individual to remain independent for longer, or delayed their admission to residential care, this could be associated with a cost savings at a societal level. As yet, this potential benefit has not been illustrated in the economic evaluations of protein and energy supplementation published currently. The economic benefit of protein and energy supplementation for treatment or prevention of malnutrition could also been through providing improvement in quality of life for individuals in the community, or slowing decline or preventing the loss of quality of life associated with malnutrition (Thomas 2001) for a relatively small additional investment. This was illustrated through the studies Neelemaat et al. (2012), and Norman et al. (2011). Therefore, currently there is evidence to suggest that economic benefits from protein and energy supplementation can be seen in the acute setting through reductions in complications and length of hospital stay, and in a community setting through improvement in quality of life. However, there is currently a lack of evidence to show that protein and energy supplementation can be economically effective through assisting older adults to maintain function and remain independent.

The results of economic evaluations should be reported as an incremental cost effectiveness ratio (ICER) wherever possible. An ICER is important as it provides the decision-maker with the opportunity to determine the potential additional cost of a new health care intervention in order to achieve a given outcome. The use of a generic measure of health outcome such as the QALY in this context has the added advantage of facilitating comparisons of value for money across the health care system for example comparing investment in nutrition interventions for malnutrition in older people versus pharmacological treatments for dementia. Comparing the benefits from different interventions in standard units is especially important in the current era of finite health budgets and competition for resources, to contribute to equitable and 'best value for money' spend of the healthcare dollar.

In conclusion, to date only twenty economic evaluations of protein and energy supplementation for treatment or prevention of malnutrition have been published and the quality of published studies is highly variable. However, the available economic evidence suggests that providing ONS of between 1068kJ and 10g protein up to 4200kJ and 23g protein is associated with positive economic benefits in both patients with malnutrition and in studies where nutritional status was not specified, and over short follow up times. While this evidence is promising, only few of these studies utilize the current preferred method of economic evaluation, cost utility analysis. In the absence of comprehensive cost utility evidence, nutrition therapy is in danger of falling by the wayside in this era of competitive health care funding. In addition, evidence for the cost effectiveness of nutritional interventions in frail older adults has been slow to appear in the published literature, and few studies are currently available to provide evidence of economic benefits to this group. Only two studies were identified that evaluated the cost effectiveness of nutritional therapy in the traditionally frail and nutritionally vulnerable group of older adults with hip fracture. One, a cost benefit analysis identified savings due to reduced complications during hospitalisations while a cost utility analysis identified a ICER just above accepted thresholds for cost effectiveness in Australia. Therefore, the economic evaluation of strategies to reduce nutritional vulnerability and frailty in older adults with a hip fracture is an area in need of further research. Future research should focus on the inclusion of high quality comprehensive economic evaluations alongside studies of clinical effectiveness to demonstrate the cost effectiveness of nutrition interventions for the treatment of malnutrition.

3 ECONOMIC EVALUATION OF A MULTIDISCIPLINARY INDIVIDUALISED NUTRITION THERAPY AND EXERCISE PROGRAM FOR HIP FRACTURE RECOVERY

3.1 Introduction

There are now a number of studies published evaluating the effectiveness of nutrition therapy to prevent or treat malnutrition in frail older patients, in particular a recent meta-analysis showed improvements in weight status, reduced risk of complications and reduced risk of mortality in malnourished older adults (Milne et al. 2009). However, few economic evaluations of nutrition support have been identified in previous reviews, and no cost effectiveness studies evaluating the use of combined nutrition and exercise therapy for rehabilitation following hip fracture (Avenell & Handoll 2010). A recently published cost utility study evaluated the use of dietetic therapy (ONS and dietetic counselling) in patients following a hip fracture found the intervention improved weight in the intervention group, and that the intervention was likely to be considered cost effective on this basis although analysis based on improvement in quality of life did not indicate cost effectiveness (Wyers et al. 2013). However, given the associations between nutritional status, muscle mass, strength, physical activity, frailty, and mobility, it is likely that increased benefits could be gained through providing a combination of nutritional and exercise therapy (Thomas et al. 2008).

This chapter discusses the methods and results of a cost utility analysis of the Individual Nutrition Therapy and Exercise Regime: A Controlled Trial of Injured, Vulnerable Elderly (INTERACTIVE) trial. Briefly, the aim of this trial was to implement a six month multidisciplinary program of nutrition and exercise therapy in patients following surgery for a hip fracture and compare this with usual care for this patient group. Section 3.3 presents the findings of the trial in relation to resource use, health care costs incurred, and changes in quality of life experienced by the intervention and control groups. These findings are discussed in section 3.4.

3.2 Methods

3.2.1 Trial participants and intervention

The protocol for the randomised controlled trial has been published previously (Thomas et al. 2008). In brief, the trial recruited patients admitted to one of four Australian Hospitals (Flinders Medical Centre, Flinders Private Hospital and Griffiths Rehabilitation Hospital, all of Adelaide, South Australia, and Hornsby Ku-Ring-Gai Hospital, Sydney, New South Wales). Patients admitted to each centre with a fall-related hip fracture were approached and assessed for eligibility to take part in a National Health and Medical Research Council (NHMRC) funded treatment study of Individual Nutrition Therapy and Exercise Regime: A Controlled Trial of Injured, Vulnerable Elderly (INTERACTIVE), (Australian Clinical Trials Registry: ACTRN12607000017426) aiming to determine the effectiveness of a 6 month individualised nutrition support and resistance training program in rehabilitation following surgery for treatment of a hip fracture. Patients were randomly allocated to either the intervention group (received alternate weekly additional nutrition support and resistance training from a trained physiotherapist and dietitian, n=86) or the control group (received weekly social visits, n=89). All patients gave informed consent to participate in the trial, with additional third party consent gained for those patients with an impaired cognitive state as defined by Mini Mental Examination Score of between 18 and 23(Folstein et al. 1975). Ethics approval was gained for the trial at the respective ethics committees for each participating hospital (Flinders Clinical Research Ethics Committee Research Application 110/067 and Hawkesbury Northern Sydney Central Coast Area Health HREC Protocol 0710-197m).

Patients were excluded if they continued to have a MMSE score of less than 18 out of 30 up to day 14 following surgery or if they had a body mass index (BMI) score less than 18.5kg/m^2 (underweight) or greater than 35kg/m^2 (morbidly obese). Other exclusion criteria included the presence of a pathological fracture or malignancy, currently residing in a residential care facility, unable to communicate with staff in English, non-ambulatory pre fracture or limited to stand transfers only post-surgery, unable to give informed consent or not deemed to be medically stable within 14 days post-surgery.

3.2.2 Health outcomes and resource use

Effectiveness was measured in terms of quality adjusted life years (QALYs) gained. The preference based scoring algorithm developed by Hawthorne and colleagues (Hawthorne et al. 2000) for the AQOL instrument was used to calculate individual scores from patient responses to the AQoL at baseline and six months follow up. The algorithm creates a value for health status on a scale where zero represents death and one represents perfect health. The valuations are based on the preference weights of 350 members of the Australian general population obtained for a series of health states from the AQoL (Hawthorne et al. 2000).

Details of healthcare utilization were collected from questionnaires provided to the participant at weekly visits by trial staff for the duration of the six month intervention. This included details on number and frequency of healthcare services visits, or visits to any health care providers, and hospital admissions. Length of stay and reason for hospital admissions was collected via self-report from the patient, and this was cross checked with routine administrative databases from each hospital by trial staff. Utilization of Medical and Pharmaceutical Benefits Scheme items was requested from the Health Insurance Commission, which included costs claimed for medications, medical or other health care worker consults, laboratory tests and radiological procedures, and any other medical procedures for the six months of the study period.

3.2.3 Unit costs

There are four main ways of describing methods of estimating costs, as described by Drummond et al. (2005) and outlined in the figure 3.1 below.

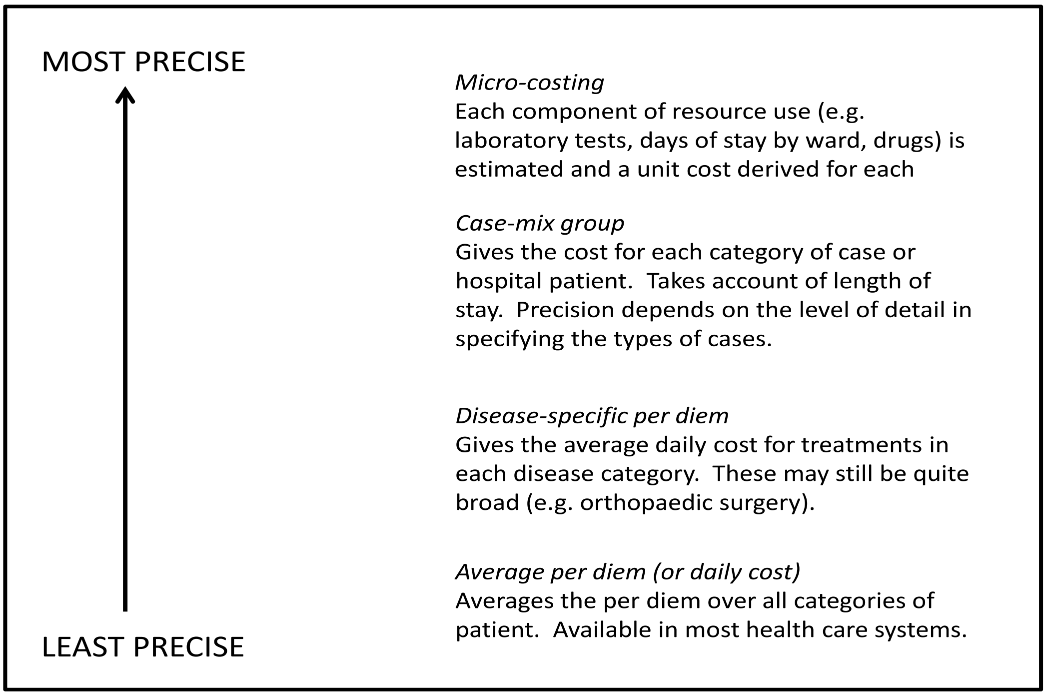

Figure 3.1 Levels of precision in hospital costing
(Reproduced from Drummond et al. 2005).

The figure highlights that the most precise and accurate estimates are likely to be those based on micro-costing studies, for example recording each type of drug a patient took and the dose and frequency, and multiplying this by a unit cost for that particular drug. On the other hand, a less accurate method is to apply a per diem cost dependent on the disease category of the patient (disease-specific per diem) or to apply an average cost for all patients admitted to the health care system, regardless of their disease state (average per diem). These methods may also be known as macro or gross-costing. Although these methods may still allow for differences in the length of stay between patients to be accounted for, they may miss differences in rates of complications, or other important determinants of use in their analysis. Overall macro or gross-costing methods will give an overall impression of the costs associated with healthcare, but micro-costing provides the detail needed for comparison of alternatives (Brown 2005). This study utilized a combination of micro- and case-mix group based costing, known to be more precise methods of measuring costs (Drummond et al. 2005).

An overview of the unit costs for the healthcare resources included in the analysis is included inTable 3.1. Sources for unit costs were based on the recommendations of the Pharmaceutical Guidelines Committee for preparation of submissions of economic evaluations for new healthcare technologies (Commonwealth Department of Health and Ageing 2002). Unit costs for hospital admissions and ambulatory and day rehabilitation services were based on national Australian data from the National Hospital Cost Data Collection (NHCDC) (Commonwealth Department of Health and Ageing 2009, 2010, 2012). We calculated a ‘cost per day’ which included hotel, supply, pharmacy, allied health, imaging, pathology, ward nursing salaries, medical salaries, non-clinical salaries, and depreciation, and a ‘once off cost’ which included emergency department, operating room, critical care, specialist procedure suites, and prostheses costs to account for the well documented phenomenon of hospital stays having a peak of costs near the date of admission, with the cost trailing off towards the end of the stay (Drummond et al. 2005 p. 66). Unit costs per day pertaining for the DRG for each hospital episode were then multiplied by the actual lengths of stay for each individual patient as documented in the individual case report forms. Costs were measured in Australian dollar prices for 2007-2011.

The cost of a day in residential transition care was estimated at $236 per day at 2006 to 2007 financial year rates in the evaluation report (Giles et al. 2008). This was then updated to 2010 using the Consumer Price Index for 2010 giving a unit cost of $262.88 per day.

For Dietetic and Physiotherapy visits, costs were taken from the rebates specified by Department of Veterans Affairs for November 2009 available freely on the Dental and Allied Health Fee Schedules section of the website (Australian Government Department of Veterans Affairs 2012). For visits by trial staff, the consultation cost was adjusted for the time spent with the participants. For providers not associated with the trial team, the appropriate consultation cost was applied in full. Cost for staff travel was taken as $2.00 per minute for driving time. Cost for use of a car was taken from the general Flinders University reimbursement rate for the 2010 to 2011 financial year at $0.63 per km. Cost for the supplements, and weights was taken from current retail prices through local suppliers, and updated to 2010 prices.

Mean costs per annum of residential aged care for HLC and LLC and Respite for 2006-2007 period were extracted from Federal Government estimates included in the policy document: Ageing and Aged Care in Australia (Australian Government Department of Health and Ageing 2008). These annual estimates were updated to reflect 2010 prices using the Consumer Price Index for 2010 (as specified by the National Aged Care Alliance (Australian Institute for Primay Care La Trobe University 2001)) to give a per day cost of residential aged care (HLC = $193.81 per day, LLC= $107.85 per day). Respite data was not collected with level of care attached, and so the average cost of a day in Residential care for LLC and HLC was taken ($66.36 per day, updated to 2010 prices $72.52).

Table 3.1 Unit costs for healthcare resources utilized

Healthcare Resource	Unit	Cost per Unit Updated to 2010 ($AUD)	Source
Community Dietetics Visits	1 Visit	$58.85	DVA
Community Physiotherapist visits	1 Visit	$58.85	DVA
Other Allied Health visits	1 Visit	Range between 26.25 – 122.50 dependant on service provided	DVA
Trial dietetic visit	Per Minute	2.00	DVA
Trial physio visit	Per Minute	2.00	DVA
Trial travel time	Per Minute	2.00	DVA
Car Maintenance	Per Km	0.63	Flinders University
Oral nutritional supplements	1 Tetra Pack	2.60	Retail price
Protein powder supplement	1 Week Supply	7.10	Retail price
Ankle/Wrist weights	1 weight	22.00-57.40 size dependant	Retail price
Hospitalizations	1 Day	DRG codes 642 + 212/day up to 23353 + 733/day	NHCDC
Drugs claimed on Medicare	1 Item	Item numbers	Medicare
Medical Tests claimed on Medicare	1 Item	Item numbers	Medicare
Doctors consults at home or hospital claimed on Medicare	1 Item	Item numbers	Medicare
Doctors consults in consulting rooms claimed on Medicare	1 Item	Item numbers	Medicare
Residential care facilities consults claimed on Medicare	1 Item	Item numbers	Medicare
Procedures claimed on Medicare	1Item	Item numbers	Medicare
Other claims on Medicare	1 Item	Item numbers	Medicare
Residential Transitional Care Program	1 day	262.88	Literature
Day Rehabilitation Program	1 day	3700 + 283.13/day	NHCDC
Ambulatory Rehabilitation Program	1 day	3700 + 283.13/day	NHCDC
High Level Care Residential Care Facility	1 day	193.81	DOHA Report
Low Level Care Residential Care Facility	1 day	107.85	DOHA Report
Respite at a Residential Care Facility	1 day	72.52	Literature

Abbreviations: DOHA = Department of Health and Ageing, DVA = Department of Veterans Affairs, NHCDC = National Hospital Cost Data Collection.

3.2.4 Health related quality of life

The health related quality of life of the participants was measured using the Assessment of Quality of Life (AQoL) instrument (Hawthorne et al. 1999). This instrument is a generic preference based measure of health related quality of life across five domains; illness, independent living, social relationships, physical senses, and psychological well-being. Within each domain, there are three items describing different aspects of that domain that show an important relationship to health-related quality of life. For example, within the independent living domain there are questions measuring a person's ability to carry out self-care tasks, ability to carry out household tasks, and level of mobility. Each of these items has four possible responses, moving from a state that would be considered worst for health-related quality of life, to a state that would be considered best.

Participants were provided with the 15 item questionnaire, which was then completed via an interview with a trial staff member. AQoL was measured retrospectively for the six months prior to fracture at baseline, and then at six months following date of randomisation, to determine return to pre-fracture level of health-related quality of life, similarly to a number of trials measuring quality of life in older adults with fractures (Ekstrom et al. 2009; Enocson et al. 2009; Gjertsen et al. 2011; Hagino et al. 2009; Hedbeck et al. 2011; Miedel et al. 2012; Orwig et al. 2011; Papaioannou et al. 2009; Rohde et al. 2012).

3.2.5 Cost utility analysis

The economic analysis was carried out on an intention to treat basis. The cost utility analysis included only those participants who completed the AQOL at six months and therefore, excluded the small number of participants who refused to complete AQOL assessment or who chose to withdraw from the study (n=10). A utility value of zero was imputed at the six month time point for those participants who died (n=8) within the first six months. Discounting of costs and outcomes was not undertaken as the time horizon of the trial did not extend beyond twelve months from baseline. We calculated the QALY gain over six months for each individual using area under the curve methods (Drummond et al. 2005). The difference in healthcare costs between the intervention and the control group was divided by the difference in QALY gain to give an incremental cost effectiveness ratio (ICER) of cost per QALY gained (i.e. ICER = C_a-C_b/E_a-E_b, where C_a is the cost of the intervention, C_b is the cost of the control, E_a is the effectiveness of the intervention, E_b is the effectiveness of the control). For calculating QALY gain between the two groups, an assessment of utility at the baseline of the intervention period was required. However, AQOL taken at baseline for the INTERACTIVE trial reflected the quality of life in the six months prior to fracture. Therefore, to enable calculation of QALY gain, baseline AQOL utility scores were imputed based upon the scores derived in a similar population of older people immediately post hip fracture participating in an intervention study (see Miller et al. 2010 for the study protocol).While this allows the calculation of the QALY gain for each group, it does not allow us to account for any differences in utility at baseline which may have been present in the two groups. Therefore, it is important to acknowledge that a difference in utility between the groups at baseline many have existed which could influence differences in utility at the six month time point. However, as participants were randomly allocated to groups it is likely that any differences between the two groups would have been minimized.

Statistical analysis was undertaken using IBM SPSS Statistics Version 19. Although the likely skewness of cost data has been documented, the arithmetic mean and standard *t* test were considered the best method of comparing the differences in costs between the groups, in line with previous recommendations in the area (Thompson & Barber 2000). Differences between the groups for categorical variables were tested using Fisher's Exact Test. Findings are presented as mean values with standard deviations, and differences in costs between the groups as mean difference with 95% confidence intervals. Statistical significance was set at p-value equal to 0.05.

Probabilistic sensitivity analysis (PSA) was undertaken using bootstrapping to provide an estimate of the uncertainty surrounding the ICER (Glick et al. 2001). This was achieved by re-sampling the original data to replicate the results of the ICER 1000 times, giving an empirical estimate of the sampling distribution.

3.3 Findings

This section presents the findings of the cost utility analysis of the Individual Nutrition Therapy and Exercise Regime: A Controlled Trial of Injured, Vulnerable Elderly (INTERACTIVE) trial. The findings presented consist of information on the movement of participants through the trial, utilizations of health services by the participants, and cost of those health services.

3.3.1 Trial participants

All patients admitted with a hip fracture were screened at the four eligible hospitals over the recruitment period which lasted from June 2007 to April 2010. A total of 1514 patients were admitted across the four sites, and of those 319 were eligible. 175 (55%) of eligible patients consented to take part in the study. Of those, 86 were recruited during their acute admission at Flinders Medical Centre, 60 from Flinders Private Hospital, 21 from Griffiths Rehabilitation Hospital, and eight from Hornsby Ku-Ring-Gai Hospital. Some demographics of the population are shown in Table 3.2.

Table 3.2 Characteristics of participants included in INTERACTIVE

Characteristic	Intervention (n=86)	Control (n=89)	p value
Mean (SD) age in years	82.4 (5.7)	83.0 (6.2)	0.506
Female n (%)	58 (67.4)	77 (86.5)	0.002
Mean (SD) MMSE score	26 (4)	26 (4)	1
Surgical Procedure			
Internal Fixation n (%)	53 (61.6)	44 (49.4)	0.105
Replacement n (%)	33 (38.4)	45 (50.6)	0.143

3.3.2 Health outcomes and resource use

A comparison of the mean utilizations of healthcare resources for the intervention and control groups is shown in the following Table 3.3, and Table 3.4. The utilizations are either presented as number of visits, number of minutes, number of units, or number of days as specified. The results for the independent t-test for comparisons between groups are also shown. The results are for the total use across the six month time period.

It can be seen that the number of utilizations for some components (for example days spent in residential care, visits to allied health providers outside the intervention) appear very low as small numbers of the participants were using these services. The number of participants that were using selected services across 6 months is shown below.

From Table 3.4, although not all of the participants attended a community day rehabilitation service (n=25 out of the 175 total participants) there was a slightly larger number of participants (n=14 vs. 11) from the control group compared to the intervention group that were using the service. Similarly, few participants visited a community dietitian in the six months following surgery, there were slightly more visits recorded in the control group (n=3) compared to the intervention group (n=1). When combined with the additional use of community based physiotherapy and other allied health providers in the community, this adds up to an overall greater use of community based allied health providers in the control group compared to the intervention group.

Table 3.3 Mean utilizations of healthcare resources for the intervention and control groups over six months

Resource	Mean (SD) utilizations for the intervention	Mean (SD) utilizations for the control	Difference in Mean (95% CI) Utilizations
Community Dietetics Visit	0.0 (0.1)	0.0 (0.3)	0.0 (-0.1 to 0.0) p=0.263
Community Physiotherapist visit	1.1 (2.2)	1.2 (2.1)	-0.1 (-0.8 to 0.5) p=0.657
Other Allied Health Visit	0.3 (0.9)	0.5 (1.3)	-0.2 (-0.6 to 0.1) p=0.205
Trial Dietetics visit (minutes)	420.9 (126.0)	273.4 (101.0)	147.5 (113.5 to 181.5) p≤0.001
Trial Physio visit (minutes)	371.0 (98.0)	221.5 (96.8)	149.4 (120.4 to 178.5) p≤0.001
Trial staff travel time (minutes)	396.4 (417.2)	318.4 (318.4)	77.9 (-39.1 to 195.0) p≤0.001
Oral nutritional supplements	108.9 (91.4)	0.0 (0.0)	108.9 (89.3 to 128.5) p≤0.001
Protein powder supplement	0.4 (1.1)	0.0 (0.0)	0.4 (0.1 to 0.6) p=0.004
Ankle and wrist weights recommended	1.3 (1.2)	0.0 (0.0)	1.3 (1.1 to 1.6) p≤0.001
Number of days in hospital	32.7 (19.9)	32.5 (20.3)	0.3 (-5.7 to 6.3) p=0.932
Drugs claimed on Medicare	27.6 (23.9)	22.6 (17.7)	5.0 (-1.4 to 11.3) p=0.124
Medical tests claimed on Medicare	21.4 (34.1)	22.6 (29.8)	-1.1 (-10.7 to 8.5) p=0.817
Doctors consults at home or hospital claimed on Medicare	2.5 (4.5)	3.6 (6.5)	-1.1 (-2.8 to 0.6) p=0.198
Doctors consults in consulting rooms claimed on Medicare	13.8 (14.2)	15.6 (17.7)	-1.8 (-6.7 to 3.0) p=0.456
Residential care facility consults claimed on Medicare	0.7 (2.9)	0.6 (2.7)	0.1 (-0.7 to 1.0) p=0.780
Procedures claimed on Medicare	4.2 (6.9)	4.4 (6.9)	-0.2 (-2.3 to 1.8) p=0.821
Other claims on Medicare	0.8 (2.1)	1.0 (3.0)	-0.2 (-1.0 to 0.6) p=0.577
Number of days in Residential Transitional Care Program	4.2 (15.7)	4.2 (17.2)	-0.1 (-5.0 to 4.9) p=0.984
Number of days in the Day Rehabilitation Program	2.6 (10.2)	2.9 (12.9)	-0.3 (-3.8 to 3.2) p=0.863

Number of days in the Ambulatory Rehabilitation Program	2.6 (7.8)	3.7 (9.0)	-1.1 (-3.6 to 1.4) p=0.379
Number of days in HLC Residential Care	4.0 (23.3)	3.7 (20.5)	0.2 (-6.3 to 6.8) p=0.944
Number of days in LLC Residential Care	3.3 (21.5)	4.9 (27.1)	-1.6 (-9.0 to 5.7) p=0.659
Number of days in Respite in Residential Aged Care Facility	0.4 (2.6)	1.1 (5.8)	-0.7 (-2.0 to 0.7) p=0.334

Table 3.4 Number of participants in the intervention and the control groups who used healthcare services during the six months

	Number utilizing service (n)		
Program	Intervention group	Control	p-value
Ambulatory Rehabilitation	11	14	0.668
Day Rehabilitation	6	5	0.764
Community Dietetics	1	3	0.621
Community Physio	32	38	0.440
Other Allied Health	12	18	0.319
ONS Use	72	Nil	≤0.001
Protein powder use	13	Nil	≤0.001
Ankle/Wrist Weights	61	Nil	≤0.001
HLC	3	3	1
LLC	2	3	1
TCP	6	6	1
Respite	2	4	0.682

3.3.3 Costs

An overview of the mean costs for the control group and the intervention group at six months are shown in Table 3.5 and the results of the Independent *t*-Test for differences between the groups.

Table 3.5 Overview of the mean costs for control and intervention group over six months ($AUD)

Resource	Mean (SD) cost for the intervention (n=86)	Mean (SD) cost for the Control (n=89)	Difference in Mean (95% CI) Costs
Total health care plus residential care costs	44840 (22757)	44265 (20448)	575 (-5876 to 7025) p=0.861
Total health care only excluding residential care costs	42626 (19341)	41906 (18364)	719 (-4906 to 6346) p=0.801
Hospitalizations	34037 (18114)	33942 (16566)	95 (-5081 to 5271) p=0.971
Community, Allied Health and Rehabilitation Services	1747 (4575)	2175 (4874)	-427 (-1839 to 984) p=0.551
Residential and Transition Care Services	2242 (6675)	2435 (7042)	-193 (-2242 to 1856) p=0.853
MBS and PBS			
Drugs	993 (1505)	691 (930)	302 (-76 to 681) p=0.116
Tests	583 (810)	681 (960)	-98 (-366 to 169) p=0.470
Consultations	1179 (1435)	1405 (1737)	-226 (-706 to 254) p=0.354
Procedures	1097 (2058)	1128 (2013)	-32 (-644 to 581) p=0.919
Other	54 (176)	69 (234)	-16 (-78 to 47) p=0.621
Intervention	1125 (1222)	-	1125 (760 to 1490) p=0.000

It can be seen from Table 3.5 that by far the greatest proportion of total costs for both intervention and control groups is attributable to hospitalisations, accounting for a mean of over $30,000. Overall, the additional cost of providing the intervention to the participants was approximately $1000 including providing the dietetic and physiotherapy staff to travel and visit the patients at either their rehabilitation centre or to their home or residential aged care facility upon discharge, maintaining a car for this purpose, and providing the supplies of oral nutritional supplements and weights recommended by staff to assist in achieving their nutrition and exercise related goals. However the intervention group consumed less in the areas of community rehabilitation, allied health services, residential and transitional care services, although none of these differences reached statistical significance. The total mean healthcare costs (including any residential care costs) were therefore very similar in both groups, with a mean difference between the intervention and control groups of $575, which did not reach statistical significance (p=0.861).

3.3.4 Health related quality of life

The utility of the participant's self-reported quality of life as measured using the AQoL instrument is shown in Table 3.6. One participant out of the 175 (0.6%) refused to complete an AQoL assessment at baseline. Ten participants out of the 175 (5.7%) had withdrawn from the study at the six month time point. The six month utility scores include an imputed value of zero for eight participants (4.6%) who died within the first six months. For the calculation of QALY gain, baseline AQOL scores were imputed based upon the scores derived in a similar population of older people immediately post hip fracture participating in an intervention study (see Miller et al. 2010 for the study protocol). Overall both groups saw a decrease in utility score for health related quality of life at 6 months compared to recollections of quality of life prior to fracture. The mean difference in utility score recollected prior to surgery between the groups was extremely small (0.003), indicating that both groups recollect their health states prior to the fracture as similar. At six months, there is a small difference in utility score between the groups in favour of the intervention group, indicating the intervention group reported a higher mean quality of life than the control group, although this did not reach statistical significance. In addition, the 6 month utility scores in the intervention group were closer to the utility score recalled for the prefracture time point compared to the control group, although this did not reach statistical significance.

Table 3.6 Utility of the intervention and control groups using AQoL over six months

Time Point	Mean (SD) for intervention	Mean (SD) for control	Difference (95% CI) in mean
Six months prior to baseline (n=174)	0.595 (0.245)	0.592 (0.244)	0.003 (-0.070 to 0.076) p=0.931
Imputed Baseline[1]	0.188 (0.192)	0.188 (0.192)	-
6 months (n=165)[2]	0.498 (0.264)	0.466 (0.297)	0.032 (-0.055 to 0.118) p=0.470
Difference between utility pre fracture and at 6 months (n=164)[2]	0.096 (0.267)	0.129 (0.275)	-0.033(-0.117 to 0.051) p=0.437

1 Imputed based upon baseline AQOL scores within 7 days following hip fracture from a similar population (n=99)

2 Including imputed value of 0 for participants who were deceased at six month time point.

3.3.5 Cost utility analysis

The Incremental Cost Effectiveness Ratio (ICER) for the intervention can be calculated at six months as shown in Table 3.7. The health resource cost displays the mean value for the total healthcare costs for the 165 participants with valid AQoL data at six months. The QALY gain gives the mean gain in quality adjusted-life years over the six month time period, based on the utility scores derived from the AQoL.

Table 3.7 Cost effectiveness of intervention group over the control group for rehabilitation following hip fracture over six months

Variable	Mean (SD) intervention	Mean (SD) control	Difference in means
Health resource cost ($AUD) (n=165)	45331 (23012)	44764 (20712)	567 (-6166 to 7300) p=0.868
QALY-gain (AQoL) (n=165)	0.155 (0.132)	0.139 (0.149)	0.02 (-0.027 to 0.059) p=0.470
ICER ($AUD) imputation	-	-	28,350 (intervention dominates to 51,768)

Table 3.7 indicates that at six months an individualised nutrition and exercise intervention is associated with a small additional cost and gain in QALY relative to usual care. The incremental cost effectiveness ratio for the intervention is positive

with a mean of $28,350 at six months. This ICER is well below the threshold of $50,000 estimated as likely to be considered cost effective by the Pharmaceutical Benefits Advisory Committee (PBAC) (Harris et al. 2008). As a result, it can be concluded that the evidence presented suggests that the intervention can be considered cost effective (Black 1990; Drummond et al. 2005).

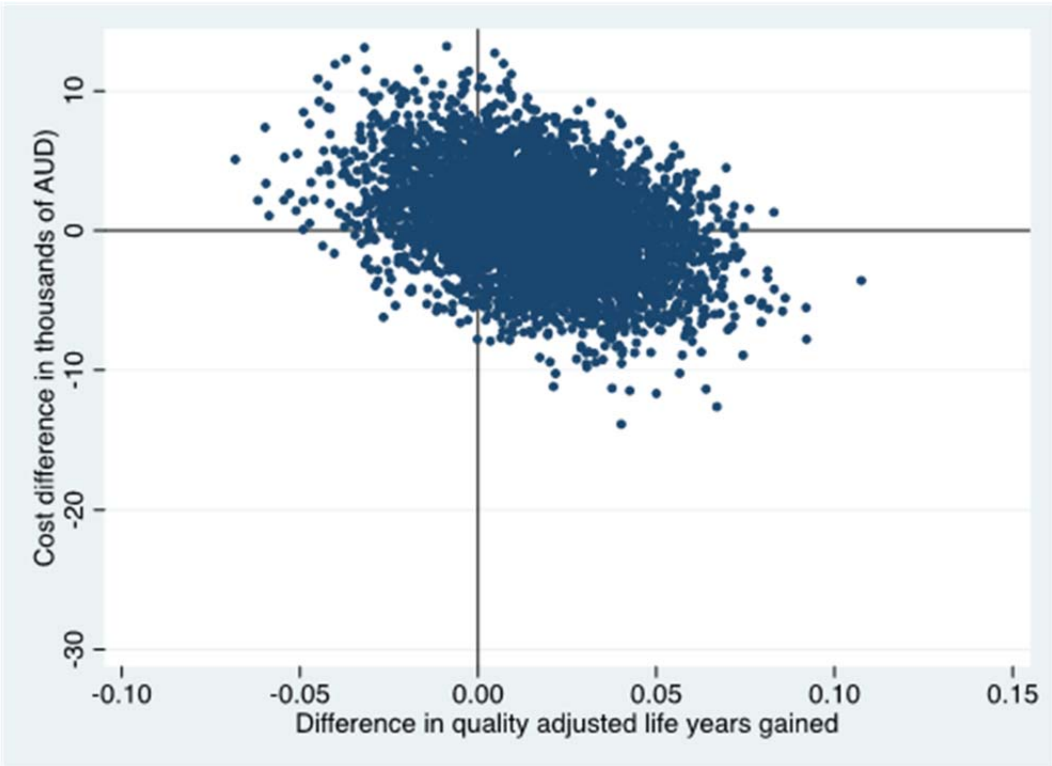

Figure 3.2 Cost effectiveness plane for the difference in quality adjusted life years

The validity of the base case results was confirmed by a probabilistic sensitivity analysis (PSA) using bootstrapping where the original data were used to provide an empirical estimate of the sampling distribution through repeated re-sampling from the observed data (Glick et al. 2001). A total of 1000 replications were utilized and the 95% confidence interval results indicate that there is a relatively large amount of variability in the data, particularly in relation to total cost estimates. In addition the results of the probabilistic sensitivity analysis are represented graphically through a cost effectiveness plane (Figure 3.2) and cost effectiveness acceptability curve (Figure 3.3). The relatively flat cost effectiveness acceptability curve indicates a high level of uncertainty in the cost effectiveness result base on this data. In interpreting the results of the cost effectiveness plane, observations falling in the north-west quadrant indicates the existing treatment is less costly and more effective than the new treatment, and in the south-east quadrant indicates the new treatment is less costly and more effective than the existing treatment. Therefore the decision to recommend an existing treatment as cost-effective (or not) is straight forward. Observations falling in the north-east quadrant indicate the new intervention is more effective but also more costly than the existing treatment, and therefore the decision of cost-effectiveness is dependent on whether society considers the health gain a worthwhile for the additional cost? Conversely, if observations fall in the south-west quadrant the new treatment is considered less effective but also less costly than the existing treatment, and the decision is whether society considers the reduction in health outcomes acceptable given the saving in cost. For the current study, the cost effectiveness acceptability plane indicates the majority of the observations are in the north and south east quadrants of the plane. Therefore, the majority of the observations generated through the sensitivity analysis indicate either that the intervention provides more health outcomes at a lower cost than the existing treatment or provides more health outcomes but at a higher cost than the existing treatment. In addition, the spread of the data point cloud indicates the uncertainty in this data also. This is partly reflective of the relatively small sample size for the

RCT coupled with the population under consideration. In our population of frail older people the mean estimates mask a wide variation mainly in relation to the frequency of hospital admissions and associated lengths of stay. The results range from a lower limit whereby the intervention dominates (i.e. it is associated simultaneously with lower costs and a higher health gain) relative to a higher limit of $51,768 which is just above the threshold implied Australian societal willingness to pay value for a QALY of $50,000 (Harris et al. 2008).

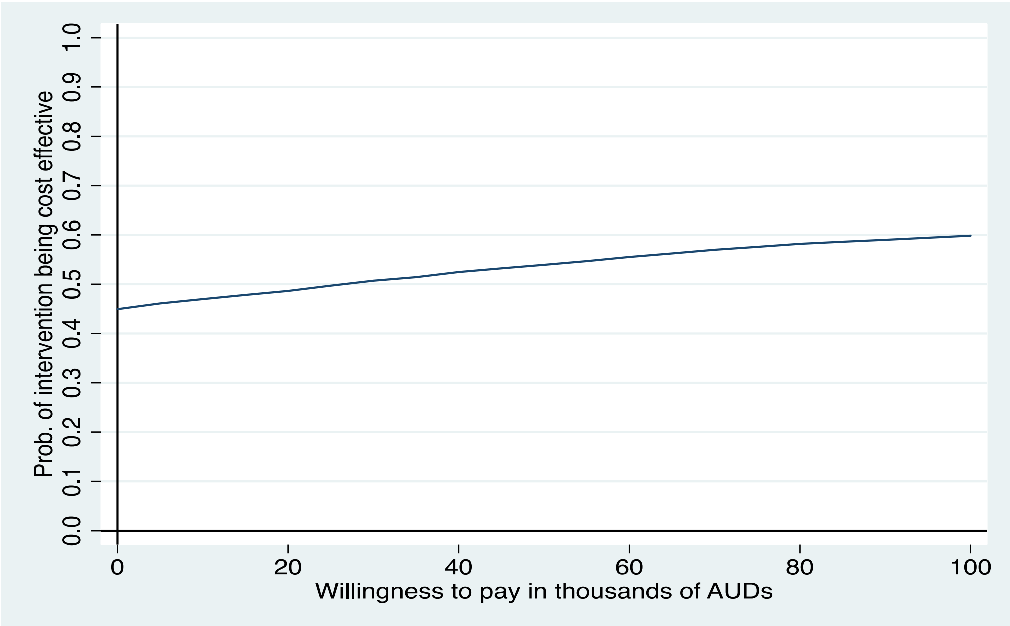

Figure 3.3 Cost effectiveness acceptability curve for difference in quality adjusted life years

3.4 Discussion

This is the first study to conduct a detailed economic evaluation of individualised nutrition and exercise therapy to patients following hip fracture. While previous studies have evaluated the costs and benefits of providing multidisciplinary geriatrician-led care of patients with hip fractures(Cameron et al. 1994; Fordham et al. 1986; Galvard & Samuelsson 1995; Huusko et al. 2002), our study is the first to evaluate the specific combination of nutrition and exercise therapy with a six month follow up period.

In comparison to the available published evidence the current study makes a unique contribution. Few evaluations of the economic effectiveness of exercise therapy for rehabilitation following a hip fracture have been undertaken. Ruchlin et al. (2001) undertook a cost benefit analysis of a high intensity strength training intervention with an in-hospital education and peer support program in 114 patients following a hip fracture. They found cost savings of $AUD138,508 in the intervention group compared to the control through reduced health and social care costs. Robertson et al. (2001) measured the cost effectiveness of the Otago home-based exercise program for falls prevention and showed a reduction in the number of falls in the intervention group compared to the control group, with an incremental cost of $AUD1670 for every fall prevented, although these participants were community dwelling older adults and therefore may not have been as frail as our group.

Whilst a previous Cochrane review (Avenell & Handoll 2010) has identified positive effects of oral nutrition therapy following hip fracture on mortality (RR 0.76, 95% CI

0.42 to 1.37) and complications (RR 0.81 95% CI 0.58 to 1.13), these effects failed to reach statistical significance. Length of stay, as a key driver of hospital costs, varied greatly between the studies, with no significant effect able to be determined. No studies in the review were identified in patients following hip fracture with economic outcomes. Only one cost utility study of nutrition therapy (oral nutritional supplementation and dietetics counselling) post hip fracture has been previously published, which found an ICER Cost/QALY of $AUD54,676 (Wyers et al. 2013). In this randomised controlled trial conducted in a smaller sample (n=152), intervention costs were less than our study (€613), which the authors argued was small compared to the other health-related expenses of the intervention group, but little change in the QALY gain was found between the two groups with a difference in means of -0.02 (95% CI -0.12 to 0.08, p>0.05). The study used the EQ5D as their measurement of QOL in the population which the authors hypothesised may not be sensitive enough to identify changes in elderly patients. The EQ5D utilized in the study contains three response levels to indicate the level of difficulty with that aspect of health: no problems, some problem, or extreme problems (Rabin et al. 2011). For our study we have utilized the AQOL instrument, which contains four response levels, which may have resulted in a more sensitive measurement of QOL.

Other previous economic evaluations of nutritional therapy included Hoogendoorn et al. (2010) who conducted a CUA in of a multidisciplinary management program in a community dwelling population of COPD patients and demonstrated an ICER of €32,425 per additional QALY gained which the authors hypothesize would be considered moderately cost effective in the Netherlands health system. However, less than a quarter of the participants received nutritional treatment, while our aim was to provide nutritional therapy to all participants. In addition, the costs for the intervention group were highly sensitive to the hospitalisation of four participants who the authors claim should never have been included in the study as their condition at baseline was so poor it was unlikely a community intervention would be sufficient to produce an improvement. Thus the benefits of nutrition intervention in this population could have been underestimated.

A study in elective and emergency orthopaedic admissions (Lawson et al. 2003) found a small reduction in costs associated with length of stay and complicated hospital care, but included a predetermined routine administration of ONS to all participants, equal to 2500kJ and 20g of protein. Studies of patients with hip fractures have routinely shown deficits of requirements greater than this (Delmi et al. 1990; Dickerson et al. 1979; Eneroth et al. 2005; Miller et al. 2006b; Nematy et al. 2006). In addition, as the admitted ward was the unit of randomisation the effect of ward procedures cannot be eliminated from this result. In comparison our current study utilised the individual as the unit of randomisation, and personalised nutrition therapy aiming to bridge the shortfall between current intake and estimated requirements.

The majority of previously identified economic evaluations of nutrition therapy utilize a cost-effectiveness or cost-benefit methodology for their analysis (Edington et al. 2004; Endevelt et al. 2011; Lawson et al. 2003; Rypkema et al. 2003) comparing cost data with a wide variety of monetary or clinical outcomes such as changes to body composition, length of stay, and medical complications. These all form important outcomes in a rehabilitation or nutritional sense, but reported individually give a picture of only a portion of the benefits to be gained in improving the health and wellbeing of patients. On the other hand, the benefit of conducting a cost utility study is that it provides a standardised measure of benefits in the QALY (Drummond et al. 2005). Using multi-attribute utility instruments (such as the AQOL) as a basis to calculate QALY also ensures that not only the expected effects of the intervention (on mobility or pain for example) are measured, but also the flow on effects to independence, and ability to carry out a usual role within society (Richardson et al. 2004). This allows costs and benefits of providing therapy targeting different clinical outcomes, diseases, and body systems to be calculated in a standard measure and compared to assist decision making on the allocation of healthcare resources. The cost utility study is currently the preferred method of economic evaluation of regulatory bodies in Australia and around the world (Commonwealth Department of Health and Ageing 2002; National Institute for Health and Clinical Excellence 2008). Analysis of previous decisions by the Australian Pharmaceutical Benefits Advisory Committee (PBAC) indicate that it considers interventions evaluated to give a cost per QALY of under $50,000 as highly likely to be cost effective and more likely to be recommended for funding (Harris et al. 2008). Therefore, the INTERACTIVE individualised nutrition therapy and resistance exercise intervention, by providing improved utility for the intervention group compared to the control group at a ICER of $28,000, is likely to be considered cost effective. However, this threshold is not explicitly defined by PBAC and an intervention having an ICER below the $50,000 threshold does not automatically guarantee funding. A number of other characteristics including clinical effectiveness, safety, and public health are also considered by the committee. But the current result provides support for further work to evaluate the clinical and economic effectiveness of multidisciplinary rehabilitation models following hip fracture.

There remain some limitations of this study, which require consideration. Our study contained a relatively small sample size of 175 participants. Studies with small sample sizes, can be more likely to exhibit sampling variation, and may not be large enough to determine statistical differences between the two groups being tested (Drummond et al. 2005; Higgins & Altman 2008). A sample size of fewer than 200 participants could be considered small, especially in economic evaluations where samples of a few hundred are considered the norm, and can reach into the thousands for large scale trials (Corrieri et al. 2011; Dahlberg et al. 2009; Davis et al. 2010; Dziedzic et al. 2011; Eisenstein et al. 2006; Johannesson et al. 1993; Pimouguet et al. 2010), and this may have led to the small difference between the group in QALY gain not reaching statistical significance. However studies with similar size samples have been published previously in the literature, especially regarding interventions in older adults (Coe et al. 2012; Pimouguet et al. 2010; Pinto et al. 2012; Theocharis et al. 2012; Tripuraneni et al. 2012).

It is also evident that there is wide variability in the cost data in our sample, with the PSA indicating that the true value for the ICER for QALY likely lies somewhere between the intervention dominating (i.e. provides both an improvement in quality of life and reduction in costs) ranging up to a cost of $51,000 per QALY gained, which is just above the accepted upper threshold of cost effectiveness in Australia. This likely eventuates from the wide range in the total costs for the participants, linked to the wide variation in number of hospital admissions, length of stay, and complications experienced. However, this situation is not unusual for economic analyses of treatment studies where the majority of participants will experience a moderate cost, but a few participants may experience more severe and rare health problems which can have an exponential effect on healthcare costs(Drummond et al. 2005). This could be especially so in our sample of frail older adults, a population where healthcare costs post fracture have been shown to range anywhere between a few thousand to hundreds of thousands of dollars (Autier et al. 2000; Sahota et al. 2012). However, although the variability in the cost outcomes for the sample is reflected in the wide confidence intervals for the ICER, it is important to note that the majority of the data points estimated through the PSA bootstrapping remain under the upper threshold of cost effectiveness accepted in Australia.

Another limitation of the study is the use of an imputed value for quality of life utility at baseline. The quality of life of the participants at baseline was measured as the quality of life in the six months prior to the intervention, similarly to a number of trials measuring quality of life in older adults with fractures (Ekstrom et al. 2009; Enocson et al. 2009; Gjertsen et al. 2011; Hagino et al. 2009; Hedbeck et al. 2011; Miedel et al. 2012; Orwig et al. 2011; Papaioannou et al. 2009; Rohde et al. 2012). However, for calculating QALY gain between the two groups, an assessment of utility at the commencement of the intervention was required (Drummond et al. 2005). Therefore, the mean utility score taken from a similar population of patients in the first week following surgery for hip fracture was imputed for all participants in the QALY calculation. While this allows us to calculate the QALY gain for each group, it does not allow us to account for any differences in utility at baseline which may have been present in the two groups. Therefore, it is important to acknowledge that a difference in utility between the groups at baseline many have existed which could influence differences in utility at the six month time point. However, as participants were randomly allocated to groups it is likely that any differences between the two groups would have been minimized. In addition, when asked about their utility in the six months prior to fracture, there was virtually no difference between the two groups and socio-demographic factors shown to influence quality of life, such as age and cognitive status, were very similar between the two groups (Grbic et al. 2011; Kanauchi et al. 2008; Molzahn et al. 2010). Hence it may be reasonable to conclude that utility in the groups at baseline was also similar.

The average total cost for medical care in the six months following hip fracture in both the intervention and control groups was over $40,000. This includes the cost for the initial acute admission, surgery, rehabilitation either as an inpatient or in a community based setting, and all subsequent hospital admissions for that six months, whether hip-related or not. This leads to distinction between the current figure and other figures published which generally quote lower estimates focusing only on acute care costs (Bessette et al. 2012; Clark et al. 2008; Maravic et al. 2005; Sahota et al. 2012; Tarride et al. 2012), excluding any readmissions (Carinci et al. 2007; Dolan & Togerson 1998; Randell et al. 1995; Woolcott et al. 2012), or non-hip related readmissions (Autier et al. 2000; Bjornelv et al. 2012; Braithwaite et al. 2003; Gabriel et al. 2002; Gutiérrez et al. 2011; Harris et al. 1998; Johansson et al. 2006;

Ohsfeldt et al. 2006; Piscitelli et al. 2007; Shi et al. 2009; Tamulaitiene & Alekna 2012; Viswanathan et al. 2012).

In addition, the estimate in this study includes costs associated with admission to residential care facilities for long term or respite care, which has typically been excluded from previous costing studies. Only 11 of the 175 (6%) participants were admitted to a residential aged care facility for long term care over the first six months of the intervention, which is below previously published estimates of up to 33% (Marks 2010). This could be due to a number of factors. For the current study, selection of participants excluded those already residing in care facilities that may have been returned to that facility with additional care needs. In addition, those with severe cognitive impairment as indicated by a score of less than 18 for the Mini Mental State Examination were excluded from the study, as were those who were not mobilising prior to fracture. Therefore, it is likely that due to the selection criteria, the rate of admission to residential aged care facilities was low. Despite this, residential care forms a large part of the long term follow up costs overall, comprising a mean value of approximately $4000. This illustrates the large costs associated with providing residential aged care and the impact that even a small number of admissions can have on societal healthcare costs.

The median value in the current study is higher than previously published estimates of the cost of hip fracture in Australia (Harris et al. 1998; Randell et al. 1995). This could be for a number of reasons. Both studies were published over 10 years ago and costs for healthcare increase over time not only due to inflation, but also as new technology and treatment methods are developed. For example, in 1994 the cost per admission for a hip fracture ranged from $3,000 to $10,000, depending on the type of treatment required (Harris et al. 1998). In current national hospital cost data, the cost of admission ranges from $8,000 to 37,000 (Commonwealth Department of Health and Ageing 2012). Therefore, it is important to consider when estimations of cost were conducted, as cost data can quickly become inaccurate. In addition, both studies excluded costs which were included in the current analysis. Harris et al. (1998) focused on estimating the direct costs of osteoporosis in Australia, and used a combination of published estimates, health system data, and expert opinion to estimate service utilization and combine these with unit costs. While Randell et al. (1995) followed a population of patients with osteoporotic fractures and were able to record actual utilizations in more detail, they included only medications prescribed post fracture and acute and rehabilitation admissions related to the fracture in their estimates. In the current study all health service utilizations following the fracture were included, providing the level of detail needed to perform a cost-utility analysis (Drummond et al. 2005). Therefore, rather than an estimation focusing on the costs associated with the treatment of osteoporosis, the current study provides a broader estimate of the costs to the health system for a group of frail older adults following a hip fracture.

Overall, the aim of this study was to conduct a cost utility study of a multidisciplinary nutrition and exercise therapy rehabilitation program in patients following surgery for hip fractures. By providing an improvement in QALY relative to usual care at a small additional cost, the intervention can be considered cost effective, and provides the first detailed cost-analysis of the combination of nutrition and exercise therapy in this patient group. However, the difference in QALY did not reach statistical significance within this study, which may have been due to the small sample size. Evidence of a statistically significant difference in QALY gain between the two groups would add weight to claims of the economic effectiveness of this intervention. Therefore, future research should focus on larger samples of participants to provide more precision to the economic estimates and to provide more evidence for the combination of nutrition and exercise therapy rehabilitation programs. Longer time frames of follow up are also important, as the benefits of providing this therapy may lie not only with the effects on the current admission to healthcare services, but also in preventing subsequent admissions, or in reducing complicated care needs during those admissions. The potential effect of nutrition and exercise therapy in this age group as a moderator of hospital length of stay and complications experienced, also provides a strong basis to measure resource use in micro-level approaches such as using DRG –based costing in future studies. In addition, given the large impact that residential care admission made to total costs despite the relatively few patients who were admitted to care, resource use in this sector should be included in future economic evaluations to provide a more comprehensive assessment of the cost impacts for this population.

4 THE MEASUREMENT AND VALUATION OF QUALITY OF LIFE IN OLDER PEOPLE UNDERGOING REHABILITATION

4.1 Introduction

The measurement and valuation of quality of life is an important component of the economic evaluation of health and aged care services, allowing the quantification of not only the volume of life years gained through an intervention, but also improvements in the quality of those years. However, there remain many questions regarding the measurement and valuation of quality of life in evaluating healthcare programs, including which of the plethora of quality of life instruments available should be used to evaluate success. The aim of this study was to compare the performance of two generic preference based quality of life instruments, EQ5D and ICECAP-O, in a population of older Australians, following surgery for hip fracture. The findings of this study are presented in section 4.4, followed by a discussion of the findings in the context of the current literature.

4.2 Background

Outcomes in health research can be described in many ways (Bowling 2005). Often outcomes are measured in terms of clinical indicators represented by physical, visible effects or measurements for example weight, volumes of markers in blood, or the presence or absence of specific symptoms. These types of classifications subscribe to a clinical or disease-focused model of health, whereby disease is described as a state of pathological abnormality as indicated by signs and symptoms. However, current definitions of health are often much broader, for example the World Health Organisation (Grad 2002) describes health as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity”. This is a much wider perspective of the concept of health, taking the focus away from the pathological and biochemical abnormalities and giving a more patient-orientated focus to the concept of health. A number of studies have demonstrated that the aspects of disease or treatment that health professionals consider as important determinants of quality of life are not necessarily the aspects that patients themselves consider important (Hallan et al. 1999; Stephens et al. 1997; Wells et al. 2004). In addition, it has been shown that the impact of health upon functioning and ability to lead a fulfilling life is an important determinant of whether patients will seek medical care (Cornally & McCarthy 2011; Tiira et al. 2012). Therefore, if it is the broader aspects of health and well-being that are motivating patients to seek medical treatment, then it is important to consider those in determining whether a treatment is successful or not.

4.2.1 Measurement of quality of life

Quality of life (or more specifically health related quality of life) has been defined in a number of ways (Carr et al. 2001). This can range from a description of overall physical, psychological, and emotional wellbeing to a consideration of the effect of disease and its treatment on ability to lead a satisfying life (Carr et al. 2001; Greer 1984). The measurement of quality of life has developed over time from early descriptions of health status (Fanshel & Bush 1970), to more complex multidimensional instruments which ask questions about the person's functional ability, ability to carry out their role, and to do things which are important to them (Brazier & Ratcliffe 2008).

A common instrument for measuring quality of life within health economics and economic evaluation is the EQ-5D or Euroqol, now known as the EQ-5D-3L (Dolan

1997). The EQ-5D-3L includes five dimensions: mobility, self-care, usual activities, pain and discomfort, and anxiety and depression. For these five dimensions there are three levels, describing having no problems with that dimension, some problems, or severe problems. These are described in the figure below.

<u>Mobility</u>

1. No problems walking about
2. Some problems walking about
3. Confined to bed

<u>Self-Care</u>

1. No problems with self-care
2. Some problems washing or dressing self
3. Unable to wash or dress self

<u>Usual Activities</u>

1. No problems with performing usual activities
2. Some problems with performing usual activities
3. Unable to perform usual activities

<u>Pain/Discomfort</u>

1. No pain or discomfort
2. Moderate pain or discomfort
3. Extreme pain or discomfort

<u>Anxiety/Depression</u>

1. Not anxious or depressed
2. Moderately anxious or depressed
3. Extremely anxious or depressed

Figure 4.1 The EuroQol descriptive dimensions

One of the levels for each of the dimensions can then be chosen to describe a health state. While the dimensions do not describe quality of life in itself (which is a rather abstract and complex concept and has different meanings to different people), they form components which are likely to impact on a person's quality of life (Beckie & Hayduk 1997). Also, whilst the dimensions provide a way of describing health, they do not provide information about which health states are more preferred by patients and the general population, or the extent to which individual dimensions influence overall quality of life. To provide information about the quality of the health state described, we need to provide a value or weight for each of the levels of the dimensions. Furthermore, to calculate quality adjusted life years (QALYs) gained as a consequence of a medical treatment or intervention, we need to be able to compare health states on a uniform scale in which full health is given a value of one and death a value of zero such that one year of life lived at full health equates to one QALY (Brazier & Ratcliffe 2008). Several generic preference-based measures of health related quality of life now exist for calculating QALYs within the framework of economic evaluation (including the EQ-5D, the SF-6D, and the AQoL), and such instruments have now become the most widely utilised mechanism within Australia and internationally for calculating QALYs for the purposes of economic evaluation.

A generic preference-based measure provides a general description of health that can be applied across different patient groups and different diseases. Typically, these instruments also have unique scoring algorithms attached to them. The scoring algorithms represent pre-calculated tariffs or weights for each of the health states that can be described by the instrument, generally based on general population valuations of the different health states described by the instrument (Brazier & Ratcliffe 2008). These values are usually based on a scale defined by the QALY (i.e. where one represents a health state equal to full health, zero represents a health state equal to death, and negative values are possible where a health state is perceived as worse than death). The advantages of the QALY as an outcome measure for health have been discussed previously (see Chapter 3). In summary QALYs provide a generic measure of outcome which allows the benefits of health programmes to be measured across different population groups, diseases, and treatment methods (Drummond et al. 2005). Many health and reimbursement authorities across the world now recommend the use of QALY generated from generic preference-based measures of quality of life as the preferred method for evaluating the economic effectiveness of healthcare programs (National Institute for Health and Clinical Excellence 2008).

Nevertheless, important questions remain in the measurement and valuation of quality of life and the QALY concept which are magnified by the importance of the QALY to economic evaluations. Although generic preference-based measures are the preferred method of capturing the benefits gained from healthcare, there are many different measures available for use which have been developed in different countries, with different populations, and different diseases and disabilities as their primary focus. This raises the vexed question of which of these measures is the preferred option for use in older people? In addition, as new instruments are developed and used to evaluate healthcare interventions aiming to improve the quality of life of patients, it raises the question of what a normal quality of life is and what do we consider good quality of life? And how much does a particular health event (such as surgery for a falls-related hip fracture) impact upon quality of life both in the immediate and longer term? The following section discusses the current evidence for some of the key questions listed above, including issues particular to the measurement of quality of life in older people, an example of an established and commonly used generic preference based instrument for measuring quality of life (EQ-5D-3L) and a comparison with a new instrument(ICECAP-O) designed specifically for older people, as well as some examples of values for quality of life for the general population and a review of current estimates of quality of life following a hip fracture.

4.2.2 Measurement of quality of life in older people

The concept of measuring quality of life has been considered in healthcare research for several decades (Cantril 1965; Karnofsky et al. 1948; Walker & Mollenkopf 2007), and has received renewed focus recently since the World Health Organisation redirected the definition of health to include aspects of well-being (Walker & Mollenkopf 2007). A body of research has been conducted within Australia and internationally to map the determinants of good quality of life and aspects of health and function that contribute to it. However, much of the early research was conducted almost exclusively in younger populations and the opinions of older people on determinants of quality of life have not been extensively researched (Walker & Mollenkopf 2007). Many commonly used generic preference based measure of quality of life (such as the SF-36 and the EQ-5D-3L) were constructed based on expert opinion rather than what the average person considers important to their quality of life (Ware 2000). The exclusion of older people from the discussion of quality of life has been further compounded by the use of third parties as a proxy-measure of quality of life in frail or cognitively impaired older adults which may or may not provide an accurate measure (Addington-Hall & Kalra 2001; Walker & Mollenkopf 2007). Researching the determinants of quality of life in older people is especially important, given that previous research has indicated some clear differences between what older people and younger people value in life (Gabriel & Bowling 2004; Walker & Mollenkopf 2007). For example, it has been found that health status and functional ability rate much higher as determinants of quality of life for older people than for younger people. Secondly, it is known that older people tend to rate a quality of life which would be considered poor by a survey of the general population more positively – a phenomenon known as “satisfaction paradox” (Walker & Mollenkopf 2007). Therefore, measurement of quality of life in older populations requires consideration of the accuracy of the measurement (for example, are we measuring determinants which are actually important to older people in their quality of life?) and the precision (are we measuring quality of life in a way that allows meaningful changes in older people to be determined?).

4.2.3 Use of the EQ-5D-3L in measuring quality of life

The EQ-5D-3L was developed in Europe in 1990 (Rabin et al. 2011). The EQ-5D-3L descriptive system describes a total of 243 discrete health statues based upon varying levels of five key dimensions; mobility, performing self-care, usual activities, and any pain or anxiety or depression experienced currently, but does not consider role or social function specifically. The 243 unique health states described by the instrument have been valued to create a preference based scoring algorithm to calculate values for a number of countries. However, the most commonly used algorithm emanates from the original valuation study based on 3000 members of the general UK population using the time trade off method (Brazier et al. 2007; Rabin et al. 2011). More recently an Australian general population specific scoring algorithm for the EQ-5D-3L have been created based upon the preferences of 414 members of the Australian general population also using a time trade off method (Viney et al. 2011).

Since its inception, the EQ-5D-3L has been used widely in the health and medical research literature as a measure of health status (Brazier & Ratcliffe 2008). Table

4.1 below illustrates the population norms for utility values that have previously been generated from the EQ-5D-3L in European, UK, and US populations.

Table 4.1 Population norms for EQ-5D-3L utility values

Study	Population	Age group (years)	Sample	Mean [1]	Mean according to age group above 65 years
(Golicki et al. 2010)	Polish	18-86	317	0.91 (0.11)[2]	≥65 years 0.80
(Perneger et al. 2010)	French-speaking Swiss Non-institutionalised	≥18	1952	0.83 (0.15)[2]	60-79 years 0.80 (0.15)[2] ≥80 years 0.75 (0.19)[2]
(Sorensen et al. 2009)	Danish	20-79	15,700	0.89 (0.154)[2]	Not reported
(Fryback et al. 2007)	US Non-institutionalised	35-89	3,844	0.83[3]	65-74 years 0.87 (0.01)[4] 75-89 years 0.85 (0.01)[4]
(Hanmer et al. 2006)	US Non-institutionalised	≥18	54,995	Not reported	60-69 years 0.84 (0.83-0.85)[5] 70-79 years 0.81 (0.788-0.816) 80-89 years 0.782 (0.76-0.81)
(Luo et al. 2005)	US Non-institutionalised	≥18	4048	0.87 (0.01)[4]	≥65 years 0.84 (0.01)[4]
(Burstrom et al. 2001b)	Swedish	20-88	3069	0.84 (0.005)[4]	Not reported
(Burstrom et al. 2001a)	Swedish	16-84	11,698	0.83	60-69 years 0.76 (0.008)[4] 70-79 years 0.71 (0.010)[4] 80-84 years 0.61 (0.017)[4]

1 Includes value for mean unless otherwise stated

2 Standard deviation

3 Median value

4 Standard error

5 95% Confidence intervals

It can be seen from Table 4.1 that in the general population norm values for the EQ-5D-3L range from 0.83 to 0.91, and when grouped according to age bracket appear to decline with age with a range of 0.61 to 0.85 for those above 80 years old.

However, population norm values often exclude the very old (often those above 80 or 90 years of age) or those residing in residential care due to the high rate of dementia in these populations, leading to a lack of data in those populations which are likely to be most at risk of poor health-related quality of life (Fryback et al. 2007). A recent study in the UK reported EQ-5D-3L utility values for 393 older people identified as likely to be socially isolated by health professionals or social services and included a small number of participants from residential care homes (Hawton et al. 2011). This study found that EQ-5D-3L values declined with increasing risk of social isolation, with a mean (SD) value of 0.65 (0.30) for those identified as at risk of social isolation, 0.69 (0.27) for those identified as socially isolated, and 0.50 (0.32) for those identified as severely socially isolated. Therefore, the health related quality of life of the oldest old and those in residential care is likely to be different to that of the general population. This issue is important to investigate as the percentage of the population in these age groups is likely to increase markedly in the future.

Studies focused specifically in older people and using the EQ-5D-3L demonstrate similar trends to the general population norm data with decreasing utility scores with increasing age, and further lower utility scores in those residing in residential care accommodation than in general population norms, as illustrated in Table 4.2.

Table 4.2 EQ-5D-3L utility values in studies targeting older people and nursing home residents

Study	Population	Age group (years)	Sample	Exclusion criteria	Mean (SD)
(Peters et al. 2012)	Dutch community dwelling, residential supported accommodation, or nursing home residents	≥65	359 124 nursing home residents	Severe cognitive dysfunction Very ill	0.70 (0.4)
(Rodriguez Blazquez et al. 2012)	Spanish community dwelling plus a convenience sample of nursing home residents	≥60	468 234 nursing home residents	Cognitive impairment according to Short Portable Mental State Questionnaire	Community dwelling 0.81 (0.26) Institutionalized 0.57 (0.36)

In summary the EQ-5D-3L appears to produce population norms within the range of 0.8 to 0.9 for general population values, with utility decreasing for general community dwelling populations of people over 65 years to 0.6 to 0.7 for those over 65 years. The health state utility of the oldest old and those residing in nursing homes has previously been excluded from the literature, but interest in the quality of life of these growing sectors of the population has increased in the last few years with two studies published recently targeting older adults and including samples from residential care, finding that the average utility in the institutionalized population is relatively low in comparison with community based samples (mean value of 0.57).

4.2.4 Use of the ICECAP-O in measuring quality of life

The ICECAP-O (Coast et al. 2008a) is a generic preference based instrument developed for the measurement and valuation of quality of life in older people (aged 65 years and above) using health and social care services in the UK. A version for adults has also recently been created, named the ICECAP-A (Al-Janabi et al. 2012).

The ICECAP-O focuses on quality of life in a broader sense, and capability (in terms of what the individual respondent considers they are able to achieve) rather than health or function or more specific influences on quality of life. The ICECAP-O therefore takes a different focus to the EQ-5D-3L and other instruments previously developed that tend to measure function and health status. This broader quality of life focus is potentially important for evaluating social and health care programmes in older people, where significant improvements in health may be unlikely given the physical aging process occurring, but improvements in wellbeing and broader aspects of quality of life are possible (Coast et al. 2008a). The ICECAP-O measures participants' capability in 5 domains: attachment, security, role, enjoyment, and control, with four levels of capability for each domain ranging from the worst or no capability, to the best or full capability (see Figure 4.2). Valuations have been performed in a population of 255 UK older persons (over 65 years) (Coast et al. 2008a) and more recently in 2456 Australian adults both using the Best-Worst Scaling technique for valuation (Flynn et al. 2010).

Whilst the ICECAP-O is a relatively new instrument, a number of studies have been published which have utilised the instrument with older people based in the UK, Australia, and the Netherlands. Table 4.3provides an overview of these studies and the values calculated from the ICECAP-O presented in these studies.

Attachment

1. I can have all of the love and friendship that I want
2. I can have a lot of the love and friendship that I want
3. I can have a little of the love and friendship that I want
4. I cannot have any of the love and friendship that I want

Security

1. I can think about the future without any concern
2. I can think about the future with only a little concern
3. I can only think about the future with some concern
4. I can only think about the future with a lot of concern

Role

1. I am able to do all of the things that make me feel valued
2. I am able to do many of the things that make me feel valued
3. I am able to do a few of the things that make me feel valued
4. I am unable to do any of the things that make me feel valued

Enjoyment

1. I can have all of the enjoyment and pleasure that I want
2. I can have a lot of the enjoyment and pleasure that I want
3. I can have a little of the enjoyment and pleasure that I want
4. I cannot have any of the enjoyment and pleasure that I want

Control

1. I am able to be completely independent
2. I am able to be independent in many things
3. I am able to be independent in a few things
4. I am unable to be at all independent

Figure 4.2 The ICECAP-O attributes

Table 4.3 Population norm values for the ICECAP-O

Study	Population	Age group (years)	Sample	Exclusion criteria	Mean (SD)[1]
(Comans et al. 2013)	Australian Participants in TCP	Average age 79 years	351	Nil	On admission to TCP 0.75 (0.16) Upon discharge from TCP 0.83 (0.16)
(Makai et al. 2013)	Dutch community dwelling population recently admitted to hospital	≥65	296	MMSE<12/30, Life expectancy <3 months	0.80 (0.17)
(Couzner et al. 2012b)	Australian general population	≥15	2937	Nil	<65 years old 0.841 (0.003)[2] ≥65 years old 0.831 (0.006)
(Couzner et al. 2012a)	Australian participants in Outpatient rehabilitation and TCP	≥65	82	Admitted to hospital more than 3 months ago, MMSE<24/30	0.81 (0.15) Outpatient 0.82 (0.15) TCP 0.79 (0.16)
(Davis et al. 2012)	Canadian Referred to Falls Clinic and assessed as increase risk of falls	≥70	215	MMSE<24/30, Unable to walk 3m, Life expectancy <12 months	0.815 (0.177)
(Flynn et al. 2011)	UK General population	≥65	809	Nil	0.832 (0.123)
(Coast et al. 2008a)	UK General Population	≥65	313	Nil	0.814 (0.152)

1 Mean and Standard deviation values given unless otherwise specified

2 Standard Error

Abbreviations: TCP=Transitional Care Program, MMSE=Mini Mental Examination Score

Generally values for ICECAP-O published in the literature are based upon community dwelling older adult populations, those within a few months of hospital admission or undergoing a treatment program such as rehabilitation or a transitional care program. All of these groups report utility values of between 0.75 and 0.83. However, no studies to date have applied the ICECAP-O in frail older people immediately following a sentinel health event, such after a hip fracture.

4.2.5 Quality of life following a hip fracture

The devastating effect of a fall-related hip fracture in older adults upon mortality, morbidity, and clinical outcomes are well described (Bentler et al. 2009; Haleem et al. 2008; O'Neill & Roy 2005; Roth et al. 2010), and the impact on psychosocial functioning and quality of life have also received increasing attention (Bryant et al. 2009; Crotty et al. 2010; Hiligsmann et al. 2008; Hutchings et al. 2011). It is now well established that hip fractures have among the largest impacts on quality of life of common chronic conditions experienced by older people (Adachi et al. 2010; Roux et al. 2012). A number of studies have determined the effect on the hip fracture on quality of life at one or two years following fracture, with the aim for these results to be incorporated into economic models of the effectiveness of treatment modalities (Hiligsmann et al. 2008; Papaioannou et al. 2009). However, the immediate impact of the hip fracture on quality of life is also an important consideration in modelling the trajectory of quality adjusted life years gained as a result of an intervention.

Several studies have measured quality of life immediately following a hip fracture (Borgstrom et al. 2013; Borgström et al. 2006; Cranney et al. 2001; Cranney et al. 2005; Hagino et al. 2009; Tidermark et al. 2002; Zethraeus et al. 2002). Table 4.4 presents the characteristics of the studies listed. The mean utility values for patients immediately following hip fracture (within 4 weeks of fracture) varies markedly from 0.01 in a Lithuanian population to 0.67 in a population of Canadian women. The majority of published studies have utilized the EQ-5D-3L to measure quality of life. In addition, most studies were single-centre trials leading to questions about whether the results are generalisable to other populations. One multicentre study (Borgstrom et al. 2013) included patients from multiple countries, and found great variation in the utility values in the acute period following a hip fracture (ranging from 0.01 for Lithuania to 0.19 in Austria). However, this study did not include any patients with hip fractures from Australia.

Table 4.4 Studies measuring quality of life in patients after surgery for hip fracture

Study	Sample	Instrument	Timing	Utility Score
Borgstrom et al. 2013	1273 patients with fractured hip from 11 countries	EQ-5D-3L	1-2 weeks following fracture	Mean (95% CI) Austria 0.19 (0.16-0.22) Lithuania 0.01 (0-0.010)
Hagino et al. 2009	37 women with hip fractures in Japan	EQ-5D-3L	2 weeks following fracture	Mean (SD) 0.37 (0.27)
Borgstrom et al. 2006	278 patients with fractured hip in Sweden	EQ-5D-3L	Within 4 weeks following fracture	Mean (95% CI) 0.18 (0.15-0.20)
Cranney et al. 2005	40 women in Canada with hip fractures	HUI Mark 2 SF-6D	Within 4 weeks following fracture	Mean (SD) HUI 0.51 (0.18) SF-6D 0.50 (0.08)
Tidermark et al. 2002	71 patients in Sweden with hip fractures	EQ-5D-3L	1 week following fracture	Mean (SD) 0.44 (0.33)
Zethraeus et al. 2002	86 patients in Sweden with hip fractures	EQ-5D-3L	2 weeks following fracture	Mean (SD) 0.42 (0.32)
Cranney et al. 2001	10 women with fracture hip in Canada	HUI Mark 2	Within 2 weeks following fracture	Mean (SD) 0.67 (0.12)

Abbreviations: CI = Confidence Intervals, HUI = Health Utilities Index, SD = Standard Deviations

The majority of published studies to date have excluded patients with dementia or those deemed as unable to reliably respond (Borgstrom et al. 2013; Borgström et al. 2006; Hagino et al. 2009), and/or those that were institutionalised prior to fracture (Borgstrom et al. 2013; Tidermark et al. 2002). However, it is known that impaired cognition and residence in a nursing home are both high risk factors for experiencing a hip fracture (Chen et al. 2009; Guo et al. 1998; Leavy et al. 2013; Marks 2010). Previous studies have also tended to exclude men as women are more likely to experience a hip fracture (Cranney et al. 2001; Cranney et al. 2005; Hagino et al.

2009), however there is conflicting evidence on whether men experience poorer function following a hip fracture compared to women which could also impact on their quality of life (Di Monaco et al. 2012).

In summary, with the growing aging population the measurement of quality of life for this age group is increasing in importance – both from an equity perspective as well as a practical perspective to ensure health and aged care interventions provide outcomes which are of value to older people. Whilst generic preference based measures have been used widely for the measurement and valuation of quality of life within the context of economic evaluation, there remain questions about whether these instruments measure aspects of quality of life that are of most importance to older people and whether they are sensitive enough to measure changes in quality of life especially where aspects of function and independence may have increasing importance. Empirical comparisons of the performance of quality of life instruments can provide important information on these questions. Additionally there is currently a lack of information about the utility values for frail older patients in the acute period following a hip fracture in Australia.

Therefore, the aims of this study were to investigate the quality of life of older people in the period immediately following a hip fracture, and to empirically compare the performance of the EQ-5D-3L and the ICECAP-O as measures of quality of life in this context.

4.3 Methods

4.3.1 Study participants

The procedures for the study have been described previously (Milte et al. 2013a). Participants were recruited from the Flinders Medical Centre and Repatriation General Hospital in Adelaide, South Australia. The study was reviewed by the Flinders Clinical Research Ethics Committee, and approval granted February 2009 (approval number 4609). Participants were approached sequentially between May 2009 and November 2010. Inclusion criteria were aged over 60 years, and diagnosed with a fall related hip fracture and not currently receiving palliative care or consented to another research study.

In cases of significant cognitive impairment where the participant was unable to give consent or respond to the questions (defined as a score on the Mini Mental State Examination (MMSE) as less than 19 out of a possible 30), consenting family members were recruited as a proxy respondent.

4.3.2 Administration of questionnaire

The EQ-5D-3L and the ICECAP-O were administered to participants as part of a larger questionnaire (including the DCE reported in Chapter Five) to determine rehabilitation preferences in a group of patients following surgery to repair a fall related hip fracture. The questions were presented to the participants during an interview with a trained research assistant, with instructions to choose one answer to each question, indicating which statement best describes their own health and quality of life today. Interviews were conducted at between one and three weeks following surgery, to capture the initial recovery period, either at the patient bedside or at their home.

4.3.3 Comparison with a general population dataset

To determine the magnitude of the difference in values generated from the patients following a hip fracture relative to those of community dwelling older people, utility values from a comparison general population dataset were sought. For the ICECAP-O, data from the South Australian Health Omnibus Survey for 2009 were utilized (Harrison Research 2010). This survey uses a random stratified sampling technique to collect cross-sectional data on a number of health indicators for members of the community 15 years and over. For the year 2009 5,200 households were randomly selected to participate in the survey with 3,007 consenting in total. The dataset also comes with a weighting variable to adjust the data to the age, gender, and geographic location distribution of the total South Australian population. The dataset weighing was used when generating frequency distribution in response to the ICECAP-O, but not when applying statistical tests of difference to the dataset (e.g. Mann-Whitney U Test). For the EQ-5D-3L the data were drawn from an online bank of survey respondents from across Australia (n=2,492 participants aged 18 years and above). Respondents were able to access the survey through a web link, and therefore were able to complete the survey in their own time. Data were collected as part of a larger study investigating preferences for EQ-5D-3L responses in Australia, where participants were first asked to describe their own current health state using the instrument (Couzner et al. 2013).

4.3.4 Calculating utility values

Individual responses to the EQ-5D-3L and the ICECAP-O were converted into utility values using generic-preference based algorithms. For the EQ-5D-3L the recently developed general population scoring algorithm was utilised based upon the EQ-5D-3L health state preferences from Australians (n=417) using a time-trade off methodology (Viney et al. 2011). For the ICECAP-O the valuations were from an Australian general population sample (n = 2456) using the best-worst scaling technique (Flynn et al. 2010).

4.3.5 Data analysis

Responses to the EQ-5D-3L and ICECAP-O were summarised in simple frequencies and percentages for the whole sample, and for specific subgroups. Statistical analysis was conducted using IBM SPSS Statistics Version 19.0. Mann-Whitney U Test was used to determine differences in utility scores for the two instruments for different subgroups. Pearson and Spearman Rho were used to determine correlations between the utility scores for the two instruments and continuous and dichotomous variables, dependant of the violation of the requirement for normal distribution. Kruskal Wallis test was used to determine association between ICECAP tariff and categorical variables. Intra-class correlation was also applied to determine correlations between the two instruments, and a Bland Altman Plot generated to test for the level of agreement (Bland & Altman 1999; Bland 2000).

4.4 Findings

4.4.1 Study participants

A total of 149 patients with a recent hip fracture were approached to participate, of which 87 (58%) consented to the study. The key demographic characteristics of the participants are shown below. The vast majority of participants living in the community resided in their own home (n=70, 80.5%).

Table 4.5 Demographic characteristics of the sample (n=87)

Characteristics	Descriptive statistics
Number of females (%)	61 (70.1)
Mean age (SD)	80.3 (8.2)
Residential status	
Number living in HLC (%)	10 (11.5)
Number living in LLC (%)	6 (6.9)
Number living in the community (%)	71 (81.6)
Mean MMSE score (SD)	23.3 (6.9)
Number of proxy respondents (%)	10 (11.5)

Abbreviations: HLC = High Level Care, LLC = Low Level Care, MMSE = Mini Mental State Examination

4.4.2 Responses to the EQ-5D-3L and ICECAP

The distribution of the responses to the EQ-5D-3L results for all participants in shown below in Table 4.6, as well as the distribution of responses for participants according to several key sub-groups based on: [1] gender, [2] proxy vs. non-proxy respondents, [3] cognitive status, [4] living status (community vs. residential care), and [5] age group (youngest old vs. oldest old).

Table 4.6 Distribution of responses to EQ-5D-3L items by all participants (n=87) and selected subgroups

EQ-5D-3L Item	All (n=87)	Males (n=26)	Females (n=61)	Non-Proxy (n=77)	Proxy (n=10)	MMSE < 24 (n=31)	MMSE ≥ 24 (n=53)	Living in Residential Care (n=16)	Living in the Community (n=71)	Age <80 years (n=39)	Age ≥80 years (n=48)
	Number (%)										
MOBILITY											
I have no problems in walking about	18 (20.7)	4 (15.4)	14 (23.0)	14 (18.2)	4 (40.0)	10 (32.3)	8 (15.1)	4 (25.0)	14 (19.7)	9 (23.1)	9 (18.8)
I have some problems in walking about	62 (71.3)	18 (69.2)	44 (72.1)	59 (76.6)	3 (30.0)	17 (54.8)	43 (81.1)	11 (68.8)	51 (71.8)	26 (66.7)	36 (75.0)
I am confined to bed	7 (8.0)	4 (15.4)	3 (4.9)	4 (5.2)	3 (30.0)	4 (12.9)	2 (3.8)	1 (6.3)	6 (8.5)	4 (10.3)	3 (6.3)
SELF-CARE											
I have no problems with self-care	31 (35.6)	9 (34.6)	22 (36.1)	29 (37.7)	2 (20.0)	11 (35.5)	20 (37.7)	3 (18.8)	28 (39.4)	11 (28.2)	20 (41.7)
I have some problems with self-care	48 (55.2)	14 (53.8)	34 (55.7)	45 (58.4)	3 (30.0)	15 (48.4)	31 (58.5)	10 (62.5)	38 (53.5)	24 (61.5)	24 (50.0)
I have many problems with self-care	8 (9.2)	3 (11.5)	5 (8.2)	3 (3.9)	5 (50.0)	5 (16.1)	2 (3.8)	3 (18.8)	5 (7.0)	4 (10.3)	4 (8.3)
USUAL ACTIVITIES											
I have no problems with performing my usual activities	26 (29.9)	8 (30.8)	18 (29.5)	26 (33.8)	0 (0.0)	6 (19.4)	20 (37.7)	0 (0.0)	26 (36.6)	11 (28.2)	15 (31.3)

(Continued)	*All (n=87)*	*Males (n=26)*	*Females (n=61)*	*Non-Proxy (n=77)*	*Proxy (n=10)*	*MMSE < 24 (n=31)*	*MMSE ≥ 24 (n=53)*	*Living in Residential Care (n=16)*	*Living in the Community (n=71)*	*Age <80 years (n=39)*	*Age ≥80 years (n=48)*
I have some problems with performing my usual activities	36 (41.4)	10 (38.5)	26 (42.6)	33 (42.9)	3 (30.0)	12 (38.7)	23 (43.4)	9 (56.3)	27 (38.0)	13 (33.3)	23 (47.9)
I am unable to perform my usual activities	25 (28.7)	8 (30.8)	17 (27.9)	18 (23.4)	7 (70.0)	13 (41.9)	10 (18.9)	7 (43.8)	18 (25.4)	15 (38.5)	10 (20.8)
PAIN OR DISCOMFORT (n=85,2 participants refused to answer)											
I have no pain or discomfort	18 (21.2)	5 (19.2)	13 (22.0)	14 (18.7)	4 (40.0)	10 (33.3)	8 (15.4)	7 (43.8)	11 (15.9)	4 (10.8)	14 (29.2)
I have moderate pain or discomfort	62 (72.9)	20 (76.9)	42 (71.2)	56 (74.7)	6 (60.0)	18 (60.0)	42 (80.8)	8 (50.0)	54 (78.3)	29 (78.4)	33 (68.8)
I have extreme pain or discomfort	5 (5.9)	1 (3.8)	4 (6.8)	5 (6.7)	0 (0.0)	2 (6.7)	2 (3.8)	1 (6.3)	4 (5.8)	4 (10.8)	1 (2.1)
ANXIETY OR DEPRESSION											
I am not anxious or depressed	47 (54.0)	12 (46.2)	35 (57.4)	43 (55.8)	4 (40.0)	13 (41.9)	32 (60.4)	7 (43.8)	40 (56.3)	21 (53.8)	26 (54.2)
I am moderately anxious or depressed	32 (36.8)	11 (42.3)	21 (34.4)	26 (33.8)	6 (60.0)	16 (51.6)	15 (28.3)	8 (50.0)	24 (33.8)	13 (33.3)	19 (39.6)
I am extremely anxious or depressed	8 (9.2)	3 (11.5)	5 (8.2)	8 (10.4)	0 (0.0)	2 (6.5)	6 (11.3)	1 (6.3)	7 (9.9)	5 (12.8)	3 (6.3)

The responses to the EQ-5D-3L indicated that the majority of participants experienced moderate or severe impairments (response levels 2 or 3) for some or all dimensions. 79.3% of participants had either some problems in walking about or were confined to bed. 64.4% of participants also had some problems or many problems with self-care. For their usual activities, 70.1% of participants had either moderate or severe problems with performing their usual activities. In addition, a high percentage of participants (78.8%) indicated they had moderate or extreme pain or discomfort, while just under half (46.0%) were either moderately or extremely anxious or depressed.

The distribution for the results for the EQ-5D-3L differ between the subgroups slightly. For example more males indicated that they were confined to bed than females (15.4% vs. 4.9%), and that they experienced either some problem or a severe problem with anxiety or depression (53.8% vs. 42.6%).

For proxy respondents, more indicated that their family member was confined to bed than non-proxy respondents (30.0% vs. 5.2%), that they were having some or severe problems with self-care (80.0% vs. 62.3%), their usual activities (100% vs. 66.2%), and anxiety or depression (60.0% vs. 44.2%), although no proxy respondents indicated that their family member was extremely anxious or depressed. Interestingly, a lower number of proxies indicated that their family member was experiencing pain or discomfort than non-proxies (60.0% vs. 81.3%), perhaps due to proxies not wanting to consider their family members as beinginpain.

When split according to the cognitive status of the participant, the response patterns to the EQ-5D-3L were fairly similar. However, slightly more of those with MMSE score lower than 24 indicated they had no problem with any pain or discomfort compared to those with a MMSE score of 24 or above (33.3% vs. 15.4%). As might be expected, more participants with a lower MMSE score indicated that they experienced a moderate or severe problem with anxiety or depression compared to the participants with the higher MMSE score (58.1% vs. 39.6%).

When the participants living in residential aged care homes were compared to those living in the community, more reported either moderate or severe problems with self-care (81.3% vs. 60.6%) and moderate or severe problems with their usual activities (100% vs. 63.4%) and anxiety or depression (56.3% vs. 43.7%). But similarly to the proxy responders, fewer participants from residential aged care homes indicated that they had either moderate or severe problems with pain or discomfort (56.3% vs. 84.1%).

Participants with an age of 80 years and above were also compared to participants with an age of less than 80 years. Compared to participants of an older age group, younger participants were slightly less likely to experience some or severe problems with mobility (77.0% vs. 81.3%) and with pain or discomfort (89.2% vs. 70.9%) but more likely to indicate they had problems with self-care (71.8% vs. 58.3%).

Table 4.7 Distribution of responses to ICECAP-O items by all participants and selected subgroups

ICECAP Item	All participants (n=87)	Males (n=26)	Females (n=61)	Non-proxy (n=77)	Proxy (n=10)	MMSE<24 (n=31)	MMSE≥24 (n=53)	Living in Residential Care (n=16)	Living in the Community (n=71)	Age <80 years (n=39)	Age ≥80 years (n=48)
	Number (%) of participants										
ATTACHMENT (n=86, 1 participant refused to answer)											
I cannot have any of the love and friendship that I want	2 (2.3)	0 (0.0)	2 (3.3)	2 (2.6)	0 (0.0)	1 (3.2)	1 (1.9)	1 (6.3)	1 (1.4)	1 (2.6)	1 (2.1)
I can have a little of the love and friendship that I want	17 (19.8)	9 (34.6)	8 (13.3)	14 (18.4)	3 (30.0)	4 (12.9)	11 (21.2)	3 (18.8)	14 (20.0)	7 (17.9)	10 (21.3)
I can have a lot of the love and friendship that I want	19 (22.1)	5 (19.2)	14 (23.3)	16 (21.1)	3 (30.0)	8 (25.8)	11 (21.2)	6 (37.5)	13 (18.6)	5 (12.8)	14 (29.8)
I can have all of the love and friendship that I want	48 (55.8)	12 (46.2)	36 (60.0)	44 (57.9)	4 (40.0)	18 (58.1)	29 (55.8)	6 (37.5)	42 (60.0)	26 (66.7)	22 (46.8)

(Continued)	*All participants*	*Males*	*Females*	*Non-proxy*	*Proxy*	*MMSE<24*	*MMSE≥24*	*Living in Residential Care*	*Living in the Community*	*Age <80 years*	*Age ≥80 years*
SECURITY											
I can only think about the future with a lot of concern	11 (12.6)	3 (11.5)	8 (13.1)	10 (13.0)	1 (10.0)	5 (16.1)	4 (7.5)	1 (6.3)	10 (14.1)	8 (20.5)	3 (6.3)
I can think about the future with some concern	21 (24.1)	9 (34.6)	12 (19.7)	19 (24.7)	2 (20.0)	7 (22.6)	14 (26.4)	6 (37.5)	15 (21.1)	5 (12.8)	16 (33.3)
I can think about the future with only a little concern	28 (32.2)	8 (30.8)	20 (32.8)	24 (31.2)	4 (40.0)	10 (32.3)	17 (32.1)	6 (37.5)	22 (31.0)	13 (33.3)	15 (31.3)
I can think about the future without any concern	27 (31.1)	6 (23.1)	21 (34.4)	24 (31.2)	3 (30.0)	9 (29.0)	18 (34.0)	3 (18.8)	24 (33.8)	13 (33.3)	14 (29.2)
ROLE (n=85, 2 participants refused to answer)											
I am unable to do any of the things that make me feel valued	17 (20.0)	6 (24.0)	11 (18.3)	13 (17.3)	4 (40.0)	8 (25.8)	8 (15.7)	5 (33.3)	12 (17.1)	7 (17.9)	10 (21.7)
I am able to do a few of the things that make me feel valued	33 (38.8)	10 (40.0)	23 (38.3)	30 (40.0)	3 (30.0)	13 (41.9)	19 (37.3)	7 (46.7)	26 (37.1)	12 (30.8)	21 (45.7)
I am able to do many of the things that make me valued	21 (24.7)	5 (20.0)	16 (26.7)	19 (25.3)	2 (20.0)	5 (16.1)	15 (29.4)	2 (13.3)	19 (27.1)	14 (35.9)	7 (15.2)
I am able to do all of the things that make me feel valued	14 (16.5)	4 (16.0)	10 (16.7)	13 (17.3)	1 (10.0)	5 (16.1)	9 (17.6)	1 (6.7)	13 (18.6)	6 (15.4)	8 (17.4)

(Continued)	*All participants*	*Males*	*Females*	*Non-proxy*	*Proxy*	*MMSE<24*	*MMSE≥24*	*Living in Residential Care*	*Living in the Community*	*Age <80 years*	*Age ≥80 years*
ENJOYMENT (n=86, 1 participant refused to answer)											
I cannot have any of the enjoyment and pleasure that I want	10 (11.6)	3 (11.5)	7 (11.7)	8 (10.5)	2 (20.0)	3 (9.7)	5 (9.6)	1 (6.7)	9 (12.7)	6 (15.4)	4 (8.5)
I can have a little of the enjoyment and pleasure that I want	51 (59.3)	19 (73.1)	32 (53.3)	48 (63.2)	3 (30.0)	18 (58.1)	33 (63.5)	8 (53.3)	43 (60.6)	23 (59.0)	28 (59.6)
I can have a lot of the enjoyment and pleasure that I want	15 (17.4)	3 (11.5)	12 (20.0)	10 (13.2)	5 (50.0)	7 (22.6)	7 (13.5)	5 (33.3)	10 (14.1)	5 (12.8)	10 (21.3)
I can have all of the enjoyment and please that I want	10 (11.6)	1 (3.8)	9 (15.0)	10 (13.2)	0 (0.0)	3 (9.7)	7 (13.2)	1 (6.7)	9 (12.7)	5 (12.8)	5 (10.6)
CONTROL (n=84, 3 participants refused to answer)											
I am unable to be at all independent	9 (10.7)	4 (16.0)	5 (8.5)	6 (8.1)	3 (30.0)	7 (23.3)	0 (0.0)	4 (26.7)	5 (7.2)	4 (10.8)	5 (10.6)
I am able to be independent in few things	35 (41.7)	11 (44.0)	24 (40.7)	31 (41.9)	4 (40.0)	11 (36.7)	24 (47.1)	6 (40.0)	29 (42.0)	17 (45.9)	18 (38.3)
I am able to be independent in many things	30 (35.7)	8 (32.0)	22 (37.3)	27 (36.5)	3 (30.0)	8 (26.7)	21 (41.2)	4 (26.7)	26 (37.7)	13 (35.1)	17 (36.2)
I am able to be completely independent	10 (11.9)	2 (8.0)	8 (13.6)	10 (13.5)	0 (0.0)	4 (13.3)	6 (11.8)	1 (6.7)	9 (13.0)	3 (8.1)	7 (14.9)

The responses to the ICECAP-O also demonstrated impairments in quality of life. While 77.9% of the participants indicated they were able to have all or a lot of the love and friendship they wanted, and 63.3% that they could think about the future without any or only a little concern, the responses for the other attributes indicated the majority of participants were experiencing problems in these areas. 58.8% were unable to do anything or only a few things that made them feel valued. 70.9% stated that they could not have any or only a little of the enjoyment and pleasure they wanted. 52.4% were unable to be independent at all or only in a few things.

Sub-group analysis by gender revealed that more men compared to women indicated they either could not have any or only a little of the love and friendship they wanted (34.6% vs. 16.7%). For security, more men indicated they could only think about the future with a lot or some concern (46.2% vs. 32.8%) and were unable to do any or only few of the things that made them feel valued (64%% vs. 56.7%), and that they couldn't have any or can only have a little of the enjoyment and pleasure that they wanted (84.6% vs. 65.0%). Men were also more likely to indicate that they were unable to be independent at all or only in a few things (60.0% vs. 49.2%).

For those participants who had a family member proxy respondent, more of the proxy respondents indicated that their family member had a problem with fulfilling their role (70.0% vs. 57.3%). Proxies also indicated more often that their family member could not have any or only a little of the enjoyment and pleasure they wanted (73.7% vs. 50.0%), and that they were unable to be independent at all or only in a few things (70.0% vs. 50.0%).

When participants were grouped according to their cognitive status, more of the participants with a lower cognitive status as indicated by a MMSE score of less than

24 indicated they were unable to do any or only few of the things that make them feel valued (67.7%) compared to those with a MMSE score of 24 and above (52.9%). Similarly, more of the participants with a low MMSE score indicated they were unable to be independent at all or only in a few things (60.0%) compared to the participants with a higher MMSE score (47.1%).

When the responses from participants who were living in residential care facilities were compared to those living in the community, those coming from residential care were more likely to report that they could only think about the future with a lot or some concern (43.8% vs. 35.2%) and they were unable to do any or only few of the things that made them feel valued (80.0% vs. 54.3%). They were also more likely to report that they were unable to be independent at all or only in a few things (66.7% vs. 50.7%). However, the community dwelling participants were more likely to report they were unable to have any or only a little of the enjoyment and pleasure they wanted (73.2% vs. 60.0%).

Responses from participants from the youngest old (under 80 years of age) were compared to responses from the oldest old (aged 80 years and above). The response patterns indicated that participants from an older age group were slightly more likely to have problems with thinking about the future with a lot or some concern (39.6% vs. 33.3%), and were more likely to be unable to do any of the things or few of the things that made them feel valued (67.4% vs. 48.7%) but less likely to indicate they are unable to be independent at all or able to be independent in few things (48.9% vs. 56.7%).

Table 4.8 shows the utility values for the ICECAP-O and the EQ-5D-3L for all participants, and for subgroups according to gender, age group, proxy and non-proxy respondents, impaired and non-impaired cognitive status as measured by the MMSE, and whether the participant resided in residential care or not prior to fracture. Differences between the groups were tested for using the Mann-Whitney U Test. In this sample, the mean value for the ICECAP for the total sample of respondents was higher than that of the EQ-5D-3L and this reached statistical significance according to the Wilcoxon signed rank test (p=0.000). This pattern followed for all of the subgroups. In addition the mean value for both instruments was higher for females than males, for the non-proxy respondents than the proxy respondents, and for those living in the community compared to those living in residential care, although these differences did not reach statistical significance. Mean utility score for the EQ-5D-3L was higher in the older age group compared to the younger age group, although this difference did not reach statistical significance.

Table 4.8 Utility values calculated from EQ-5D-3L and ICECAP for all patients with hip fractures, and selected subgroups

Characteristics	N	ICECAP-O: Mean (SD)	Median (IQR)	P Value*	EQ-5D-3L: Mean (SD)	Median (IQR)	P Value*
Total	82	0.639 (0.206)	0.661 (0.280)		0.545 (0.251)	0.619 (0.18)	
Gender							
Female	58	0.665 (0.207)	0.677 (0.268)		0.566 (0.236)	0.619 (0.17)	
Male	24	0.575 (0.193)	0.548 (0.364)	0.054	0.494 (0.281)	0.588 (0.89)	0.457
Age group							
60-79 years	37	0.639 (0.223)	0.620 (0.314)		0.499 (0.274)	0.601 (0.24)	
80-100 years	45	0.639 (0.193)	0.667 (0.266)	0.959	0.582 (0.227)	0.641 (0.24)	0.130
Proxy Status							
Proxy Respondent	10	0.580 (0.221)	0.601 (0.444)		0.375 (0.353)	0.362 (0.68)	
Non-proxy Respondent	72	0.647 (0.204)	0.663 (0.281)	0.353	0.567 (0.229)	0.619 (0.18)	0.122
Cognitive status							
MMSE Score <24	30	0.616 (0.229)	0.620 (0.381)		0.510 (0.298)	0.591 (0.44)	
MMSE Score ≥24	52	0.669 (0.179)	0.680 (0.261)	0.332	0.578 (0.200)	0.643 (0.18)	0.343
Residential care status							
Residential care	15	0.587 (0.212)	0.578 (0.375)		0.487 (0.222)	0.522 (0.41)	
Community dwelling	67	0.651 (0.204)	0.670 (0.284)	0.291	0.558 (0.257)	0.619 (0.18)	0.104

*According to Mann Whitney-*U* Test

Figure 4.3 shows a scatterplot comparison of the ICECAP-O and EQ-5D-3L utilities. From the scatterplot, at higher values of EQ-5D-3L utility, the plots cluster around the regression line. However, at lower values of EQ-5D-3L utility, the plots are clustered above the regression line, indicating the tendency for participants with lower values of EQ-5D-3L utility to have higher values for ICECAP-O utility.

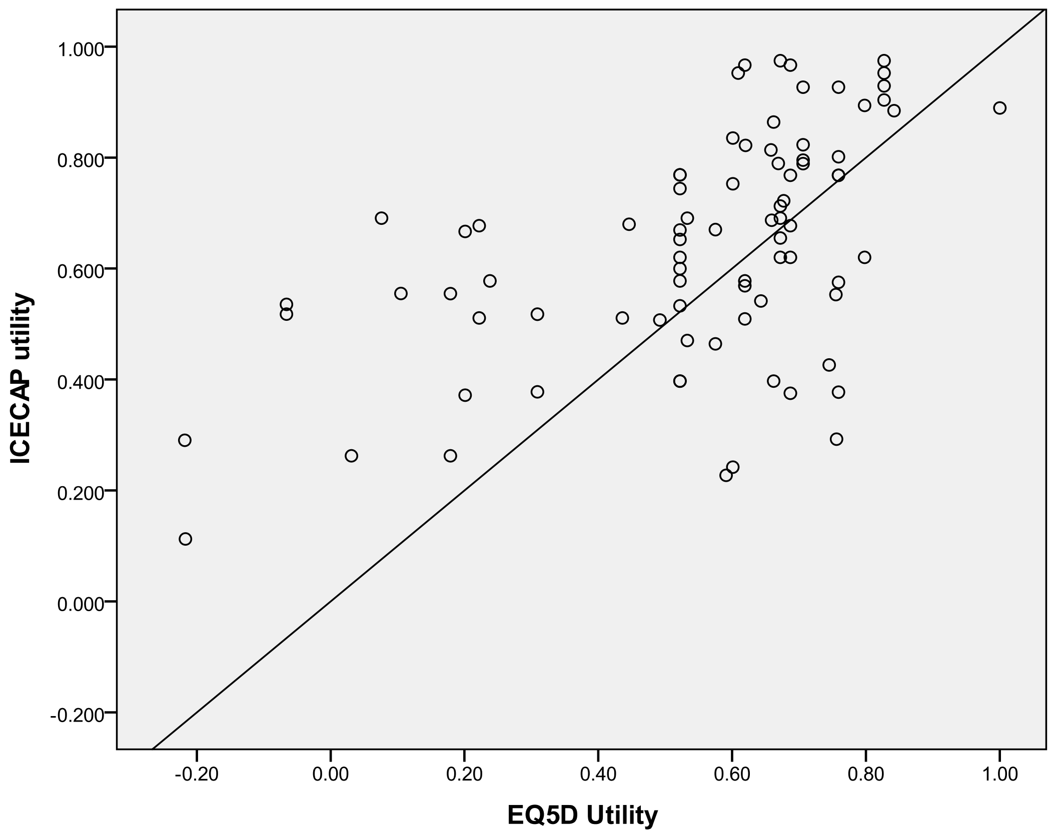

Figure 4.3 Scatter plot comparison of the ICECAP-O and EQ-5D-3L utilities

The results of the correlation tests, show a small negative correlation between ICECAP scores and age, a small positive correlation between ICECAP scores and MMSE, gender, and living independently (i.e. community dwelling as compared to living in Residential Care) although none of these results reached statistical significance (see Table 4.9). A small positive correlation was also found between

EQ-5D-3L score and living independently, which did not reach statistical significance. There was a statistically significant large positive correlation between the ICECAP score and the EQ5D score for the total sample.

Table 4.9 Correlations between participant characteristics and ICECAP and EQ-5D-3L score measured by Pearson correlation or Spearman Rho

Characteristic	ICECAP	EQ5D
Age	-0.164	0.049
ICECAP	-	0.529 (p=0.000)**
MMSE Score	0.132	0.093
Gender	0.214	0.080
Living independently	0.117	0.175

Abbreviations: MMSE = Mini Mental State Examination

** Significant at the p≤0.001 level

However, the above coefficients only take account of the pure correlations between the two scores, not any agreement between the two scores. The intraclass correlation coefficient gives a measure of the agreement as well as the correlation between the EQ-5D-3L and the ICECAP-O and was also calculated and is presented in Table 4.10. This gives a much smaller correlation coefficient of 0.487, indicating only a moderate degree of correlation between the two instruments when the agreement between the two scores is taken into account.

Table 4.10 Paired comparison of the ICECAP-O and EQ-5D-3L utilities

ICECAP-O Mean Score (SD) Median Score (IQR)	EQ-5D-3L Mean Score (SD) Median Score (IQR)	Wilcoxon signed rank test	Intra-class correlation (ICC)
0.639 (0.206) 0.661 (0.280)	0.545 (0.251) 0.619 (0.18)	z=-3.613 p=0.000**	0.487

**indicates the differences in the mean rank scores are statistically significant at the p≤0.001 level

The differences in utility score calculated by the EQ-5D-3L and the ICECAP-O for each participant were tested using the Wilcoxon signed rank test (see Table 4.10), which found the score calculated from the ICECAP-O was higher than that calculated by the EQ-5D-3L and this difference reached statistical significance (z=-3.613 p=0.000, r=0.399).

Table 4.11 Association between ICECAP-O score and sample characteristics as measured by Kruskal Wallis or Mann-Whitney U Test

Characteristic	P value
EQ-5D-3L Mobility	0.002*
EQ-5D-3L Self Care	0.001**
EQ-5D-3L Usual Activities	0.004*
EQ-5D-3L Pain/discomfort	0.324
EQ-5D-3L Anxiety/depression	0.004*
Education Level	0.474
Born in Australia	0.750
Length of time since fracture	0.339

* Significant at the p<0.05 level

** Significant at the p≤0.001 level

The level of association between the ICECAP-O score and responses to EQ-5D-3L items and characteristics of the sample are shown in Table 4.11. These results suggest that there is a statistically significant association between ICECAP scores and scores on the EQ-5D-3L items for mobility, self-care, usual activities and anxiety/depression.

A Bland-Altman plot was also generated showing the difference between the ICECAP-O and the EQ-5D-3L utility against the mean utility for the participant.

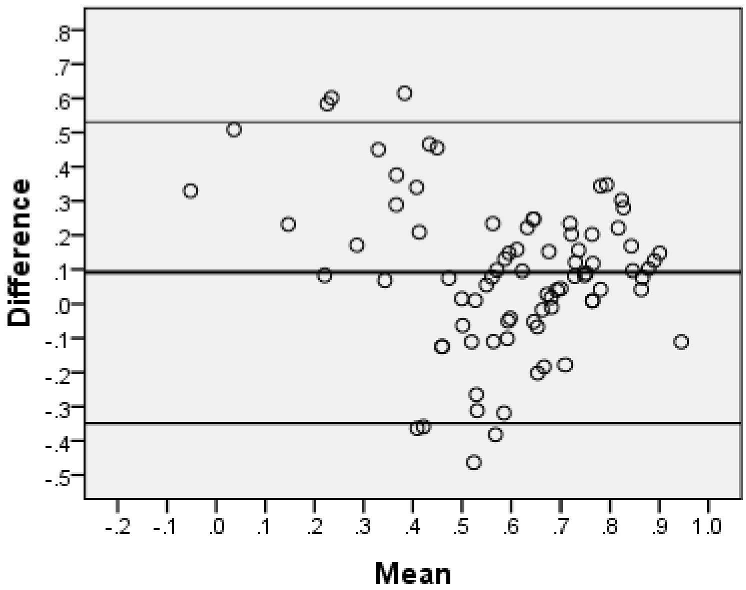

Figure 4.4 Bland-Altman plot of differences in ICECAP-O and EQ-5D-3L utilities.
——— Mean + 1.96*SD=0.529; Mean – 1.96*SD=-0.349; ——— Mean=0.09

As seen in Figure 4.4, the 95% limits of agreement calculated for the mean difference between the ICECAP-O and EQ-5D-3L range from 0.529 (95% CI 0.446 to 0.615) to -0.349 (95% CI -0.433 to -0.264). This indicates for some individuals there is a large difference in utilities generated by the two instruments, and overall agreement is poor (Bland & Altman 1999; Kottner et al. 2011). Whilst the majority of within participant differences between the two instruments range between -0.2 to 0.2, for one participant these differences increased up to 0.61 between the two instruments. The plot also shows indication of systematic effect bias which is supported by the results of the Wilcoxon Signed Ranks Test indicating that the ICECAP-O utilities are significantly above the results of the EQ-5D-3L value ($p \leq 0.001$). There is also evidence of proportional bias within the plot, such that as the average utility value increases there is a tendency for the differences between the two scores to become smaller.

4.4.3 Comparison with a general population dataset

Utility values using the Australian algorithm for the ICECAP-O and the EQ-5D-3L were calculated for the general population samples. The mean values for the general population and the hip fracture population are compared below, as well as comparisons within the general population according to gender and age subgroups, with differences between groups tested for using the Mann-Whitney U Test.

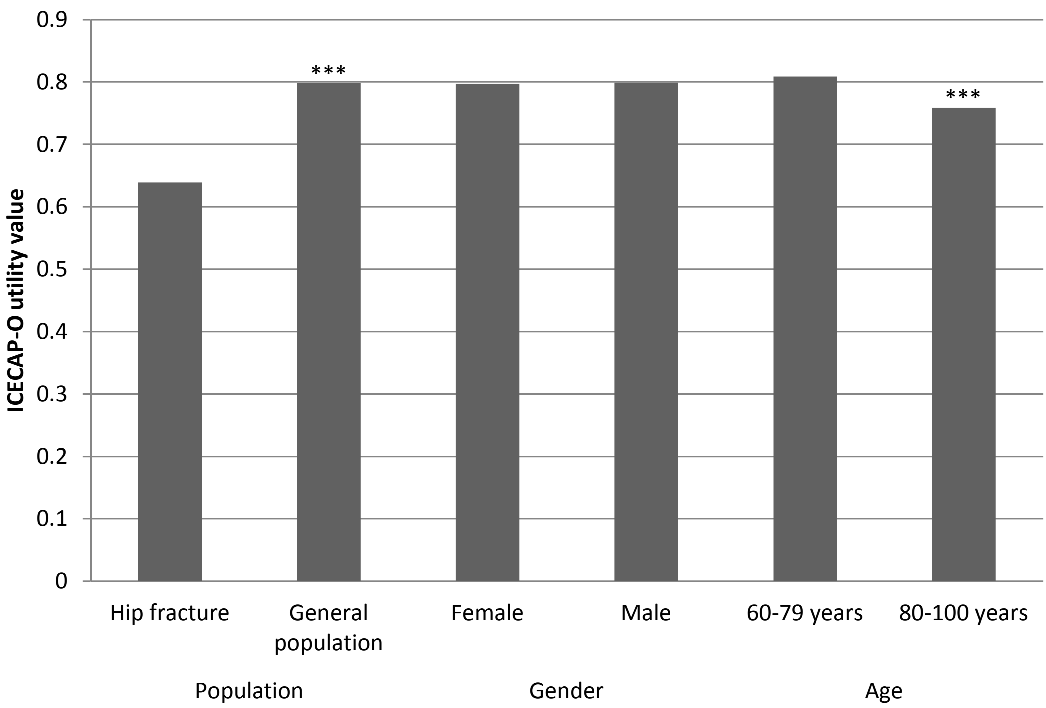

Figure 4.5 Comparison of the utility values for the ICECAP-O for the general population (n=1052) and hip fracture (n=82) samples

*** indicates statistically significant difference between hip fracture and general population utility values at the p≤0.001 level

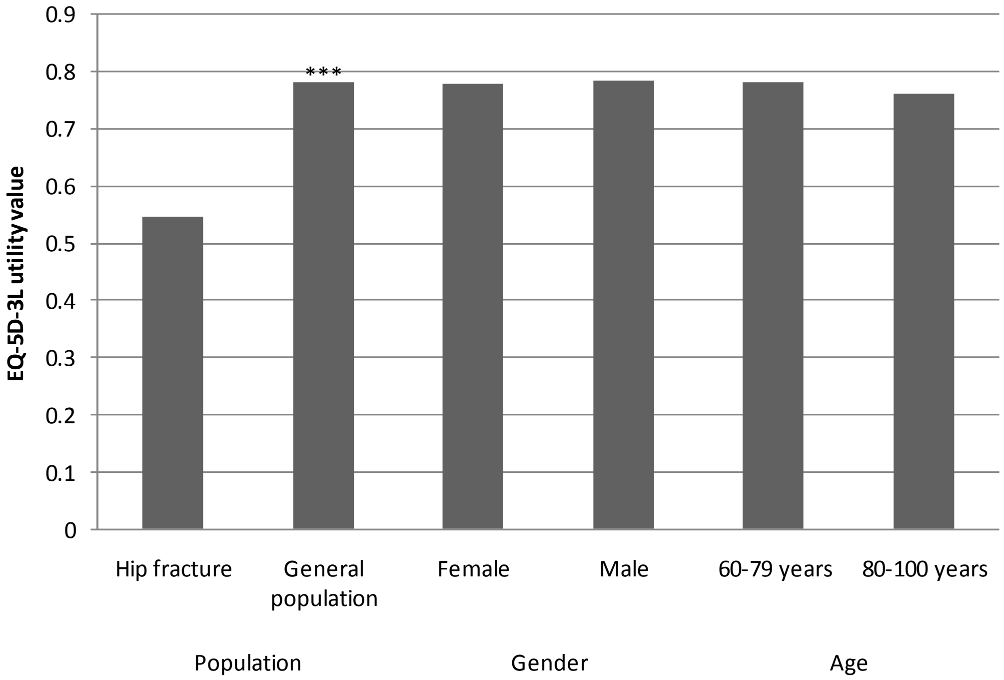

Figure 4.6 Comparison of the utility values for the EQ-5D-3L for the general population (n=632) and hip fracture (n=82) samples

*** indicates statistically significant difference between hip fracture and general population utility values at the p≤0.001 level

There was a statistically significant difference in the ICECAP-O score for the hip fracture population and the general population samples (p≤0.001). In addition, there were differences in utility score between men and women within the general population data, with men having a higher ICECAP-O utility score than women, although this did not reach statistical significance. In contrast, the differences in utility score between those aged between 60 and 79 years and those aged 80 years and above reached statistical significance (p=0.001).

For the EQ-5D-3L utilities, there was a statistically significant difference between the hip fracture and the general population samples (p≤0.001), with the general population sample exhibiting greater utility than the hip fracture population. For differences within the general population sample, men had slightly higher mean utility than women, although this difference did not reach statistical significance, and those of age between 60 and 79 years had slightly higher mean utility than those aged 80 and above, although this did not reach statistical significance.

4.5 Discussion

We aimed to apply a new instrument for the measurement of quality of life (ICECAP-O) and compare its use to a more established instrument (EQ-5D-3L) in a population of older adults following a hip fracture. We identified a reduced quality of life in our sample compared to values published previously for the general population and the general population of a similar age, for both instruments. This finding is supported by the statistically significant difference in the utility score for both instruments between the hip fracture population and general population samples drawn from the South Australian Health Omnibus Study and an online bank of Australian survey respondents. The majority of our sample of patients with a hip fracture indicated they had problems with the EQ-5D-3L dimensions of mobility, self-care, usual activities, and pain or discomfort, and just under half of our sample indicated they were moderately or extremely anxious or depressed. Large proportions of our sample also indicated they had problems with the ICECAP-O attributes of role, enjoyment, and control. However, in the attributes of attachment and security, the majority of our sample indicated that they had no or only a slight impairment with these attributes.

This study represents a new application of an instrument measuring broad aspects of quality of life in a sample of older people following hip fracture. The ICECAP-O is a relatively new addition to the battery of instruments available for the measurement of quality of life of older people. Most current published studies using the ICECAP-O focus on general community dwelling populations (Coast et al. 2008b; Couzner et al. 2012b; Flynn et al. 2011) or those recently discharged from hospital or receiving Transition Care (Comans et al. 2013; Couzner et al. 2012a; Davis et al. 2012; Makai et al. 2013), whereas our study measured quality of life in older people within one month of surgery to repair a hip fracture, which is often regarded as a sentinel event in the health status of older people (Bertram et al. 2011). Therefore, our study was an opportunity to apply the ICECAP-O in a population of older people who are beginning to recover following a period of poor health but are still experiencing the reduced function and increased needs for support associated with this.

Our study also represents a unique contribution in the comparison of the ICECAP-O with more established generic preference based measures of quality of life such as the EQ-5D-3L. The EQ-5D-3L has been used comprehensively to measure health status and health-related quality of life globally, and there are five studies published comparing the use of the EQ-5D-3L with ICECAP-O in populations of older adults.

Coastet al. (2008b) compared the EQ-5D-3L with the ICECAP-O in their investigation of the construct validity of the new instrument. They applied the two instruments in a sample of older adults from the UK general population (n=351). Their distribution of responses to the ICECAP-O were similar to the hip fracture population for the attachment and security attributes, but a much lower proportion of the sample exhibited the worst level of capability in the role attribute (3.5% vs. 20.0% in the hip fracture sample), the enjoyment attribute (4.1% vs. 11.6%) and the control attribute (2.2% vs. 10.7%). The EQ-5D-3L utility score showed a significant relationship with the ICECAP-O attributes of enjoyment, control, role, and security, but no relationship with the attachment attribute.

Makai et al. (2013) compared the use of the ICECAP-O with the EQ-5D-3L in a population of older adults recently admitted to hospital, three months after their admission. They collected data on a range of aspects of health and quality of life including level of independence with daily activities using the I-ADL scale, depression using the Geriatric Depression Scale, social functioning measured using the social activity limitation item from the SF-20, life satisfaction with Cantrils Ladder Life Satisfaction Scale, history of chronic diseases, wellbeing as measured by the Social Production Function Instrument for Level (SPF-IL) of Well-being, as well as the ICECAP-O and EQ-5D-3L instruments to measure quality of life. This study found that ICECAP-O scores were strongly and significantly correlated to Cantrils Ladder, SPF-IL, Geriatric Depression Scale and the I-ADL and moderately and significantly correlated with the EQ-5D-3L utilities. Interestingly, in bivariate analysis the ICECAP-O score was able to significantly discriminate between groups according to age, presence of chronic conditions, dependence in their I-ADL, and presence of depression. But the ICECAP-O was not able to significantly differentiate according to gender, education level or living status. Similarly in the sample of patients with hip fractures, there was no statistically significant difference in utility score according to age, gender, education level, and admission to a residential care facility. They also compared those with the highest vs. those with the lowest ICECAP-O scores. They found that those with the lower scores were more likely to be older, living in a nursing home, have multiple chronic conditions, have lower scores for wellbeing and EQ-5D-3L measures, be depressed, and be more dependent in their daily activities. In terms of their responses to the ICECAP-O attributes, slightly less of the sample had full capability in the attachment item (36% vs. 56% in hip fracture sample). In comparison, for the other attributes the post hospital discharge population had more capability than the hip fracture population. For example, more indicated they had full capability in the security attribute (52% vs. 31% in hip fracture sample), the role attribute (21% vs. 16.5%), the enjoyment attribute (29% vs. 12%) and a much higher proportion had full capability in the control item (41% vs. 12% in hip fracture population). Overall, this study illustrated higher capability in this population of older adults three months following admission to hospital, showing the recovery in capability over time. There was also correlation illustrated between the ICECAP-O and the EQ-5D-3L, including in utilities calculated from both instruments ($r=0.4$, $p<0.01$) of a similar magnitude to the correlation found in our estimates. Correlations were also found between the ICECAP-O utility score and all of the EQ-5D-3L attributes ($p<0.01$).

Comans et al. (2013) compared the EQ-5D-3L and the ICECAP-O instruments in a population of Australian older adults (n=351) taking part in the transition care program. The EQ-5D-3L and ICECAP-O were administered at admission to the program, discharge, and at 3 and 6 months following admission to the program. The study showed that most participants had problems with the attributes mobility, self-care, and carrying out usual activities at baseline, and these attributes showed the most improvement at discharge and three and six months follow up. At the initial time point, fewer of the participants reported the lowest capability for the role attribute (10% vs. 20% in the hip fracture sample), for the enjoyment attribute (4% vs. 12% in the hip fracture sample), and the control attribute (5% vs. 11% in the hip fracture sample) and responses to all attributes improved at the follow up assessments, except for the attachment domain which did not show improvement. Initial mean utility scores on admission to the TCP program were similar to the hip fracture sample for the EQ-5D-3L instrument (0.55 SD 0.20), but higher for the ICECAP-O score (0.75 SD 0.16) perhaps illustrating the sensitivity of the ICECAP-O instrument in measuring change in quality of life in older people post hospital admission. However, both instruments showed an improvement in utility score at the discharge from TCP time point (EQ-5D-3L: 0.70 SD 0.20, ICECAP-O: 0.83 SD 0.16).

Couzner, Ratcliffe, and Crotty (2012a) conducted a study applying the EQ-5D-3L and the ICECAP-O in a population of older adults (n=82) undertaking residential transition care or outpatient day rehabilitation. These participants were again at a later stage of recovery following admission to hospital than the current sample of patients with hip fractures, and similarly to Comans et al. (2013) exhibited a higher mean utility score calculated from the ICECAP-O (0.81 SD 0.15) but a similar score calculated from the EQ-5D-3L (0.52 SD 0.27). In terms of comparison of frequencies of distribution for responses to the ICECAP-O instrument, again the responses to attachment were broadly similar, but fewer participants chose the lowest level of the security attribute (7.3% vs. 12.6% in the hip fracture sample), the role attribute (12.2% vs. 20.0% in the hip fracture sample), the enjoyment attribute (3.7% vs. 11.6% in the hip fracture sample) and the control attribute (4.9% vs. 10.7% in the hip fracture sample). Moderate correlation between the EQ-5D-3L and ICECAP-O utilities was also demonstrated ($r=0.437$, $P<0.01$).

Davis et al. (2012) applied both the EQ-5D-3L and the ICECAP-O in a population of Canadian older adults (n=215) referred to a falls prevention clinic. They showed a mean utility score for both instruments (EQ-5D-3L: 0.701 SD 0.291, ICECAP-O: 0.815 SD 0.177) which was higher than the values calculated for the hip fracture populations, and again a moderate correlation between the instruments ($r=0.474$, $p<0.01$). They also found that the EQ-5D-3L and the ICECAP-O were associated with reliable markers of general balance, falls risk, and mobility but ICECAP-O showed more relationship to specific indicators of impaired mobility as well as independence in daily activities. This led the authors to conclude that the ICECAP-O may be more appropriate a measurement of utility in older adults with mobility impairments than traditional instruments such as the EQ-5D-3L.

The results of the correlation and agreement tests show large correlations between the newly developed ICECAP-O and the more established EQ-5D-3L, however the ICECAP-O utility score was found to be significantly higher than the EQ-5D-3L score. In addition, the Bland-Altman plot measuring agreement of the two instruments showed large differences in the utilities measured by the two instruments of up to 0.6. This is considered a large difference for the measurement of utilities where a value of zero is equal to death and one is equal to perfect health or capabilities. But therein lies the difference – while both instruments are measuring quality of life, they are measuring different aspects quality of life. Both instruments appear to be sensitive to the reduced quality of life following a hip fracture, but further work is needed to assess whether one instrument captures the recovery following a hip fracture better than another, and would therefore more fully represent the benefits of treatment options from the perspective of older people for application within the framework of economic evaluations.

In addition, the Bland-Altman plot is a relatively new method for analysis of agreement, and there is still discussion on the best method for undertaking this analysis (Ludbrook 2010; Watson & Petrie 2010). Where data points exhibit a "funnel effect" (i.e. where magnitude of differences between the two measures changes as the mean value increases) there is concern the traditional method of estimating limits of agreement could result in overestimation, due to the assumption of univariate differences between the data points being violated (Ludbrook 2010).

This is considered a common occurrence in medical research, and noticeable also in this dataset. This can be accounted for one of two ways, either transforming the data to achieve normally distributed differences or adjusting the limits of agreement to account for the heteroscedasticity of the data (Ludbrook 2010; Watson & Petrie 2010). Such adjustments are outside the scope of this exploratory pilot study, but they are important to consider for future research.

In this study due to significant cognitive impairment we were not able to elicit responses from those individuals with MMSE scores lower than nineteen. Other studies have also excluded participants with cognitive impairment (Bilotta et al. 2010; Hall et al. 2000; Rohde et al. 2008). However, there is currently no universally agreed threshold level of cognitive impairment beyond which proxy responses should be sought (Hounsome et al. 2011; Ratcliffe et al. 2010). There is also some evidence of proxy responders tending to overestimate limitations in unobservable items (e.g. pain, anxiety) for measuring health-related quality of life (Coucill et al. 2001; Hounsome et al. 2011; Sitoh et al. 2003), although we noted pain was reported less commonly by our proxy respondents than self-reporting respondents. Therefore, the best method of eliciting quality of life data from patients with cognitive impairment is still open to debate and requires further research.

This chapter has provided pilot data to assess the performance of a new generic preference based instrument for measuring quality of life (ICECAP-O) specifically designed for use in older people in a post hip fracture population. The question of how to measure quality of life is an important one to economic evaluation as it forms a standardised measure of benefits of health interventions for the costs to be compared against. The ICECAP-O, which has been developed to measure quality of life in older people, appears to behave similarly to more established instruments (EQ-5D-3L) in a population of older people post hip fracture. However there is evidence of differences in agreement between the two instruments, which highlights the importance of determining which instrument is preferred for measuring quality of life in this population. Ultimately, the question of which instrument to use in particular contexts is dependent upon the performance of each instrument in adequately capturing the most important changes in quality of life over time as a result of providing social and health interventions. Therefore, future studies should focus on the important determinants of quality of life for older people recovering from hip fracture and the sensitivity of instruments to change over time, a key indicator for assessing the benefits of social and health interventions within economic evaluation (Milte et al. 2014).

5 PREFERENCES FOR REHABILITATION AFTER HIP FRACTURE

This chapter contains material from:

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture? a discrete choice experiment', *Journal of Rehabilitation* Medicine, vol. 45, no. 1, pp. 81-6.

5.1 Introduction

Hip fractures are amongst the most devastating consequences of osteoporosis and injurious accidental falls with around 25% of patients dying in the first year after fracture (Braithwaite et al. 2003; Koval et al. 1999), with only 40% returning to pre-fracture levels of mobility (Koval et al. 1999), and annual expenditures exceeding $AUD700 million (Randell et al. 1995). Rehabilitation strategies for frail older people following hip fractures are still evolving. However there is evidence to suggest that a multidisciplinary rehabilitation programme and physical therapy is associated with improvements in mobility relative to usual orthopaedic care (Handoll et al. 2009; Handoll et al. 2011).A previous study by Salkeld and colleagues to assess the preferences for health of older women at risk of hip fracture living in the community indicated that even a small improvement in mobility was very highly valued and could have a large positive impact on quality of life(Salkeld et al. 2000). Whilst arehabilitation programme has the ability to achieve large improvements in mobility (Halbert et al. 2007), typically this also involves a period of substantial effort and endurance by the individual participant, as well as the endurance of significant levels of pain. In addition, paradoxically this type of intervention may also increase the risk of further falls and injuries principally because the individual achieves greater mobility as a consequence. Presently, scant evidence is available concerning the preferences of older people for an individualised multidisciplinary rehabilitation programme to promote recovery from a hip fracture.

Discrete Choice Experiments (DCE) are a stated preference technique originating in mathematical psychology designed to establish the relative importance and impact of individual attributes, or characteristics, upon the overall utility of a good or service(Street & Burgess 2007). Within health economics there has been an exponential increase in the number of DCE studies undertaken within the last decade, with the majority focused upon the assessment of patient preferences within a wide variety of health care programs and services(De Bekker-Grob et al. 2012; Ratcliffe et al. 2010). However, DCE studies specifically designed for and conducted with older people (aged 65 years and over) remain rare in comparison with those conducted with general adult samples(De Bekker-Grob et al. 2012; Ratcliffe et al. 2010). A recent commentary highlighted the potential for the application of discrete choice experiments in promoting patient choice for older people(Ratcliffe et al. 2010).

DCEs are typically administered through a questionnaire in which the respondent is presented with a series of choices between alternative health or rehabilitation programs and asked to choose the program that they would prefer. The alternative programs are described in terms of their attributes and associated levels (for example waiting time, location of treatment, type of treatment and staff providing the treatment). DCEs therefore provide information about the acceptability of different characteristics of programs, the trade-offs that patients are willing to make between these characteristics, and the relative importance of each of these characteristics in determining overall utility or value(Ryan & Gerard 2003). This study sought to apply discrete choice experiment methodology to investigate the preferences of older people for rehabilitation to promote recovery from a hip fracture. Specifically, the DCE sought to investigate what older people would be prepared to endure in terms of levels of pain, physical effort and the risk of further falls and injury to recover the ability to mobilise independently following hip fracture through participation in an individualised multidisciplinary rehabilitation programme.

5.2 Methods

5.2.1 Questionnaire design

A DCE questionnaire was developed for completion via a face to face interview between the consenting participant and a trained interviewer. The questionnaire contained two main sections. Section A comprised a series of attitudinal statements relating to recovery following hip fracture, mobility, and quality of life. Respondents were asked to indicate the degree to which they agreed or disagreed with each statement on a 5 point Likert scale ranging from completely agree to completely disagree. Section B of the questionnaire contained the DCE questions. The scenarios presented for consideration in the DCE were based upon four salient attributes identified by the research team in consultation with rehabilitation clinicians based upon increasing levels of pain, effort, risk of further falls and mobility. The full factorial options resulted in 81 possible scenarios for presentation ($=3^4$). A fractional factorial design was employed to reduce this to a more practical total of 36 scenarios, generating 18 binary choice sets, which were 100% efficient for the estimation of main effects(Street & Burgess 2007). This design was divided into three versions and six binary choice sets were presented within each version. Within each binary choice set, participants were asked to indicate their preferred choice between a pair of hypothetical scenarios reflecting the characteristics of an individualised multidisciplinary rehabilitation programme they would receive at two alternative locations. Given that patients were already currently participating in a rehabilitation program, a "forced choice" experiment was considered appropriate and no opt out option was provided.

5.2.2 Study participants

Participants were recruited as part of a larger project to also investigate quality of life in patients following hip fracture, as described in Chapter 4. Details of the recruitment of participants has been described in detail in Chapter 4 and in Milteet al. (2013a). Briefly, participants were recruited from Flinders Medical Centre, and the Repatriation General Hospital in Adelaide, South Australia**.** The study was approved by the Flinders Clinical Research Ethics Committee (Approval No. 4609, Approval Granted February 2009). Patients were approached sequentially between May 2009 and November 2010 following referral to the research team by a key contact staff member at each hospital. Inclusion criteria were admission with a fall related proximal femur fracture, 60 years old and above, and not currently receiving palliative care. Both those participants who were to receive rehabilitation and those currently ineligible for rehabilitation were eligible for participation in the study.

There is evidence that the preferences of proxies often do not correspond well with the preferences of the patients themselves(Shalowitz et al. 2006). In cases where significant cognitive impairment (defined in terms of a score less than 19/30 on the MMSE) prevented an individual from giving informed consent and responding directly to the questionnaire, consenting family carer preferences were elicited by proxies directed to answer from the patient's perspective. Whilst previous DCE studies in health care have tended to include participants with a reasonably high level of cognitive function (defined in terms of a MMSE score of 24 or above) for this study we attempted to be more inclusive in order to reflect more fully the views and preferences of older people themselves (including those from a residential care background), as opposed to obtaining proxy responses from a family member. The DCE was initially piloted with a small sample of patients (n=10) with a range of levels of cognitive function to check respondents level of understanding of the questions and to indicate that they were providing meaningful responses.

5.2.3 Administration of questionnaire

The findings from the pilot study indicated that patients with mild cognitive impairment (MMSE 19-23) were able to complete the questionnaire and were also able to provide meaningful responses. Minor changes to question layout and phraseology were made as a consequence of the findings of the pilot study to improve participant understanding. All patients who gave informed consent to participate took part in a face to face interview with one of two study researchers. The interviews were completed approximately seven days following their surgery, either at the patient bedside or at their home.

5.2.4 Data analysis

The data from the DCE were analysed within a random utility theory framework using a conditional logit regression model(Ryan & Gerard 2003). The function to be estimated was of the following form:

V= β75%risk_fall + β50%risk_fall + β25% risk_fall + βmild_pain + βmoderate_pain + βsevere_pain+ β30_mins + βone_hour + βtwo_hours + βmobility-Independant + βmobility_frame + βmobility-wheelchair + *e* + *u*

V is the utility or satisfaction associated with the different rehabilitation programs.

β_x are the estimated parameters of the model. *e*is the error term for the difference in observations. *u* is the error term for the differences between responses.

The estimated coefficients and their statistical significance (or otherwise) indicate the relative importance of the different attributes on individual preferences. A positive sign on a coefficient indicates that as the level of the attribute increases so does the utility derived and the converse applies for a negative sign on a coefficient. The base levels of the coefficients could then be calculated using the formula that they were equal to the negative 1 multiplied by the sum of the coefficients for the two other levels. For every respondent, tests were also carried out to determine if any of the attributes were dominant (Lancsar & Louviere 2006). A dominant response implies that the scenario with the preferred direction of preference for one particular attribute is always chosen, irrespective of the levels of the remaining attributes presented. For example, a participant who always chooses the best level for mobility in every choice situation (irrespective of falls risk and the levels of pain or effort presented) has a dominant response pattern for mobility. Sub group analyses were undertaken by estimating two separate DCE models for [1] residential status: living in residential care versus living in the community, [2] education level: completed high school versus no qualifications, [3] age: 79 years and below versus 80 years and above, and the results were compared.

In order to estimate marginal rates of substitution (MRS), a conditional logit model was estimated including the risk of falling and the duration of effort required in the rehabilitation session as continuous variables. The MRS were then calculated by dividing the estimated coefficient for the attribute by the estimated coefficient for the selected value attribute (risk of falling or duration of effort).

5.3 Findings

As the same sample was used for the study described in chapter 4, characteristics of the sample have been described in detail previously. Briefly, a total of 149 patients with a recent proximal femoral fracture were approached of whom 87 (58%) consented to participate in the study. The majority n=61 (70%) of the participants were women and were between 71 and 80 years of age, n=64 (74%). A small proportion were living in residential care prior to fracture (n= 16 (18%)), the majority were living independently in the community prior to admission, n= 71 (82%). A total of 34 (39%) participants had a MMSE of 23 or below, of whom 10 (11%) had an MMSE of 19 or lower and therefore the questionnaire was completed on their behalf by a proxy family carer.

The number of respondents who were dominant for each attribute and the total number of participants who were dominant for any attribute is presented in Figure 5.1, along with the breakdown of dominant respondents for each attribute by sub group: living in residential care vs. community prior to fracture in Figure 5.2. Figure 5.1 shows that 42 out of 81 (52%) participants who completed this section of the questionnaire were dominant for the mobility attribute, this being much more common than dominance for any other attribute. Sub-group analysis revealed that the proportion of dominant respondents was largely similar for those living in residential care vs. the community prior to fracture.

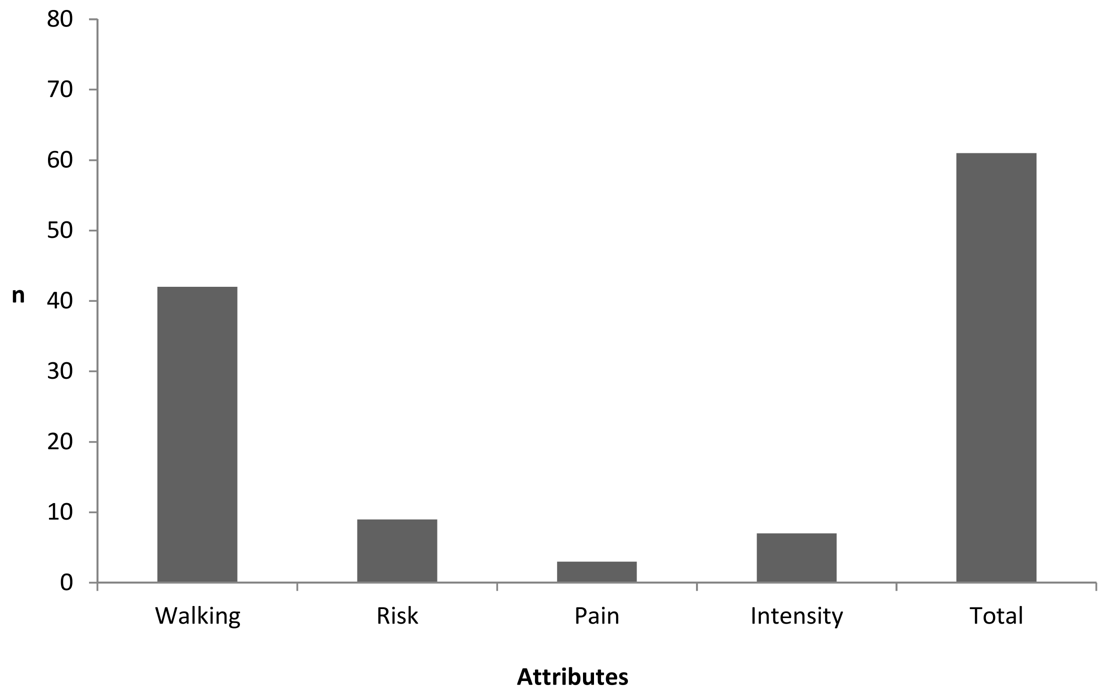

Figure 5.1 Number of dominant responses for each attribute

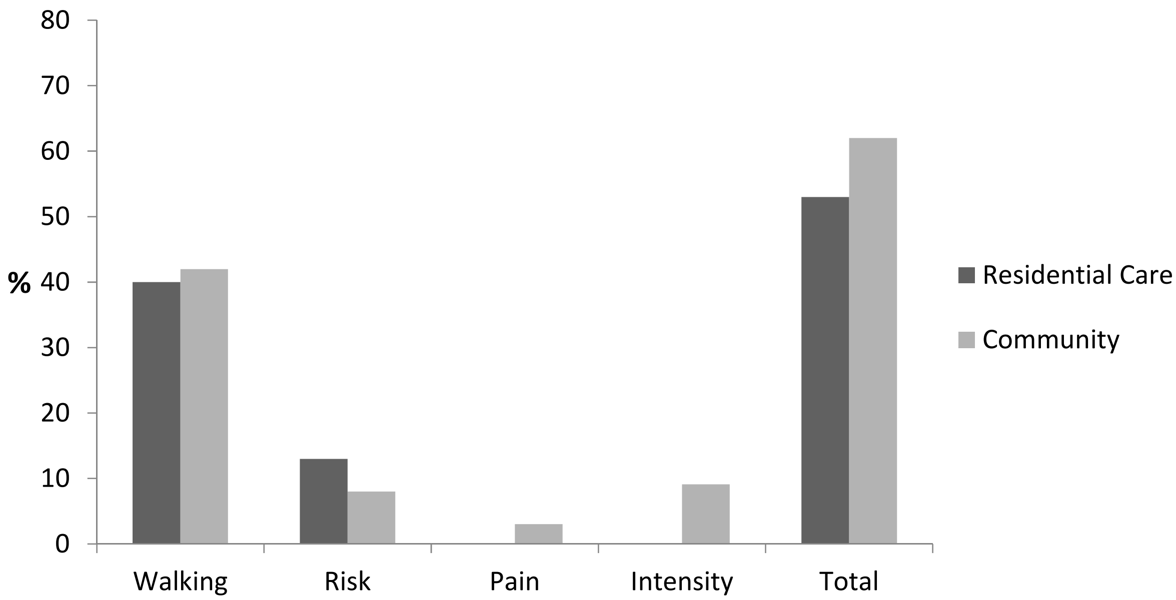

Figure 5.2 Proportion of dominant responses in participants from residential care

Table 5.1 Responses to attitudinal questions for total sample and by subgroup: living in residential care vs the community prior to fracture

Subgroup	Response n(%)	A. *	B.	C.	D.	E.	F.	G.	H.
Total	Strongly Agree	51 (58.6)	32 (36.8)	40 (46.0)	0 (0)	27 (31.0)	3 (3.4)	0 (0)	9 (10.3)
	Agree	31 (35.6)	44 (50.6)	38 (43.7)	0 (0)	55 (63.2)	11 (12.6)	5 (5.7)	39 (44.8)
	Neither agree nor disagree	3 (3.4)	7 (8.0)	6 (6.9)	0 (0)	2 (2.3)	5 (5.7)	1 (1.1)	20 (23.0)
	Disagree	1 (1.1)	4 (4.6)	3 (3.4)	23 (26.4)	2 (2.3)	37 (42.5)	24 (27.6)	11 (12.6)
	Strongly disagree	1 (1.1)	0 (0)	0 (0)	64 (73.6)	0 (0)	31 (35.6)	57 (65.5)	4 (4.6)
	Did not answer	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.1)	0 (0)	0 (0)	4 (4.6)
Residential Care	Strongly Agree	6 (37.5)	3 (18.8)	3 (18.8)	0 (0)	3 (18.8)	0 (0)	0 (0)	3 (18.8)
	Agree	7 (43.8)	10 (62.5)	8 (50.0)	0 (0)	11 (68.8)	2 (12.5)	0 (0)	10 (62.5)
	Neither agree nor disagree	1 (6.3)	2 (12.5)	3 (18.8)	0 (0)	1 (6.3)	2 (12.5)	0 (0)	1 (6.3)
	Disagree	1 (6.3)	1 (6.3)	2 (12.5)	7 (43.7)	1 (6.3)	5 (31.3)	6 (37.5)	2 (12.5)
	Strongly disagree	1 (6.3)	0 (0)	0 (0)	9 (56.3)	0 (0)	7 (43.8)	10 (62.5)	0 (0)
Community based	Strongly Agree	45 (63.4)	29 (40.8)	37 (52.1)	0 (0)	24 (33.8)	3 (4.2)	5 (7.0)	6 (8.5)
	Agree	24 (33.8)	34 (47.9)	30 (42.3)	0 (0)	44 (62.0)	9 (12.7)	0 (0)	29 (40.8)
	Neither agree nor disagree	2 (2.8)	5 (7.0)	3 (4.2)	0 (0)	1 (1.4)	3 (4.2)	1 (1.4)	19 (26.8)
	Disagree	0 (0)	3 (4.2)	1 (1.4)	16 (22.5)	1 (1.4)	32 (45.1)	18 (25.4)	9 (12.7)
	Strongly disagree	0 (0)	0 (0)	0 (0)	554 (77.5)	0 (0)	24 (33.8)	47 (66.2)	4 (5.6)
	Missing					1 (1.4)			4 (5.6)

*A. I am confident that I will be able to walk again eventually, B. I want to be able to walk again even if there is a high risk that I could fall again and break another bone in the future, C. I am prepared to make a large physical effort over a period of several weeks to enable me to walk again, D. I would prefer to go into a wheelchair now and forget about walking again, E. I am prepared to accept pain for a number of weeks whilst following an exercise programme if it will enable me to walk again, F. I am very tired and I don't want to have physiotherapy to help me with walking, G. I would be happy to use a mechanical lifter to move me from the bed to a chair for the rest of my life, H. I would be prepared to pay a fee to receive an 8 week rehabilitation programme in the nursing home to help me walk again

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Table 5.2 Conditional logit model results (total sample). Data shown as Coefficients with 95% confidence intervals

Attributes	Attribute Level	Coefficient (95% CI)	P
FALLS: Your risk of falling and breaking another bone at some time point following rehabilitation	50% or a 1 in 2 chance	0.0354 (-0.1670 to 0.2378)	0.732
	25% or a 1 in 4 chance	0.5450 (0.3316 to 0.7583)	0.000
PAIN: The level of pain you would need to accept during rehabilitation with the aim of recovering your ability to walk short distances	Moderate pain for 6 to 8 weeks	0.2097 (-0.0004 to 0.4199)	0.051
	Severe pain for 6 to 8 weeks	-0.4036 (-0.6111 to -0.1962)	0.000
EFFORT: The level of effort you would need to make during rehabilitation by working hard and exercising with a physiotherapist	One hour per day for 2 months	0.0088 (-0.1985 to 0.2162)	0.933
	Two hours per day for 2 months	-0.4916 (-0.7020 to -0.2812)	0.000
MOBILITY: Your ability to recover walking following participation in the programme	Walking with a frame with one person close by	0.4032 (0.2063 to 0.6001)	0.000
	Walking with a stick independently without help	1.3807 (1.1697 to 1.5916)	0.000

Abbreviations: CI= Confidence intervals

Table 5.1 Responses to attitudinal questions for total sample and by subgroup: living in residential care vs the community prior to fracture

Subgroup	Response n(%)	A. *	B.	C.	D.	E.	F.	G.	H.
Total	Strongly Agree	51 (58.6)	32 (36.8)	40 (46.0)	0 (0)	27 (31.0)	3 (3.4)	0 (0)	9 (10.3)
	Agree	31 (35.6)	44 (50.6)	38 (43.7)	0 (0)	55 (63.2)	11 (12.6)	5 (5.7)	39 (44.8)
	Neither agree nor disagree	3 (3.4)	7 (8.0)	6 (6.9)	0 (0)	2 (2.3)	5 (5.7)	1 (1.1)	20 (23.0)
	Disagree	1 (1.1)	4 (4.6)	3 (3.4)	23 (26.4)	2 (2.3)	37 (42.5)	24 (27.6)	11 (12.6)
	Strongly disagree	1 (1.1)	0 (0)	0 (0)	64 (73.6)	0 (0)	31 (35.6)	57 (65.5)	4 (4.6)
	Did not answer	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.1)	0 (0)	0 (0)	4 (4.6)
Residential Care	Strongly Agree	6 (37.5)	3 (18.8)	3 (18.8)	0 (0)	3 (18.8)	0 (0)	0 (0)	3 (18.8)
	Agree	7 (43.8)	10 (62.5)	8 (50.0)	0 (0)	11 (68.8)	2 (12.5)	0 (0)	10 (62.5)
	Neither agree nor disagree	1 (6.3)	2 (12.5)	3 (18.8)	0 (0)	1 (6.3)	2 (12.5)	0 (0)	1 (6.3)
	Disagree	1 (6.3)	1 (6.3)	2 (12.5)	7 (43.7)	1 (6.3)	5 (31.3)	6 (37.5)	2 (12.5)
	Strongly disagree	1 (6.3)	0 (0)	0 (0)	9 (56.3)	0 (0)	7 (43.8)	10 (62.5)	0 (0)
Community based	Strongly Agree	45 (63.4)	29 (40.8)	37 (52.1)	0 (0)	24 (33.8)	3 (4.2)	5 (7.0)	6 (8.5)
	Agree	24 (33.8)	34 (47.9)	30 (42.3)	0 (0)	44 (62.0)	9 (12.7)	0 (0)	29 (40.8)
	Neither agree nor disagree	2 (2.8)	5 (7.0)	3 (4.2)	0 (0)	1 (1.4)	3 (4.2)	1 (1.4)	19 (26.8)
	Disagree	0 (0)	3 (4.2)	1 (1.4)	16 (22.5)	1 (1.4)	32 (45.1)	18 (25.4)	9 (12.7)
	Strongly disagree	0 (0)	0 (0)	0 (0)	554 (77.5)	0 (0)	24 (33.8)	47 (66.2)	4 (5.6)
	Missing					1 (1.4)			4 (5.6)

*A. I am confident that I will be able to walk again eventually, B. I want to be able to walk again even if there is a high risk that I could fall again and break another bone in the future, C. I am prepared to make a large physical effort over a period of several weeks to enable me to walk again, D. I would prefer to go into a wheelchair now and forget about walking again, E. I am prepared to accept pain for a number of weeks whilst following an exercise programme if it will enable me to walk again, F. I am very tired and I don't want to have physiotherapy to help me with walking, G. I would be happy to use a mechanical lifter to move me from the bed to a chair for the rest of my life, H. I would be prepared to pay a fee to receive an 8 week rehabilitation programme in the nursing home to help me walk again

Table 5.2 presents the results from the conditional logit model for the total sample. Both of the higher attribute levels relating to mobility (walking with a stick independently and walking with a frame) and the attribute level relating to the lowest risk of further falls (25%) were found to be highly important in determining positive preferences for an individualised multidisciplinary rehabilitation programme and were highly statistically significant ($P<0.001$). Participants also exhibited negative preferences for the attribute levels relating to severely painful interventions and levels of effort involving rehabilitation intervention durations of two hours or more per day and both of these attribute levels were statistically significant.

Table 5.3 presents the results from the conditional logit model for the subgroups according to place of residence prior to the hip fracture. It can be seen that both groups exhibited strong positive preferences for higher levels of the mobility attribute. However in contrast to those participants living in the community those living in residential care prior to hip fracture were less averse to severely painful interventions and levels of effort involving rehabilitation intervention durations of two hours or more per day. Both of these attribute levels were statistically significant in influencing the preferences of the community group but were not significant for the residential care group.

Table 5.3 Results of conditional logit model for subgroups based on living in the community or in residential care

Attributes	Attribute Levels	Residential Care (N=16)		Community (N=71)	
		Coefficient (95% CI)	P	Coefficient (95% CI)	P
FALLS: Your risk of falling and breaking another bone at some time point following rehabilitation	50% or a 1 in 2 chance	-0.0684 (-0.5481, 0.4113)	0.780	0.0583 (-0.1672, 0.2837)	0.613
	25% or a 1 in 4 chance	0.7499 (0.2344, 1.2653)	0.004	0.4999 (0.2629, 0.7369)	0.000
PAIN: The level of pain you would need to accept during rehabilitation with the aim of recovering your ability to walk short distances	Moderate pain for 6 to 8 weeks	0.2129 (-0.2808, 0.7066)	0.398	0.2175 (-0.0168, 0.4519)	0.069
	Severe pain for 6 to 8 weeks	-0.1673 (-0.6592, 0.3247)	0.505	-0.4675 (-0.6991, -0.2359)	0.000
EFFORT: The level of effort you would need to make during rehabilitation by working hard and exercising with a physiotherapist	One hour per day for 2 months	-0.4692 (-0.9482, 0.0096)	0.055	0.1287 (-0.1036, 0.3609)	0.277
	Two hours per day for 2 months	-0.1620 (-0.6513, 0.3273)	0.516	-0.5774 (-0.8138, -0.3411)	0.000
MOBILITY: Your ability to recover walking following participation in the programme	Walking with a frame with one person close by	0.8300 (0.3556, 1.3045)	0.001	0.3062 (0.0871, 0.5253)	0.006
	Walking with a stick independently without help	1.2330 (0.7463, 1.7197)	0.000	1.4322 (1.1949 1.6695)	0.000

Abbreviations: CI= Confidence intervals

The responses to the attitudinal questions for the total sample, and also for each subgroup can be found in Table 5.1. The responses to the attitudinal statements broadly reinforce the findings from the DCE, indicating a strong preference to undertaking rehabilitation programmes with an aim to increase mobility, in both the residential and community care subgroups and the total sample.

Table 5.4 Marginal rates of substitution using risk of falls and duration of effort as value attributes

Attribute	Level	Coefficient (SE)	MRS risk (%)	MRS duration of effort (minutes)
FALLS	Risk	-0.0160*** (0.0057)	-	2.000
PAIN	Mild	0.138	-8.625	-0.005
	Moderate	0.209** (0.104)	-13.063	-26.125
	Severe	-0.347*** (0.010)	21.688	43.375
EFFORT	Duration	-0.0078*** (0.0020)	0.500	-
MOBILITY	Wheelchair bound	-1.361	85.063	170.125
	Walking with a frame	0.304*** (0.091)	-19.000	-38.000
	Walking with a stick	1.057*** (0.105)	-66.063	-132.125

*** p<0.01, **p<0.05, *p<0.1

Table 5.4 presents the results of the conditional logit model for the sample with risk of falling and duration of effort for rehabilitation included as linear, continuous variables and the results of the marginal rates of substitution using risk of falling (risk) and duration of effort (duration) as value attributes. Plotting of the coefficient values attached to alternative levels of these two value attributes indicated that the assumption of a linear relationship was appropriate. The results indicate that, in general, participants would be prepared to accept a 22% increase in the risk of falling and breaking another bone to avoid enduring severe pain from participating in a rehabilitation programme. In general participants would also be prepared to accept an increase in the duration of the rehabilitation programme of over 2 hours in a 2 month period (132 minutes) in order to achieve the highest mobility outcome of walking with a stick unaided.

5.4 Discussion

This is the first time DCE methodology has been applied to ascertain patient preferences for an individualised multidisciplinary rehabilitation programme following hip fracture. The findings from this DCE study indicate that mobility outcomes and the achievement of independent mobility have significant and positive impacts for frail older people recovering from hip fracture. A previous study of preferences for service configuration in rehabilitation inpatients also found that recovery was the dominant factor in determining preferences (Laver et al. 2013). In addition, while patients were averse to very high doses of therapy (6 hours per day) they were not averse to moderate does of therapy (3 hours per day) (Laver et al. 2013). Another study in frail older adults, in this case participants in a Transitional Care program designed to increase independence following a hospital admission, found participants were averse to very high doses of therapy (greater than 15 visits per week from therapists) but not averse to lower doses of therapy (ranging from contact a few times per week to daily therapy) (Dixon et al. 2013). The preferred model of care based on this study was in-home care provided seven times per week principally organised by the therapist. In addition to contributing knowledge of older adult preferences for rehabilitation, the current study also provides important preliminary evidence for the feasibility and future potential for DCE methodology to be applied to elicit the treatment preferences of frail older people, a sub-group of the population traditionally excluded from studies of this nature (De Bekker-Grob et al. 2012).

Although our sub-sample of participants from residential care was small (n=16), we found that the preferences of participants from a residential care background were broadly similar to those from a community background. Participants from both residential care and the community exhibited strong positive preferences for improved mobility following hip fracture and these differences were found to be statistically significant. This finding is reinforced by the responses to the attitudinal questions whereby all participants from both residential care and the community (100%) expressed they disagreed or strongly disagreed with the statement 'I would prefer to go into a wheelchair now and forget about walking'. Presently in Australia, patients from high care residential aged care facilities (nursing homes) are denied the same opportunities in relation to rehabilitation care as compared to people from community or low care residential aged care settings, an approach which is increasingly being questioned (Crotty & Ratcliffe 2011). Recently updated hip fracture guidelines from the National Institute of Health and Clinical Excellence (NICE) in the UK have recommended that priority research be undertaken into the provision of rehabilitation strategies for rehabilitating older people from residential care following a hip fracture (National Clinical Guideline Centre 2011). A recent systematic review has also highlighted the likely clinical benefit to this group (Forster et al. 2010). The findings from this study suggest residents and their family members have similar levels of interest in recovery and rehabilitation as those from the community.

The DCE study represents a snapshot study of patient preferences at one time point only, following surgery for hip fracture. It may be the case that patients could change their preferences for rehabilitation over time, for example, if optimal rehabilitation is not achieved, or if their health declines further. We elected to survey patients about their preferences for rehabilitation early after their surgery when they were first commencing rehabilitation as it has been demonstrated that it is at this time-point that their engagement with a rehabilitation program is most important as rehabilitation must commence early following surgery to achieve the best outcomes (National Clinical Guideline Centre 2011). The chosen attributes and levels were developed with health professionals engaged in the provision of rehabilitation programmes and piloted with patients receiving rehabilitation for relevance, language and coverage. However it is important that future research includes a comprehensive and client-focused method of defining attributes and levels for DCEs. The selection criteria recently presented by Coast et al. (2012) recommending more rigorous methods of attribute selection based on qualitative techniques would be useful in this regard.

This study provides important preliminary evidence relating to the preferences of frail older people for improved mobility as a consequence of an individualised multidisciplinary rehabilitation intervention following hip fracture. The findings indicate that, in general, the desire to recover mobility through a rehabilitation intervention is tempered by an aversion to high levels of risk of further falls and pain. This finding is important to note, given the current NICE recommendations to investigate the effectiveness of higher intensity rehabilitation programs, which may result in increased pain and fatigue for patients (National Clinical Guideline Centre 2011). If these guidelines were implemented in Australia, our study provides evidence that frail older adults are willing to participate in programmes of requiring increasing effort and resulting in increasing pain during rehabilitation. However, a significant proportion are averse to programmes of severe pain and very long duration. Therefore, while higher intensity rehabilitation programmes are likely to be acceptable to this group, especially if they provide the chance of improved mobility outcomes for participants, it would be important for those designing such programmes to consider process outcomes such as the level of effort involved. It will be important in the future for both researchers and clinicians to determine novel strategies to design rehabilitation programmes which provide the intensity required to gain the mobility outcomes that older people so highly value but within levels of effort and pain which are acceptable. Physical exercise programmes are not only of interest for hip fracture rehabilitation, but are also of interest in older adults as a way of reducing the functional decline associated with hospitalisation (De Morton et al. 2007) and in older community dwelling adults to reduce functional decline to maintain health and independence (Liu & Latham 2009). In particular, in their Cochrane review of the effects of resistance strength training on physical function in older adults, Liu and Latham (2009) found effects on strength and vitality with higher intensity interventions, although the number of published studies was small. It would be interesting to consider whether the findings we have reported in patients with hip fractures would also apply to other groups of older adults. While this may be the case, the preferences of older adults in other groups receiving rehabilitation programs needs further examination.

The study also adds to the bourgeoning literature highlighting the potential for the wider application of DCE methodology as a valuable instrument for engaging with, and eliciting the views and preferences of, frail older people in relation to their health and health care (Darbà et al. 2011; De Bekker-Grob et al. 2013; Dixon et al. 2013; Laver et al. 2011a; Laver et al. 2013; Laver et al. 2011b; McNamara et al. 2013; Ratcliffe et al. 2010), a group traditionally excluded from studies of this nature (De Bekker-Grob et al. 2012; Ratcliffe et al. 2010). We attempted to be inclusive with the DCE by not excluding older adults with mild cognitive impairment. The preferences of those with mild cognitive impairment are particularly important given the increasing awareness that those which cognitive difficulties should not be excluded from rehabilitation programmes (National Clinical Guideline Centre 2011). The preliminary finding from our study are generally positive and indicate the potential for DCE's to be conducted in samples of older people with mild cognitive impairment. However it is important that further work is conducted to assess the practicality and feasibility of this approach in older people with cognitive impairment. The application of qualitative research methods, including think aloud approaches (Van Someren et al. 1994), may be particularly helpful in this regard to investigate the process of DCE decision making in this group. Further research should also be directed towards achieving greater equity in access to rehabilitation services for the wide spectrum of patients attending hospital with hip fractures.

6 GENERAL DISCUSSION

6.1 Introduction

This chapter providesa discussion of the overall findings of the thesis. In addition, recommendations will be provided for future research directions based upon the key findings from the body of work presented in this thesis.

6.2 Cost effectiveness of nutrition interventions for frail older adults: Adding to the evidence

The systematic review of the published literature demonstrated that whilst there are some published economic evaluations of nutrition strategies for the treatment or prevention of protein and energy malnutrition in adults, there are very few high quality cost-effectiveness studies in this area (Milte et al. 2013b). This is concerning for researchers, clinicians and decision makers, as without good quality economic evidence for the effectiveness of nutrition strategies, nutrition programs may be undervalued and overlooked for funding priorities within future health care programs. The cost-effectiveness studies that have been conducted to date show varying results dependent on the characteristics of the population under analysis, but there are a number indicating likely cost-effectiveness of the interventions under consideration in malnourished patients with benign gastrointestinal disease (Norman et al. 2011), in patients less than 75 years old following a hip fracture (Wyers et al. 2013), and in patients with COPD as part of a wider multidisciplinary care program (Hoogendoorn et al. 2010). In addition, there is evidence for cost-effectiveness of protein and energy supplementation based upon the amount of weight gain

(Rypkema et al. 2003; Wyers et al. 2013), additional calories consumed (Simmons et al. 2010), and per one day reduction in length of stay (Kruizenga et al. 2005). These are all promising results which show the potential for the cost effectiveness of nutrition interventions in a number of clinical groups. However, there remains a need to determine the cost-effectiveness of nutrition as part of a multidisciplinary rehabilitation strategy following hip fracture, given the current movement towards multidisciplinary strategies for rehabilitation in practice.

Chapter 3 described a cost-utility analysis of an individualised multidisciplinary nutrition and exercise regime for rehabilitation following a hip fracture. The baseline ICER calculated was $AUD28,350, which is not insignificant but remains well below the implied cost-effectiveness threshold for Australia of $50,000 (Harris et al. 2008).

The study findings highlighted that whilst the additional utility gained by the intervention group compared to the control group was small, the additional costs to provide a comprehensive program of nutrition and exercise therapy to these participants, in their own home, and by trained staff for six months, was also small in comparison to the other healthcare costs these participants accrued over a six month time period. Therefore, even a small gain in utility as a result of nutrition and exercise therapy is likely to be considered cost effective. This is similar to previous cost-utility studies of nutrition therapy that have found only a moderate improvement in utility in the intervention group, but have assessed the cost-effectiveness of the intervention as favourable due to the small relative costs of providing nutrition support (Hoogendoorn et al. 2010; Norman et al. 2011).

Overall, this study shows that whilst the methods of economic evaluation are currently predominantly used to evaluate drug or surgical therapies, trial based economic evaluation of combined nutrition and exercise interventions for rehabilitation of frail older adults are possible. This type of evidence is increasingly important in facilitating funding priorities in healthcare and it is therefore recommended that economic evaluation forms an integral part of randomised controlled trials and future evaluations of nutrition and exercise therapy for this age group in order to maintain the relevance of these therapies into the future.

6.3 Calculating utilities via Multi Attribute Utility Instruments: applying a new instrument

Appropriate measurement of utility is an important concept for future economic evaluations as multi attribute utility instruments used need to be sensitive enough to pick up meaningful changes in populations of older adults as a result of receiving an intervention. This is an important consideration as a number of the most widely utilised instruments were developed in populations of younger adults and focus primarily on changes in health status (i.e. use of medications, function, or presence of disease) rather than broader considerations of quality of life. In older adults a focus on health status alone may fail to incorporate improvements in utility that may be generated by other broader determinants of quality of life for example the value of social interactions, safety in the home and the community (Milte et al. 2014). Therefore, utility measurements that take a different focus, for example related to capability (i.e. ability to do the activities that make life meaningful) rather than health status may be more relevant in this group and may be more likely to pick up the improvements to utility as a result of social and supportive interventions for older adults, such as multidisciplinary rehabilitation interventions. We found that a new instrument, the ICECAP-O was practical and feasible for administration in a group of frail older adults following a hip fracture in addition to the widely utilised EQ-5D-3L. The two instruments correlated well with each other; however in our sample we found that there were some systematic differences between the two instruments. The mean utility score generated from the ICECAP-O was higher than that generated from the EQ-5D-3L by almost 0.01, and for some individuals there were marked differences in scores for the two instruments. These differences may be due to the fact that the instruments are measuring slightly different aspects of quality of life. For example, the ICECAP-O focuses on issues of attachment, security, role, enjoyment, and control as determinants of quality of life in older adults. By comparison, the EQ-5D-3L focuses on more standard determinants of health status including mobility, self-care ability, usual activities, pain or discomfort, and anxiety or depression. Therefore, as the two instruments are measuring different determinants of quality of life the end utilities they are generating are different. This is especially of interest in measuring benefits of providing health services, including nutrition and exercise interventions, in frail older adults where large changes in overall health status may not be possible, given the natural progression of the aging process, but where changes in other determinants affecting quality of life such as independence and ability to perform valued activities may be possible and of value to older people. Therefore, this body of work indicates that the ICECAP-O can be successfully used to measure utilities in older adults, and may be a relevant instrument to apply to measure the benefits of nutrition and exercise interventions in this population in the future.

6.4 Preferences for rehabilitation strategies: value of outcome

Whilst the costs and outcomes are the main focus of traditional economic evaluations, it is also well known that consumers may derive value from aspects of the process of providing healthcare as well (De Bekker-Grob et al. 2012). An important component of this thesis was therefore to capture patient preferences for the process characteristics compared to the outcomes achieved from a rehabilitation program following a hip fracture using a discrete choice experiment methodology. Several key process characteristics of the rehabilitation program delivery were found to be important to patients, including the subsequent risk of falls, and the amount of pain and effort the program would involve. However, by far the largest determinant of patient preferences was the achieved improvement in mobility, indicating the high value older adults place upon this outcome. Similarly, previous studies have found that maintaining independence and avoiding nursing home admission is highly important to older women identified as at risk of a hip fracture (Salkeld et al. 2000). In addition, while participants were averse to interventions involving severe pain and of high levels of effort (two hours per day of therapy) they were not averse to interventions involving moderate pain and moderate levels of effort (one hour per day of therapy). This is also similar to previous discrete choice experiments in rehabilitation following stroke, that have shown patients to be averse to very high levels of therapy, but not averse to moderate levels of therapy, and recovery of function to be highly valued by patients (Laver et al. 2011a; Laver et al. 2013). However, in contrast to previous studies in this area, the current study included participants usually excluded from studies of this nature including those with mild cognitive impairment and those admitted to residential aged care facilities. Therefore, this study is important for its inclusivity and it demonstrated that even for frail older adults living in residential care facilities achieving and maintaining functional outcomes is of great importance, further strengthening the importance of conducting economic evaluations of nutrition and exercise interventions targeting older adults in the future. In addition, the study demonstrated that older adults with cognitive impairment could complete the discrete choice experiment and that their preferences should be included in future studies.

6.5 Limitations of the study design

There are some limitations to the design of the studies presented in this thesis that are important to highlight. Some of these limitations have been discussed alongside the presentation of the results in chapters three, four, and five, but will be summarised here to give a clear picture of the overall impact of these on the findings of this thesis.

The cost-utility analysis of the INTERACTIVE nutrition and exercise program forms a major part in the results of this thesis, and was able to add to the findings of the systematic review which indicated that protein and energy supplementation in adults for the treatment or prevention of malnutrition shows evidence of economic benefits. This study makes a unique contribution to the field as it represents the first published study to conduct an economic evaluation of nutrition and exercise therapy in combination for rehabilitation in older adults following a hip fracture. However it is important to note the study limitations. The relatively small sample size of 175 participants, may have partially accounted for the large range of possible true ICER generated through the probabilistic sensitivity analysis. However, even with this variability, the range of possible ICER identified by the analysis ranged from the intervention dominating (i.e. producing both an improvement in QALY and cost savings) up to a cost per QALY gained of $51,000, which is just above the implied threshold of cost effectiveness identified in Australia (Harris et al. 2008). In addition, economic evaluations of a similar small size have been published in the literature (Coe et al. 2012; Pimouguet et al. 2010; Pinto et al. 2012; Theocharis et al. 2012; Tripuraneni et al. 2012). The measurement of utility at the baseline time point of the study was a retrospective collection of the quality of life in the six months prior to fracture. While this technique has been used commonly in measurement of quality of life in patients following a hip fracture, it necessitated the imputation of a utility value at baseline for the two groups for the calculation of QALY gain. Therefore, the calculation of the QALY gain in the two groups assumes that the utility at baseline was the same for both intervention and control groups. The validity of this assumption cannot be determined in the current study, however there were no significant differences in utility values for the two groups in the six months prior to fracture, and the two groups were also similar in other demographic considerations, so it is reasonable to conclude that utility score at the baseline time point was also similar.

The question remains whether ultimately the benefits found in this study can be attributed to the nutrition or exercise intervention or both or neither. The combination of nutrition and exercise therapy was chosen as the relevant intervention for this particular study, as previous work had indicated that the combination of both was associated with a reduced loss of weight compared to providing just exercise training or nutrition alone (Miller et al. 2006b). Therefore, it could be possible that the benefits from providing both therapies together were greater than those that would have been gained from providing one therapy only, although similarly the costs of providing both interventions are also likely to be greater than providing a single intervention only. Determining the role of the nutrition and exercise interventions individually in generating improved utility was outside the scope of the current thesis, but remains a pertinent issue in the design of multidisciplinary rehabilitation interventions and is an important issue to consider for future research.

The second study of the thesis administered MAUIs and a DCE to patients following a recent hip fracture. The study recruited patients within a few weeks of their hip fracture to capture their preferences for rehabilitation early in their recovery, when their engagement with therapy is most important for maximum recovery, and also to provide data on limitations to quality of life in this early phase following hip fracture, which has been missing from many previous studies. However, it follows that by targeting patients early in their recovery, we are only able to report a snapshot of their preferences and quality of life at that time point, and are unable to provide data on how these may change over time. For example, would experiences with rehabilitation therapy and whether they achieve their expected outcomes or not influence patient preferences? Previous studies have shown changes in patient preferences overtime in rehabilitation following stroke (Laver et al. 2011a), and therefore changes may also occur over time in populations of older adults following a hip fracture. Similarly, the comparison of the two utility instruments can only provide data on their performance at one time point. At the initial recovery phase the mean utility score calculated from the ICECAP-O was higher than that calculated by the EQ-5D-3L by almost 0.1, although there was much variation in the direction and volume of the difference for individuals. Couzner, et al. (2013) similarly found higher mean utility value calculated using the ICECAP-O instrument than the EQ-5D-3L instrument in their sample of Australian older adults. However, for application in cost-utility studies as a measure of benefits, how these instruments perform in older adults over time and after administration of healthcare interventions and therefore whether they are able to pick up changes in quality of life that are important to older adults and to society will be an important consideration. Assessment of preferences and utility at multiple time points was outside the scope of the current study, but should be considered in future studies in this area.

6.6 Conclusions

As the first study of a combination of exercise and nutrition therapy for rehabilitation following a hip fracture, this study is unique and indicates it is worthwhile to consider cost-effectiveness research for future nutrition and rehabilitation interventions. While older adults derive value from the process characteristics of the provision of healthcare programmes, the work of this thesis indicated that the end outcome, in this case maintaining mobility, is one of the most important. The results of the DCE study of preferences showed that patients most highly valued being able to walk independently above all other program characteristics. Patients were averse to high levels of effort (two hours of physical therapy per day) and severe levels of pain. However, patients were not averse to programmes involving moderate effort (one hour of physical therapy per day) and moderate pain. Therefore this shows the value that even frail older adults place on regaining mobility, and that they are willing to undertake physical therapy of a reasonable amount of pain and effort to gain the mobility outcomes that they desire. Therefore, the overall picture from this thesis is that frail older adults are motivated to achieve good mobility outcomes from rehabilitation programs, and that long-term nutrition and exercise therapy can be applied to this group in a cost-effective manner. Therefore, it will be increasingly important for future healthcare planners to develop and evaluate programs to improve and maintain functional and mobility outcomes in older adults as aging occurs in populations in Australia and across the world, as maintaining these aspects of health are of great value to older people.

In addition, it will be important for the future to ensure standard measures of benefits are identified that can evaluate programs that make a difference to aspects of quality of life which are both modifiable and important to older adults. To ensure this, consideration needs to be applied to choice of multi-attribute utility instrument used in cost-utility studies. This thesis has demonstrated the application of a new instrument for measuring utilities (ICECAP-O) and shows its correlation with the much used EQ-5D-3L instrument. However, more studies are needed to determine how the ICECAP-O performs in measurement of utility in frail older adults over time and after application of healthcare interventions.

Cost-effectiveness of nutrition therapy as a treatment and for prevention of malnutrition in older adults was also a focus of this thesis. This thesis identified there is evidence currently available indicating cost savings, and benefits from nutrition therapy for small additional costs. In addition, we were able to demonstrate a comprehensive program of nutrition and exercise therapy could be applied in frail older adults following a hip fracture, and that is likely to be considered cost-effective.

6.7 Future research directions

Given demand for healthcare is likely to continue to grow, as adults continue to live longer and survival from previously fatal conditions continues to improve, it is likely that providing the best 'value for money' healthcare interventions for the community will receive increasing focus. Therefore, economic methods of evaluating healthcare programs are likely to be increasingly important as part of the process for determining effectiveness of healthcare interventions. Part of this thesis represents the first cost-utility study of the combination of nutrition and exercise therapy for rehabilitation following hip fracture, as well as one of only a few cost utility studies of nutrition therapy for malnutrition. The further investigation of the cost-effectiveness of combinations of therapy for modifying the nutrition risk in older adults undergoing rehabilitation following a hip fracture is needed, and consideration should be given to the design of such studies. A multi-arm randomised controlled trial, where combinations of interventions are compared including nutrition therapy, exercise therapy, and a combination of nutrition and exercise therapy would allow investigation of how the benefits and costs compare from these interventions. While single-therapy arms of the trial may be associated with lower costs, the nutrition and exercise combination-arm may provide additional benefits which may affect ICER. A cost-effectiveness study of a multi-arm randomised trial of a nutrition and exercise therapy has already been conducted (Dangour et al. 2011), but didn't give consideration to the cost of providing the nutritional intervention in generating the ICER for walking speed. Utility values for the groups were not reported, although quality of life was measured through the SF-36 physical and mental component scores, with little difference seen between the groups. However, there is reason to believe that frail older adults post hip fracture may achieve additional benefits for combination nutrition and exercise therapy than the healthy community dwelling sample of this previous study. In addition future studies should utilize the preferred method of economic evaluation, i.e. the cost utility approach. This measures benefits in a standardised way that would allow for synthesis of the outcomes of studies in the future, as well as comparison with the cost-effectiveness of alternative therapies.

In future use of cost utility analysis, measurement of benefits will form an important component. There are many validated MAUI available, so their use to generate QALYs as the measurement of benefits in economic evaluation would be logical in many cases. However, there is a need to determine which MAUIs are most suitable for use in older adults and following rehabilitation interventions. Most MAUIs are developed in general adult populations and focus on aspects of function and health status. In this thesis we applied a new instrument (ICECAP-O) specifically developed for the measurement of quality of life in older people and focusing on capability or the ability of a person to do the things which are important to them. However, we were only able to illustrate how the instrument performed at a single time point, for application within economic evaluations it will be important to determine how the instrument performs over time and as a consequence of theprovision of health and aged care interventions. Therefore, studies comparing the use of the ICECAP-O and more traditional instruments administered at multiple time points would create a more detailed picture of performance and whether they are sensitive to changes in quality of life over time in this population for future application in economic evaluation.

7 REFERENCES

Abrahamsen, B, van Staa, T, Ariely, R, Olson, M & Cooper, C 2009, 'Excess mortality following hip fracture: a systematic epidemiological review', *Osteoporosis International*, vol. 20, no. 10, pp. 1633-50.

Adachi, JD, Adami, S, Anderson, FA, Jr., Boonen, S, Chapurlat, RD, Compston, JE, Cooper, C, Delmas, P, Diez-Perez, A, Gehlbach, S, Greenspan, SL, Hooven, FH, LaCroix, AZ, Lindsay, R, Netelenbos, JC, Nika, G, Pfeilschifter, J, Roux, C, Saag, KG, Sambrook, PN, Silverman, S, Siris, ES, Watts, NB & Wu, O 2010, 'Impact of prevalent fractures on quality of life: baseline results from the Global Longitudinal Study of Osteoporosis in Women', *Mayo Clinic Proceedings*, vol. 85, no. 9, p. 806+.

Addington-Hall, J & Kalra, L 2001, 'Who should measure quality of life?', *British Medical Journal*, vol. 322, no. 7299, pp. 1417-20.

Australian Government Department of Veterans’ Affairs 2012, *Dental and Allied Health Fee Schedules*, Australian Government Department of Veterans' Affairs, Canberra, Australia, viewed 21st November 2012, Available from: <http://www.dva.gov.au/service_providers/Fee_schedules/Pages/Dental_and_Allied_Health.aspx>.

Al-Janabi, H, Flynn, TN & Coast, J 2012, 'Development of a self-report measure of capability wellbeing for adults: The ICECAP-A', *Quality of Life Research*, vol. 21, no. 1, pp. 167-76.

Allen, B 2013, 'Effects of a Comprehensive Nutritional Program on Pressure Ulcer Healing, Length of Hospital Stay, and Charges to Patients', *Clinical Nursing Research*, vol. 22, no. 2, pp. 186-205.

Alves, SM, Economou, T, Oliveira, C, Ribeiro, AI, Neves, N, Gomez-Barrena, E & Pina, MF 2013, 'Osteoporotic hip fractures: bisphosphonates sales and observed turning point in trend. A population-based retrospective study', *Bone*, vol. 53, no. 2, pp. 430-6.

Australian and New Zealand Hip Fracture Registry Steering Group 2013, *Australian and New Zealand Guideline for Hip Fracture Care: Improving Outcomes in Hip Fracture Management*, Australian and New Zealand Hip Fracture Registry Steering Group, Sydney, Australia.

Australian Government Department of Health and Ageing 2008, *Ageing and aged care in Australia*, Publications Number: P3-4147, Canberra, Australia.

Australian Institute for Health and Welfare 2013, *Australian hospital statistics 2011-2012*, AIHW, Canberra.

Australian Institute for Primay Care La Trobe University 2001, *Residential aged care funding: second report*, ISBN: 0909599467, Canberra, Australia.

Autier, P, Haentjens, P, Bentin, J, Baillon, JM, Grivegnee, AR, Colson, MC & Boonen, S 2000, 'Costs induced by hip fractures: a prospective controlled study in Belgium', *Osteoporosis International*, vol. 11, no. 5, pp. 373-80.

Avenell, A & Handoll, HG 2010, 'Nutritional supplementation for hip fracture aftercare in older people', *Cochrane Database of Systematic Reviews*, no. 1, DOI 10.1002/14651858.CD001880.pub5, Available from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD001880.pub5/abstract>.

Bachrach-Lindstrom, MA, Ek, AC & Unosson, M 2000, 'Nutritional state and functional capacity among elderly Swedish people with acute hip fracture', *Scandinavian Journal of Caring Sciences*, vol. 14, no. 4, pp. 268-74.

Baulderstone, L, Yaxley, A, Luszcz, M & Miller, M 2012, 'Diet liberalisation in older Australians decreases risk of frailty without increasing the risk of developing chronic disease', *The Journal of Frailty & Aging*, vol. 1, no. 4, pp. 174-82.

Beaupre, LA, Jones, CA, Johnston, DWC, Wilson, DM & Majumdar, SR 2012, 'Recovery of function following a hip fracture in geriatric ambulatory persons living in nursing homes: prospective cohort study', *Journal of the American Geriatrics Society*, vol. 60, no. 7, pp. 1268-73.

Beck, AM, Wijnhoven, HAH & Lassen, KØ 2011, 'A review of the effect of oral nutritional interventions on both weight change and functional outcomes in older nursing home residents', *e-SPEN*, vol. 6, no. 3, pp. e101-e5.

Beckie, TM & Hayduk, LA 1997, 'Measuring quality of life', *Social Indicators Research*, vol. 42, no. 1, pp. 21-39.

Bentler, SE, Liu, L, Obrizan, M, Cook, EA, Wright, KB, Geweke, JF, Chrischilles, EA, Pavlik, CE, Wallace, RB, Ohsfeldt, RL, Jones, MP, Rosenthal, GE & Wolinsky, FD 2009, 'The aftermath of hip fracture: discharge placement, functional status change, and mortality', *American Journal of Epidemiology*, vol. 170, no. 10, pp. 1290-9.

Bertram, M, Norman, R, Kemp, L & Vos, T 2011, 'Review of the long-term disability associated with hip fractures', *Injury Prevention*, vol. 17, no. 6, pp. 365-70.

Bessette, L, Jean, S, Lapointe-Garant, MP, Belzile, EL, Davison, KS, Ste-Marie, LG & Brown, JP 2012, 'Direct medical costs attributable to peripheral fractures in Canadian post-menopausal women', *Osteoporosis International*, vol. 23, no. 6, pp. 1757-68.

Bilotta, C, Bowling, A, Case, A, Nicolini, P, Mauri, S, Castelli, M & Vergani, C 2010, 'Dimensions and correlates of quality of life according to frailty status: a cross-sectional study on community-dwelling older adults referred to an outpatient geriatric service in Italy', *Health and Quality of Life Outcomes*, vol. 8, no. 56, pp. 1-10.

Bjornelv, GMW, Frihagen, F, Madsen, JE, Nordsletten, L & Aas, E 2012, 'Hemiarthroplasty compared to internal fixation with percutaneous cannulated screws as treatment of displaced femoral neck fractures in the elderly: cost-utility analysis performed alongside a randomized, controlled trial', *Osteoporosis International*, vol. 23, no. 6, pp. 1711-9.

Black, WC 1990, 'The CE plane: a graphic representation of cost-effectiveness', *Medical Decision Making*, vol. 10, no. 3, pp. 212-4.

Bland, JM & Altman, DG 1999, 'Measuring agreement in method comparison studies', *Statistical Methods in Medical Research*, vol. 8, no. 2, pp. 135-60.

Bland, M 2000, *An Introduction to Medical Statistics*, Oxford University Press, Oxford.

Bliuc, D, Nguyen, ND, Milch, VE, Nguyen, TV, Eisman, JA & Center, JR 2009, 'Mortality risk associated with low-trauma osteoporotic fracture and subsequent fracture in men and women', *JAMA - Journal of the American Medical Association*, vol. 301, no. 5, pp. 513-21.

Borgstrom, F, Lekander, I, Ivergard, M, Strom, O, Svedbom, A, Alekna, V, Bianchi, ML, Clark, P, Curiel, MD, Dimai, HP, Jurisson, M, Kallikorm, R, Lesnyak, O, McCloskey, E, Nassonov, E, Sanders, KM, Silverman, S, Tamulaitiene, M, Thomas, T, Tosteson, ANA, Jonsson, B & Kanis, JA 2013, 'The international costs and utilities related to osteoporotic fractures study (ICUROS)- quality of life during the first 4 months after fracture', *Osteoporosis International*, vol. 24, no. 3, pp. 811-23.

Borgström, F, Zethraeus, N, Johnell, O, Lidgren, L, Ponzer, S, Svensson, O, Abdon, P, Ornstein, E, Lunsjö, K, Thorngren, K, Sernbo, I, Rehnberg, C & Jönsson, B 2006, 'Costs and quality of life associated with osteoporosis-related fractures in Sweden', *Osteoporosis International*, vol. 17, no. 5, pp. 637-50.

Bowling, A 2005, 'Measuring health outcomes from the patient's perspective', in A Bowling & S Ebrahim (eds), *Handbook of Health Research Methods: Investigation, Measurement, and Analysis*, Open University Press, Maidenhead, England.

Braithwaite, RS, Col, NF & Wong, JB 2003, 'Estimating hip fracture morbidity, mortality and costs', *Journal of the American Geriatrics Society*, vol. 51, no. 3, pp. 364-70.

Brazier, J & Ratcliffe, J 2008, 'The measurement and valuation of health for economic evaluation', in K Heggenhougen (ed.), *International Encyclopedia of Public Health*, Academic Press, Oxford, pp. 252-61.

Brazier, J, Ratcliffe, J, Salomon, J & Tsuchiya, A 2007, 'Methods for obtaining health state values: generic preference-based measures of health and the alternatives', in *Measuring and Valuing Health Benefits for Economic Evaluation*, Oxford University Press, Oxford.

Brown, J 2005, 'Economic evaluation of health care', in A Bowling & S Ebrahim (eds), *Handbook of Health Research Methods: Investigation, Measurement and Analysis*, Open University Press, Maidenhead.

Bruce, D, Laurance, I, Ng, L & Goldswain, P 1999, 'Undernourished patients with hip fracture: poor outcome is not due to excess infections', *Australasian Journal on Ageing*, vol. 18, no. 3, pp. 119-23.

Bryant, DM, Sanders, DW, Coles, CP, Petrisor, BA, Jeray, KJ & Laflamme, GY 2009, 'Selection of outcome measures for patients with hip fracture', *Journal of*

Orthopaedic Trauma, vol. 23, no. 6, pp. 434-41.

Burstrom, K, Johannesson, M & Diderichsen, F 2001a, 'Health-related quality of life by disease and socio-economic group in the general population in Sweden', *Health Policy*, vol. 55, no. 1, pp. 51-69.

Burstrom, K, Johannesson, M & Diderichsen, F 2001b, 'Swedish population health-related quality of life results using the EQ-5D', *Quality of Life Research*, vol. 10, no. 7, pp. 621-35.

Butterworth, CE 1974, 'The skeleton in the hospital closet', *Nutrition Today*, vol. 9, no. 2, pp. 4-8.

Cameron, ID, Lyle, DM & Quine, S 1994, 'Cost effectiveness of accelerated rehabilitation after proximal femoral fracture', *Journal of Clinical Epidemiology*, vol. 47, no. 11, pp. 1307-13.

Cantril, H 1965, *The pattern of human concerns*, Rutgers University Press, New Brunswick, USA.

Carinci, F, Roti, L, Francesconi, P, Gini, R, Tediosi, F, Di Iorio, T, Bartolacci, S & Buiatti, E 2007, 'The impact of different rehabilitation strategies after major events in the elderly: the case of stroke and hip fracture in the Tuscany region', *BMC Health Services Research*, vol. 7, no. 95, pp. 1-10.

Carr, AJ, Gibson, B & Robinson, PG 2001, 'Measuring quality of life: is quality of life determined by expectations or experience?', *British Medical Journal*, vol. 322, no. 7296, pp. 1240-3.

Cassell, E & Clapperton, A 2012, 'A decreasing trend in fall-related hip fracture incidence in Victoria, Australia', *Osteoporosis International*, pp. 1-11.

Center, JR, Bliuc, D, Nguyen, TV & Eisman, JA 2007, 'Risk of subsequent fracture after low-trauma fracture in men and women', *Journal of the American Medical Association*, vol. 297, no. 4, pp. 387-94.

Chen, JS, Sambrook, PN, Simpson, JM, Cameron, ID, Cumming, RG, Seibel, MJ, Lord, SR & March, LM 2009, 'Risk factors for hip fracture among institutionalised older people', *Age and Ageing*, vol. 38, no. 4, pp. 429-34.

Cheng, SY, Levy, AR, Lefaivre, KA, Guy, P, Kuramoto, L & Sobolev, B 2011, 'Geographic trends in incidence of hip fractures: a comprehensive literature review', *Osteoporosis International*, vol. 22, no. 10, pp. 2575-86.

Chevalier, S, Saoud, F, Gray-Donald, K & Morais, JA 2008, 'The physical functional capacity of frail elderly persons undergoing ambulatory rehabilitation is related to their nutritional status', *Journal of Nutrition, Health and Aging*, vol. 12, no. 10, pp. 721-6.

Clark, P, Carlos, F, Barrera, C, Guzman, J, Maetzel, A, Lavielle, P, Ramirez, E, Robinson, V, Rodriguez-Cabrera, R, Tamayo, J & Tugwell, P 2008, 'Direct costs of osteoporosis and hip fracture: an analysis for the Mexican healthcare system', *Osteoporosis International*, vol. 19, no. 3, pp. 269-76.

Coast, J, Al-Janabi, H, Sutton, EJ, Horrocks, SA, Vosper, AJ, Swancutt, DR & Flynn, TN 2012, 'Using qualitative methods for attribute development for discrete choice experiments: issues and recommendations', *Health Economics*, vol. 21, no. 6, pp. 730-41.

Coast, J, Flynn, TN, Natarajan, L, Sproston, K, Lewis, J, Louviere, JJ & Peters, TJ 2008a, 'Valuing the ICECAP capability index for older people', *Social Science &Medicine*, vol. 67, no. 5, pp. 874-82.

Coast, J, Peters, TJ, Natarajan, L, Sproston, K & Flynn, T 2008b, 'An assessment of the construct validity of the descriptive system for the ICECAP capability measure for older people', *Quality of Life Research*, vol. 17, no. 7, pp. 967-76.

Coe, MP, Greiwe, RM, Joshi, R, Snyder, BM, Simpson, L, Tosteson, ANA, Ahmad, CS, Levine, WN & Bell, JE 2012, 'The cost-effectiveness of reverse total shoulder arthroplasty compared with hemiarthroplasty for rotator cuff tear arthropathy', *Journal of Shoulder and Elbow Surgery*, vol. 21, no. 10, pp. 1278-88.

Comans, TA, Peel, NM, Gray, LC & Scuffham, PA 2013, 'Quality of life of older frail persons receiving a post-discharge program', *Health and Quality of Life Outcomes*, vol. 11, no. 58, pp. 1-7.

Commonwealth Department of Health and Ageing 2002, *Guidelines for the* *pharmaceutical industry on preparation of submissions to the Pharmaceutical Benefits Advisory Committee: including major submissions involving economic analyses*, ISBN: 0 642 82144 5, Australian Government, Canberra, Australia.

—— 2009, *National hospital cost data collection cost report round 12 (2007-2008)*, Australian Government, Canberra, Australia.

—— 2010, *National hospital cost data collection cost report round 13 (2008-2009)*, Australian Government, Canberra, Australia.

—— 2012, *National hospital cost data collection cost report round 14 (2009-2010)*, Australian Government, Canberra, Australia.

Cooper, C, Cole, ZA, Holroyd, CR, Earl, SC, Harvey, NC, Dennison, EM, Melton, LJ, Cummings, SR & Kanis, JA 2011, 'Secular trends in the incidence of hip and other osteoporotic fractures', *Osteoporosis International*, vol. 22, no. 5, pp. 1277-88.

Cornally, N & McCarthy, G 2011, 'Help-seeking behaviour for the treatment of chronic pain', *British Journal of Community Nursing*, vol. 16, no. 2, pp. 90-8.

Corrieri, S, Heider, D, Riedel-Heller, SG, Matschinger, H & König, HH 2011, 'Cost-effectiveness of fall prevention programs based on home visits for seniors aged over 65 years: a systematic review', *International Psychogeriatrics*, vol. 23, no. 5, pp. 711-23.

Coucill, W, Bryan, S, Bentham, P, Buckley, A & Laight, A 2001, 'EQ-5D in patients with dementia- an investigation of inter-rater agreement', *Medical Care*, vol. 39, no. 8, pp. 760-71.

Couzner, L, Crotty, M, Norman, R & Ratcliffe, J 2013, 'A comparison of the EQ-5D-3L and ICECAP-O in an older post-acute patient population relative to the general population', *Applied Health Economics and Health Policy*, vol. 11, no. 4, pp. 415-25.

Couzner, L, Ratcliffe, J & Crotty, M 2012a, 'The relationship between quality of life, health and care transition: an empirical comparison in an older post-acute population', *Health & Quality of Life Outcomes*, vol. 10, no. 69, pp. 1-9.

Couzner, L, Ratcliffe, J, Lester, L, Flynn, T & Crotty, M 2012b, 'Measuring and valuing quality of life for public health research: application of the ICECAP-O capability index in the Australian general population', *International Journal of Public Health*, vol. 53, no. 3, pp. 367-76.

Cranney, A, Coyle, D, Pham, BA, Tetroe, J, Wells, G, Jolly, E & Tugwell, P 2001, 'The psychometric properties of patient preferences in osteoporosis', *Journal of Rheumatology*, vol. 28, no. 1, pp. 132-7.

Cranney, AB, Coyle, D, Hopman, WM, Hum, V, Power, B & Tugwell, PS 2005, 'Prospective evaluation of preferences and quality of life in women with hip fractures', *Journal of Rheumatology*, vol. 32, no. 12, pp. 2393-9.

Crisp, A, Dixon, T, Jones, G, Cumming, RG, Laslett, LL, Bhatia, K, Webster, A & Ebeling, PR 2012, 'Declining incidence of osteoporotic hip fracture in Australia', *Archives of Osteoporosis*, vol. 7, no. 1-2, pp. 179-85.

Crotty, M & Ratcliffe, J 2011, 'If Mohammed won't come to the mountain, the mountain must go to Mohammed', *Age and Ageing*, vol. 40, no. 3, pp. 290-2.

Crotty, M, Unroe, K, Cameron Ian, D, Miller, M, Ramirez, G & Couzner, L 2010, 'Rehabilitation interventions for improving physical and psychosocial functioning after hip fracture in older people', *Cochrane Database of Systematic Reviews*, no. 1, DOI 10.1002/14651858.CD007624.pub3, Available from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD007624.pub3/abstract>.

Cummings-Vaughn, LA & Gammack, JK 2011, 'Falls, osteoporosis, and hip fractures', *Medical Clinics of North America*, vol. 95, no. 3, pp. 495-506, x.

Curran, D, Maravic, M, Kiefer, P, Tochon, V & Fardellone, P 2010, 'Epidemiology of osteoporosis-related fractures in France: a literature review', *Joint Bone Spine*, vol. 77, no. 6, pp. 546-51.

DAA Malnutrition Guideline Steering Committee 2009, 'Evidence based practice guidelines for the nutritional management of malnutrition in adult patients across the continuum of care', *Nutrition & Dietetics*, vol. 66, pp. S1-S34.

Dahlberg, LE, Holme, I, Høye, K & Ringertz, B 2009, 'A randomized, multicentre, double-blind, parallel-group study to assess the adverse event-related discontinuation rate with celecoxib and diclofenac in elderly patients with osteoarthritis', *Scandinavian Journal of Rheumatology*, vol. 38, no. 2, pp. 133-43.

Dangour, AD, Albala, C, Allen, E, Grundy, E, Walker, DG, Aedo, C, Sanchez, H, Fletcher, O, Elbourne, D & Uauy, R 2011, 'Effect of a nutrition supplement and physical activity program on pneumonia and walking capacity in Chilean older people: a factorial cluster randomized trial', *PLoS Medicine*, vol. 8, no. 4, p. e1001023.

Darbà, J, Restovic, G, Kaskens, L, Balbona, MA, Carbonell, A, Cavero, P, Jordana, M, Prieto, C, Molina, Á & Padró, I 2011, 'Patient preferences for osteoporosis in Spain: a discrete choice experiment', *Osteoporosis International*, vol. 22, no. 6, pp. 1947-54.

Darmon, P, Lochs, H & Pichard, C 2008, 'Economic impact and quality of life as endpoints of nutritional therapy', *Current Opinion in Clinical Nutrition and Metabolic Care*, vol. 11, no. 4, pp. 452-8.

Davis, JC, Bryan, S, McLeod, R, Rogers, J, Khan, K & Liu-Ambrose, T 2012, 'Exploration of the association between quality of life, assessed by the EQ-5D and ICECAP-O, and falls risk, cognitive function and daily function, in older adults with mobility impairments', *BMC Geriatrics*, vol. 12, no. 65, pp. 1-7.

Davis, JC, Robertson, MC, Ashe, MC, Liu-Ambrose, T, Khan, KM & Marra, CA 2010, 'Does a home-based strength and balance programme in people aged ≥80 years provide the best value for money to prevent falls? A systematic review of economic evaluations of falls prevention interventions', *British Journal of Sports Medicine*, vol. 44, no. 2, pp. 80-9.

De Bekker-Grob, EW, Bliemer, MCJ, Donkers, B, Essink-Bot, ML, Korfage, IJ, Roobol, MJ, Bangma, CH & Steyerberg, EW 2013, 'Patients' and urologists' preferences for prostate cancer treatment: a discrete choice experiment', *British Journal of Cancer*, vol. 109, no. 3, pp. 633-40.

De Bekker-Grob, EW, Ryan, M & Gerard, K 2012, 'Discrete choice experiments in health economics: a review of the literature', *Health Economics*, vol. 21, pp. 145-72.

De Laet, C, van Hout, BA, Burger, H, Weel, A, Hofman, A & Pols, HAP 1999, 'Incremental cost of medical care after hip fracture and first vertebral fracture: the Rotterdam study', *Osteoporosis International*, vol. 10, no. 1, pp. 66-72.

De Morton, NA, Keating, JL & Jeffs, K 2007, 'The effect of exercise on outcomes for older acute medical inpatients compared with control or alternative treatments: a systematic review of randomized controlled trials', *Clinical Rehabilitation*, vol. 21, no. 1, pp. 3-16.

Delmi, M, Rapin, CH, Bengoa, JM, Delmas, PD, Vasey, H & Bonjour, JP 1990, 'Dietary supplementation in elderly patients with fractured neck of the femur', *Lancet*, vol. 335, no. 8696, pp. 1013-6.

Di Monaco, M, Castiglioni, C, Vallero, F, Di Monaco, R & Tappero, R 2012, 'Men recover ability to function less than women do: an observational study of 1094 subjects after hip fracture', *American Journal of Physical Medicine and Rehabilitation*, vol. 91, no. 4, pp. 309-15.

Dickerson, JW, Soper, R & Older, MW 1979, 'Nutrient intake in elderly women after femoral neck fracture', *The Proceedings of the Nutrition Society*, vol. 38, no. 2, p. 52A.

Dixon, S, Nancarrow, SA, Enderby, PM, Moran, AM & Parker, SG 2013, 'Assessing patient preferences for the delivery of different community-based models of care using a discrete choice experiment', *Health Expectations*.

Dolan, P 1997, 'Modeling valuations for EuroQol health states', *Medical Care*, vol. 35, no. 11, pp. 1095-108.

Dolan, P & Togerson, DJ 1998, 'The cost of treating osteoporotic fractures in the United Kingdom female population', *Osteoporosis International*, vol. 8, no. 6, pp. 611-7.

Drummond, MF, Sculpher, MJ, Torrance, GW, O'Brien, BJ & Stoddart, GL 2005, *Methods for the Economic Evaluation of Health Care Programmes*, 3rd edn, Oxford University Press, Oxford.

Dziedzic, KS, Hill, S, Nicholls, E, Hammond, A, Myers, H, Whitehurst, T, Bailey, J, Clements, C, Whitehurst, DGT, Jowett, S, Handy, J, Hughes, RW, Thomas, E & Hay, EM 2011, 'Self management, joint protection and exercises in hand osteoarthritis: a randomised controlled trial with cost effectiveness analyses', *BMC Musculoskeletal Disorders*, vol. 12, no. 156, pp. 1-15.

Edington, J, Barnes, R, Bryan, F, Dupree, E, Frost, G, Hickson, M, Lancaster, J, Mongia, S, Smith, J, Torrance, A, West, R, Pang, F & Coles, SJ 2004, 'A prospective randomised controlled trial of nutritional supplementation in malnourished elderly in the community: clinical and health economic outcomes', *Clinical Nutrition*, vol. 23, no. 2, pp. 195-204.

Eisenstein, EL, Yusuf, S, Bindal, V, Bourassa, MG, Horney, A, Collins, JF & Mark, DB 2006, 'What is the economic value of Digoxin therapy in congestive heart failure patients? Results from the DIG trial', *Journal of Cardiac Failure*, vol. 12, no. 5, pp. 336-42.

Ekstrom, W, Nemeth, G, Samnegard, E, Dalen, N & Tidermark, J 2009, 'Quality of life after a subtrochanteric fracture: a prospective cohort study on 87 elderly patients', *Injury-International Journal of the Care of the Injured*, vol. 40, no. 4, pp. 371-6.

Elia, M, Stratton, R, Russell, C, Green, C & Pan, F 2005, *The cost of disease-related malnutrition in the UK and economic consideration for the use of oral nutritional supplements (ONS) in adults*,Avaliable from: http://www.bapen.org.uk/pdfs/health_econ_exec_sum.pdf. Accessed 11 January 2012.

Endevelt, R, Lemberger, J, Bregman, J, Kowen, G, Berger-Fecht, I, Lander, H, Karpati, T & Shahar, DR 2011, 'Intensive dietary intervention by a dietitian as a case manager among community dwelling older adults: the Edit study', *Journal of Nutrition, Health and Aging*, vol. 15, no. 8, pp. 624-30.

Eneroth, M, Olsson, U-B & Thorngren, K-G 2005, 'Insufficient fluid and energy intake in hospitalised patients with hip fracture. A prospective randomised study of 80 patients', *Clinical Nutrition*, vol. 24, no. 2, pp. 297-303.

Enocson, A, Pettersson, H, Ponzer, S, Tornkvist, H, Dalen, N & Tidermark, J 2009, 'Quality of life after dislocation of hip arthroplasty: a prospective cohort study on 319 patients with femoral neck fractures with a one-year follow-up', *Quality of Life Research*, vol. 18, no. 9, pp. 1177-84.

Fanshel, S & Bush, JW 1970, 'A health-status index and its application to health-services outcomes', *Operations Research*, vol. 18, pp. 1021-66.

Feehan, LM, Beck, CA, Harris, SR, Macintyre, DL & Li, LC 2011, 'Exercise prescription after fragility fracture in older adults: a scoping review', *Osteoporosis International*, vol. 22, no. 5, pp. 1289-322.

Flynn, T, Louviere, J, Huynh, E & Terlich, F 2010, 'What are Australian preferences for quality of life? Results from best-worst scaling studies to value the ICECAP instruments', paper presented to Australian Health Economics Society Meeting, 30 September-1 October, Sydney.

Flynn, TN, Chan, P, Coast, J & Peters, TJ 2011, 'Assessing quality of life among British older people using the ICEPOP CAPability (ICECAP-O) measure', *Applied Health Economics and Health Policy*, vol. 9, no. 5, pp. 317-29.

Folstein, MF, Folstein, SE & McHugh, PR 1975, '"Mini-mental state": a practical method for grading the cognitive state of patients for the clinician', *Journal of Psychiatric Research*, vol. 12, no. 3, pp. 189-98.

Fordham, R, Thompson, R, Holmes, J & Hodkinson, C 1986, *A cost-benefit study of geriatric-orthopaedic management of patients with fractured neck of femur*, University of York Centre for Health Economics, York.

Forster, A, Lambley, R & Young, JB 2010, 'Is physical rehabilitation for older people in long-term care effective? Findings from a systematic review', *Age and Ageing*, vol. 39, no. 2, pp. 169-75.

Freijer, K & Nuijten, MJ 2010, 'Analysis of the health economic impact of medical nutrition in the Netherlands', *European Journal of Clinical Nutrition*, vol. 64, no. 10, pp. 1229-34.

Freijer, K, Nuijten, MJC & Schols, JMGA 2012, 'The budget impact of oral nutritional supplements for disease related malnutrition in elderly in the community setting', *Frontiers in Pharmacology*, vol. 3, no. 78, pp. 1-8.

Frost, SA, Nguyen, ND, Center, JR, Eisman, JA & Nguyen, TV 2013, 'Excess mortality attributable to hip-fracture: a relative survival analysis', *Bone*, vol. 56, no. 1, pp. 23-9.

Fryback, DG, Dunham, NC, Palta, M, Hanmer, J, Buechner, J, Cherepanov, P, Herrington, SA, Hays, RD, Kaplan, RM, Ganiats, TG, Feeny, D & Kind, P 2007, 'US norms for six generic health-related quality-of-life indexes from the national health measurement study', *Medical Care*, vol. 45, no. 12, pp. 1162-70.

Gabriel, SE, Tosteson, ANA, Leibson, CL, Crowson, CS, Pond, GR, Hammond, CS & Melton, LJ 2002, 'Direct medical costs attributable to osteoporotic fractures', *Osteoporosis International*, vol. 13, no. 4, pp. 323-30.

Gabriel, Z & Bowling, A 2004, 'Quality of life from the perspectives of older people', *Ageing & Society*, vol. 24, no. 05, pp. 675-91.

Gallagher-Allred, CR, Coble Voss, A, Finn, SC & McCamish, MA 1996, 'Malnutrition and clinical outcomes: the case for medical nutrition therapy', *Journal of the American Dietetic Association*, vol. 96, no. 4, pp. 361-9.

Galvard, H & Samuelsson, SM 1995, 'Orthopedic or geriatric rehabilitation of hip fracture patients: a prospective, randomized, clinically controlled study in Malmo, Sweden', *Aging*, vol. 7, no. 1, pp. 11-6.

Gariballa, S & Forster, S 2007, 'Dietary supplementation and quality of life of older patients: a randomized, double-blind, placebo-controlled trial', *Journal of the American Geriatrics Society*, vol. 55, no. 12, pp. 2030-4.

Gary, R & Fleury, J 2002, 'Nutritional status: key to preventing functional decline in hospitalized older adults', *Topics in Geriatric Rehabilitation*, vol. 17, no. 3, pp. 40-71.

Giles, L, Halbert, J, Stepien-Hulleman, J, Eckermann, S, Masters, S, Prendergast, J, Whitehead, C, Cheney, F & Crotty, M 2008, *National evaluation of the Transition Care Program: final report RFT 206/0506*, Australian Government, Canberra, Australia.

Gjertsen, J-E, Fevang, JM, Matre, K, Vinje, T & Engesaeter, LB 2011, 'Clinical outcome after undisplaced femoral neck fractures', *Acta Orthopaedica*, vol. 82, no. 3, pp. 268-74.

Glick, HA, Briggs, AH & Polsky, D 2001, 'Quantifying stochastic uncertainty and presenting results of cost-effectiveness analyses', *Expert Review of Pharmacoeconomics and Outcomes Research*, vol. 1, no. 1, pp. 25-36.

Gold, M, Siegel, J, Russell, L & Weinstein, M (eds) 1996, *Cost-Effectiveness in Health and Medicine*, Oxford University Press, New York, NY.

Golicki, D, Niewada, M, Jakubczyk, M, Wrona, W & Hermanowski, T 2010, 'Self-assessed health status in Poland: EQ-5D findings from the Polish valuation study', *Polskie Archiwum Medycyny Wewnetrznej*, vol. 120, no. 7-8, pp. 276-81.

Grad, FP 2002, 'The preamble of the constitution of the World Health Organization', *Bulletin of the World Health Organization*, vol. 80, no. 12, pp. 981-4.

Grbic, G, Djokic, D, Kocic, S, Mitrasinovic, D, Rakic, L, Prelevic, R, Krivokapic, Z & Miljkovic, S 2011, 'Influence of demographic and socioeconomic characteristics on the quality of life', *Srpski Arhiv Za Celokupno Lekarstvo*, vol. 139, no. 5-6, pp. 360-5.

Greer, S 1984, 'The psychological dimension in cancer treatment', *Social Science and Medicine*, vol. 18, no. 4, pp. 345-9.

Guo, Z, Wills, P, Viitanen, M, Fastbom, J & Winblad, B 1998, 'Cognitive impairment, drug use, and the risk of hip fracture in persons over 75 years old: a community-based prospective study', *American Journal of Epidemiology*, vol. 148, no. 9, pp. 887-92.

Gutiérrez, L, Roskell, N, Castellsague, J, Beard, S, Rycroft, C, Abeysinghe, S, Shannon, P, Robbins, S & Gitlin, M 2011, 'Study of the incremental cost and clinical burden of hip fractures in postmenopausal women in the United Kingdom', *Journal of Medical Economics*, vol. 14, no. 1, pp. 99-107.

Hagino, H, Nakamura, T, Fujiwara, S, Oeki, M, Okano, T & Teshima, R 2009, 'Sequential change in quality of life for patients with incident clinical fractures: a prospective study', *Osteoporosis International*, vol. 20, no. 5, pp. 695-702.

Halbert, J, Crotty, M, Whitehead, C, Cameron, I, Kurrle, S, Graham, S, Handoll, H, Finnegan, T, Joness, T, Foleys, A & Shanahan, M 2007, 'Multi-disciplinary rehabilitation after hip fracture is associated with improved outcome: a systematic review', *Journal of Rehabilitation Medicine*, vol. 39, no. 7, pp. 507-12.

Haleem, S, Lutchman, L, Mayahi, R, Grice, JE & Parker, MJ 2008, 'Mortality following hip fracture: trends and geographical variations over the last 40 years', *Injury*, vol. 39, no. 10, pp. 1157-63.

Hall, SE, Williams, JA, Senior, JA, Goldswain, PR & Criddle, RA 2000, 'Hip fracture outcomes: quality of life and functional status in older adults living in the community', *Australian and New Zealand Journal of Medicine*, vol. 30, no. 3, pp. 327-32.

Hallan, S, Åsberg, A, Indredavik, B & Widerøe, TE 1999, 'Quality of life after cerebrovascular stroke: a systematic study of patients' preferences for different functional outcomes', *Journal of Internal Medicine*, vol. 246, no. 3, pp. 309-16.

Hammond, KA 2004, 'Dietary and clinical assessment', in LK Mahan & S Escott-Stump (eds), *Krause's Food Nutrition and Diet Therapy*, 11th edn, Saunders, Philadelphia.

Handoll, HHG, Cameron, ID, Mak, JCS & Finnegan, TP 2009, 'Multidisciplinary rehabilitation for older people with hip fractures', *Cochrane Database of Systematic Reviews*, no. 4, DOI 10.1002/14651858.CD007125.pub2, Availble from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD007125.pub2/abstract>.

Handoll, HHG, Sherrington, C & Mak, JCS 2011, 'Interventions for improving mobility after hip fracture surgery in adults', *Cochrane Database of Systematic Reviews*, no. 3, DOI 10.1002/14651858.CD001704.pub4, Availble from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD001704.pub4/abstract>.

Hanmer, J, Lawrence, WF, Anderson, JP, Kaplan, RM & Fryback, DG 2006, 'Report of nationally representative values for the noninstitutionalized US adult population for 7 health-related quality-of-life scores', *Medical Decision Making*, vol. 26, no. 4, pp. 391-400.

Harris, AH, Cumming, R, Watts, J, Ebeling, P & Crowley, S 1998, *The burden of illness and the cost of osteoporosis in Australia*, Centre for Health Program Evaluation, Melbourne.

Harris, AH, Hill, SR, Chin, G, Jing Jing, L & Walkom, E 2008, 'The role of value for money in public insurance coverage decisions for drugs in Australia: a retrospective analysis 1994-2004', *Medical Decision Making*, vol. 28, no. 5, pp. 713-22.

Harris, I, Madan, A, Naylor, J & Chong, S 2012, 'Mortality rates after surgery in

New South Wales', *ANZ Journal of Surgery*, vol. 82, no. 12, pp. 871-7.

Harris, NG 2004, 'Nutrition in Aging', in LK Mahan & S Escott-Stump (eds), *Krause's Food, Nutrition, and Diet Therapy*, 11th edn, Saunders, Philadelphia.

Harrison Research 2010, *Findings from spring 2009 health omnibus survey*, Harrison Research, Kent Town, Adelaide.

Hawthorne, G, Richardson, J, Day, N, Osborne, R & McNeil, H 2000, *Construction and utility scaling of the Assessment of Quality of Life (AQOL) instrument*, Centre for Health Program Evaluation, Melbourne.

Hawthorne, G, Richardson, J & Osborne, R 1999, 'The Assessment of Quality of Life (AQoL) instrument: a psychometric measure of health-related quality of life', *Quality of Life Research*, vol. 8, no. 3, pp. 209-24.

Hawton, A, Green, C, Dickens, AP, Richards, SH, Taylor, RS, Edwards, R, Greaves, CJ & Campbell, JL 2011, 'The impact of social isolation on the health status and health-related quality of life of older people', *Quality of Life Research*, vol. 20, no. 1, pp. 57-67.

Hedbeck, CJ, Blomfeldt, R, Lapidus, G, Tornkvist, H, Ponzer, S & Tidermark, J 2011, 'Unipolar hemiarthroplasty versus bipolar hemiarthroplasty in the most elderly patients with displaced femoral neck fractures: a randomised, controlled trial', *International Orthopaedics*, vol. 35, no. 11, pp. 1703-11.

Hedström, M, Ljungqvist, O & Cederholm, T 2006, 'Metabolism and catabolism in hip fracture patients: nutritional and anabolic intervention - a review', *Acta Orthopaedica*, vol. 77, no. 5, pp. 741-7.

Hershkovitz, A, Kalandariov, Z, Hermush, V, Weiss, R & Brill, S 2007, 'Factors affecting short-term rehabilitation outcomes of disabled elderly patients with proximal hip fracture', *Archives of Physical Medicine and Rehabilitation*, vol. 88, no. 7, pp. 916-21.

Higgins, JPT & Altman, DG 2008, 'Assessing risk of bias in included studies', in *Cochrane Handbook for Systematic Reviews of Interventions*, John Wiley & Sons, Ltd, pp. 187-241.

Hiligsmann, M, Ethgen, O, Richy, F & Reginster, JY 2008, 'Utility values associated with osteoporotic fracture: a systematic review of the literature', *Calcified Tissue International*, vol. 82, no. 4, pp. 288-92.

Hoffer, LJ 2014, 'Metabolic consequences of starvation', in AC Ross, B Caballero, RJ Cousins, KL Tucker & TR Ziegler (eds), *Modern Nutrition in Health and Disease*, 11th edn, Lippincott Williams and Wilkins, Philadelphia.

Hollingworth, W, Todd, CJ & Parker, MJ 1995, 'The cost of treating hip-fractures in the 21st century', *Journal of Public Health Medicine*, vol. 17, no. 3, pp. 269-76.

Hommel, A, Bjorkelund, KB, Thorngren, KG & Ulander, K 2007, 'Nutritional status among patients with hip fracture in relation to pressure ulcers', *Clinical Nutrition*, vol. 26, no. 5, pp. 589-96.

Hoogendoorn, M, Van Wetering, CR, Schols, AM & Rutten-van Mölken, MPMH 2010, 'Is INTERdisciplinary COMmunity-based COPD management (INTERCOM) cost-effective?', *European Respiratory Journal*, vol. 35, no. 1, pp. 79-87.

Hounsome, N, Orrell, M & Edwards, RT 2011, 'EQ-5D as a quality of life measure in people with dementia and their carers: evidence and key issues', *Value in Health*, vol. 14, no. 2, pp. 390-9.

Hutchings, L, Fox, R & Chesser, T 2011, 'Proximal femoral fractures in the elderly: how are we measuring outcome?', *Injury*, vol. 42, no. 11, pp. 1205-13.

Huusko, TM, Karppi, P, Avikainen, V, Kautiainen, H & Sulkava, R 2002, 'Intensive geriatric rehabilitation of hip fracture patients: a randomised controlled trial', *Acta Orthopaedica*, vol. 73, no. 4, pp. 425-31.

Icks, A, Arend, W, Becker, C, Rapp, K, Jungbluth, P & Haastert, B 2013, 'Incidence of hip fractures in Germany, 1995-2010', *Archives of Osteoporosis*, vol. 8, no. 140, pp. 1-7.

Iorio, R, Healy, WL, Appleby, D, Milligan, J & Dube, M 2004, 'Displaced femoral neck fractures in the elderly: disposition and outcome after 3- to 6-year follow-up evaluation', *Journal of Arthroplasty*, vol. 19, no. 2, pp. 175-9.

Jean, S, O'Donnell, S, Lagace, C, Walsh, P, Bancej, C, Brown, JP, Morin, S, Papaioannou, A, Jaglal, SB & Leslie, WD 2013, 'Trends in hip fracture rates in Canada: an age-period-cohort analysis', *Journal of Bone and Mineral Research*, vol. 28, no. 6, pp. 1283-9.

Johannesson, M, Dahlof, B, Lindholm, LH, Ekbom, T, Hansson, L, Oden, A, Scherstein, B, Wester, PO & Jonsson, B 1993, 'The cost-effectiveness of treating hypertension in elderly people - an analysis of the Swedish trial in old patients with hypertension (STOP Hypertension)', *Journal of Internal Medicine*, vol. 234, no. 3, pp. 317-23.

Johansson, T, Bachrach-Lindstrom, M, Aspenberg, P, Jonsson, D & Wahlstrom, O 2006, 'The total costs of a displaced femoral neck fracture: comparison of internal fixation and total hip replacement - a randomised study of 146 hips', *International Orthopaedics*, vol. 30, no. 1, pp. 1-6.

Kanauchi, M, Kubo, A, Kanauchi, K & Saito, Y 2008, 'Frailty, health-related quality of life and mental well-being in older adults with cardiometabolic risk factors', *International Journal of Clinical Practice*, vol. 62, no. 9, pp. 1447-51.

Kanis, JA, Johansson, H, Oden, A & McCloskey, EV 2009, 'Assessment of fracture risk', *European Journal of Radiology*, vol. 71, no. 3, pp. 392-7.

Kanis, JA, Johnell, O, De Laet, C, Jonsson, B, Oden, A & Ogelsby, AK 2002, 'International variations in hip fracture probabilities: implications for risk assessment', *Journal of Bone and Mineral Research*, vol. 17, no. 7, pp. 1237-44.

Kanis, JA, Oden, A, McCloskey, EV, Johansson, H, Wahl, DA & Cooper, C 2012, 'A systematic review of hip fracture incidence and probability of fracture worldwide', *Osteoporosis International*, vol. 23, no. 9, pp. 2239-56.

Karnofsky, DA, Abelmann, WH, Craver, LF & Burchenal, JH 1948, 'The use of the nitrogen mustards in the palliative treatment of carcinoma. With particular reference to bronchogenic carcinoma', *Cancer*, vol. 1, no. 4, pp. 634-56.

Koren-Hakim, T, Weiss, A, Hershkovitz, A, Otzrateni, I, Grosman, B, Frishman, S, Salai, M & Beloosesky, Y 2012, 'The relationship between nutritional status of hip fracture operated elderly patients and their functioning, comorbidity and outcome', *Clinical Nutrition*, vol. 31, no. 6, pp. 917-21.

Kottner, J, Audigé, L, Brorson, S, Donner, A, Gajewski, BJ, Hróbjartsson, A, Roberts, C, Shoukri, M & Streiner, DL 2011, 'Guidelines for reporting reliability and agreement studies (GRRAS) were proposed', *Journal of Clinical Epidemiology*, vol. 64, no. 1, pp. 96-106.

Koval, KJ, Maurer, SG, Su, ET, Aharonoff, GB & Zuckerman, JD 1999, 'The effects of nutritional status on outcome after hip fracture', *Journal of Orthopaedic Trauma*, vol. 13, no. 3, pp. 164-9.

Kowal, SL, Dall, TM, Chakrabarti, R, Storm, MV & Jain, A 2013, 'The current and projected economic burden of Parkinson's disease in the United States', *Movement Disorders*, vol. 28, no. 3, pp. 311-8.

Kruizenga, HM, Van Tulder, MW, Seidell, JC, Thijs, A, Ader, HJ & Van Bokhorst-de van der Schueren, MA 2005, 'Effectiveness and cost-effectiveness of early screening and treatment of malnourished patients', *American Journal of Clinical Nutrition*, vol. 82, no. 5, pp. 1082-9.

Lai, JK, Lucas, RM, Armstrong, M & Banks, E 2013, 'Prospective observational study of physical functioning, physical activity and time outdoors and the risk of hip fracture: a population based cohort study of 158 057 older adults in the 45 and Up Study', *Journal of Bone and Mineral Research*.

Lancsar, E & Louviere, J 2006, 'Deleting 'irrational' responses from discrete choice experiments: a case of investigating or imposing preferences?', *Health Economics*, vol. 15, no. 8, pp. 797-811.

Laver, K, Ratcliffe, J, George, S, Burgess, L & Crotty, M 2011a, 'Is the Nintendo Wii Fit really acceptable to older people?: a discrete choice experiment', *BMC Geriatrics*, vol. 11, no. 64, pp. 1-6.

Laver, K, Ratcliffe, J, George, S, Lester, L & Crotty, M 2013, 'Preferences for rehabilitation service delivery: a comparison of the views of patients, occupational therapists and other rehabilitation clinicians using a discrete choice experiment', *Australian Occupational Therapy Journal*, vol. 60, no. 2, pp. 93-100.

Laver, K, Ratcliffe, J, George, S, Lester, L, Walker, R, Burgess, L & Crotty, M 2011b, 'Early rehabilitation management after stroke: what do stroke patients prefer?', *Journal of Rehabilitation Medicine*, vol. 43, pp. 354-8.

Lawson, RM, Doshi, MK, Barton, JR & Cobden, I 2003, 'The effect of unselected post-operative nutritional supplementation on nutritional status and clinical outcome of orthopaedic patients', *Clinical Nutrition*, vol. 22, no. 1, pp. 39-46.

Leavy, B, Åberg, AC, Melhus, H, Mallmin, H, Michaëlsson, K & Byberg, L 2013, 'When and where do hip fractures occur? A population-based study', *Osteoporosis International*, vol. 24, no. 9, pp. 2387-96.

Leibson, CL, Tosteson, ANA, Gabriel, SE, Ransom, JE & Melton Iii, LJ 2002, 'Mortality, disability, and nursing home use for persons with and without hip fracture: a population-based study', *Journal of the American Geriatrics Society*, vol. 50, no. 10, pp. 1644-50.

Li, HJ, Cheng, HS, Liang, J, Wu, CC & Shyu, YIL 2013, 'Functional recovery of older people with hip fracture: does malnutrition make a difference?', *Journal of Advanced Nursing*, vol. 69, no. 8, pp. 1691-703.

Liu, C-j & Latham, NK 2009, 'Progressive resistance strength training for improving physical function in older adults', *Cochrane Database of Systematic Reviews*, no. 3, DOI 10.1002/14651858.CD002759.pub2, Available from: <http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD002759.pub2/abstract>.

Lorefält, B, Andersson, A, Wirehn, AB & Wilhelmsson, S 2011, 'Nutritional status and health care costs for the elderly living in municipal residential homes - an intervention study', *Journal of Nutrition, Health and Aging*, vol. 15, no. 2, pp. 92-7.

Ludbrook, J 2010, 'Confidence in Altman-Bland plots: a critical review of the method of differences', *Clinical and Experimental Pharmacology and Physiology*, vol. 37, no. 2, pp. 143-9.

Lumbers, M, New, SA, Gibson, S & Murphy, MC 2001, 'Nutritional status in elderly female hip fracture patients: comparison with an age-matched home living group attending day centres', *British Journal of Nutrition*, vol. 85, no. 6, pp. 733-40.

Luo, N, Johnson, JA, Shaw, JW, Feeny, D & Coons, SJ 2005, 'Self-reported health status of the general adult US population as assessed by the EQ-5D and Health Utilities Index', *Medical Care*, vol. 43, no. 11, pp. 1078-86.

Lyritis, GP, Rizou, S, Galanos, A & Makras, P 2013, 'Incidence of hip fractures in Greece during a 30-year period: 1977-2007', *Osteoporosis International*, vol. 24, no. 5, pp. 1579-85.

Maffulli, N, Dougall, TW, Brown, MT & Golden, MH 1999, 'Nutritional differences in patients with proximal femoral fractures', *Age and Ageing*, vol. 28, no. 5, pp. 458-62.

Mak, J, Wong, E & Cameron, I 2010a, *Position statement 5: orthogeriatric care*, Australian and New Zealand Society for Geriatric Medicine, viewed 12th December 2012, Available from: <http://www.anzsgm.org/documents/PositionStatementNo5-OrthogeriatricCareRevision2010.pdf>.

Mak, JCS, Cameron, ID & March, LM 2010b, 'Evidence-based guidelines for the management of hip fractures in older persons: an update', *Medical Journal of Australia*, vol. 192, no. 1, pp. 37-41.

Makai, P, Koopmanschap, MA, Brouwer, WBF & Nieboer, AAP 2013, 'A validation of the ICECAP-O in a population of post-hospitalized older people in the Netherlands', *Health and Quality of Life Outcomes*, vol. 11, no. 57, pp. 1-11.

Maravic, M, Le Bihan, C, Landais, P & Fardellone, P 2005, 'Incidence and cost of osteoporotic fractures in France during 2001. A methodological approach by the national hospital database', *Osteoporosis International*, vol. 16, no. 12, pp. 1475-80.

Marks, R 2010, 'Hip fracture epidemiological trends, outcomes, and risk factors, 1970-2009', *International Journal of General Medicine*, vol. 3, pp. 1-17.

McNamara, A, Chen, G, George, S, Walker, R & Ratcliffe, J 2013, 'What factors influence older people in the decision to relinquish their driver's licence? A discrete choice experiment', *Accident Analysis and Prevention*, vol. 55, pp. 178-84.

Mejhert, M, Lindgren, P, Schill, O, Edner, M, Persson, H & Kahan, T 2013, 'Long term health care consumption and cost expenditure in systolic heart failure', *European Journal of Internal Medicine*, vol. 24, no. 3, pp. 260-5.

Miedel, R, Tornkvist, H, Ponzer, S & Tidermark, J 2012, 'Musculoskeletal function and quality of life after an unstable trochanteric fracture treated with the trochanteric gamma nail', *Archives of Orthopaedic and Trauma Surgery*, vol. 132, pp. 1495-503.

Miller, M, Crotty, M, Whitehead, C, Daniels, L & Finucane, P 2001, 'Nutritional assessment and intervention in patients admitted with a femoral neck fracture: a chronicle of missed opportunities', *Australian Journal of Nutrition & Dietetics*, vol. 58, no. 2, pp. 86-91.

Miller, MD, Bannerman, E, Daniels, LA & Crotty, M 2006a, 'Lower limb fracture, cognitive impairment and risk of subsequent malnutrition: a prospective evaluation of dietary energy and protein intake on an orthopaedic ward', *European Journal of Clinical Nutrition*, vol. 60, no. 7, pp. 853-61.

Miller, MD, Crotty, M, Whitehead, C, Bannerman, E & Daniels, LA 2006b, 'Nutritional supplementation and resistance training in nutritionally at risk older adults following lower limb fracture: a randomized controlled trial', *Clinical Rehabilitation*, vol. 20, no. 4, pp. 311-23.

Miller, MD, Yaxley, A, Villani, A, Cobiac, L, Fraser, R, Cleland, L, James, M & Crotty, M 2010, 'A trial assessing N-3 as treatment for injury-induced cachexia (ATLANTIC trial): does a moderate dose fish oil intervention improve outcomes in older adults recovering from hip fracture?', *BMC Geriatrics*, vol. 10, no. 76, pp. 1-10.

Miller, SL & Wolfe, RR 2008, 'The danger of weight loss in the elderly', *Journal of Nutrition, Health and Aging*, vol. 12, no. 7, pp. 487-91.

Milne, AC, Potter, J, Vivanti, A & Avenell, A 2009, 'Protein and energy supplementation in elderly people at risk from malnutrition', *Cochrane Database of Systematic Reviews*, no. 2, DOI 10.1002/14651858.Cd003288.Pub3.

Milte, CM, Walker, R, Luszcz, MA, Lancsar, E, Kaambwa, B & Ratcliffe, J 2014, 'How Important Is Health Status in Defining Quality of Life for Older People? An Exploratory Study of the Views of Older South Australians', *Applied health economics and health policy*, vol. 12, no. 1, pp. 73-84.

Milte, R 2009, 'Usual Nutrition Care in Patients with a Fall related Fracture of the Femoral Neck', Bachelor of Science (Honours) thesis, Flinders University.

Milte, R, Ratcliffe, J, Miller, M, Whitehead, C, Cameron, ID & Crotty, M 2013a, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture? A discrete choice experiment', *Journal of Rehabilitation*

Medicine, vol. 45, no. 1, pp. 81-6.

Milte, RK, Ratcliffe, J, Miller, MD & Crotty, M 2013b, 'Economic evaluation of protein and energy supplementation in adults: opportunities to strengthen the evidence', *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-50.

Molzahn, A, Skevington, SM, Kalfoss, M & Makaroff, KS 2010, 'The importance of facets of quality of life to older adults: an international investigation', *Quality of Life Research*, vol. 19, no. 2, pp. 293-8.

Momsen, A-M, Rasmussen, JO, Nielsen, CV, Iversen, MD & Lund, H 2012, 'Multidisciplinary team care in rehabilitation: an overview of reviews', *Journal of Rehabilitation Medicine*, vol. 44, no. 11, pp. 901-12.

National Clinical Guideline Centre 2011, *The Management for Hip Fracture in Adults*, National Clinical Guideline Centre, London, Available from: <http://www.ncgc.ac.uk>.

National Institute for Health and Clinical Excellence 2008, *Guide to the Methods of Technology Appraisal*, National Institute for Health and Clinical Excellence, London, Avaliable from: <http://www.nice.org.uk/media/B52/A7/TAMethodsGuideUpdatedJune2008.pdf>.

Neelemaat, F, Bosmans, JE, Thijs, A, Seidell, JC & van Bokhorst-de van der Schueren, MAE 2012, 'Oral nutritional support in malnourished elderly decreases functional limitations with no extra costs', *Clinical Nutrition*, vol. 31, no. 2, pp. 183-90.

Nematy, M, Hickson, M, Brynes, AE, Ruxton, CHS & Frost, GS 2006, 'Vulnerable patients with a fractured neck of femur: nutritional status and support in hospital', *Journal of Human Nutrition and Dietetics*, vol. 19, no. 3, pp. 209-18.

Neumann, M, Friedmann, J, Roy, MA & Jensen, GL 2004, 'Provision of high-protein supplement for patients recovering from hip fracture', *Nutrition*, vol. 20, no. 5, pp. 415-9.

Neumann, SA, Miller, MD, Daniels, L & Crotty, M 2005, 'Nutritional status and clinical outcomes of older patients in rehabilitation', *Journal of Human Nutrition and Dietetics*, vol. 18, no. 2, pp. 129-36.

Nguyen, TV, Sambrook, PN & Eisman, JA 1998, 'Bone loss, physical activity, and weight change in elderly women: the Dubbo Osteoporosis Epidemiology study', *Journal of Bone and Mineral Research*, vol. 13, no. 9, pp. 1458-67.

Nieuwenhuizen, WF, Weenen, H, Rigby, P & Hetherington, MM 2010, 'Older adults and patients in need of nutritional support: review of current treatment options and factors influencing nutritional intake', *Clinical Nutrition*, vol. 29, no. 2, pp. 160-9.

Nikkel, LE, Fox, EJ, Black, KP, Davis, C, Andersen, L & Hollenbeak, CS 2012, 'Impact of comorbidities on hospitalization costs following hip fracture', *Journal of Bone and Joint Surgery*, vol. 94, no. 1, pp. 9-17.

Norman, K, Pirlich, M, Smoliner, C, Kilbert, A, Schulzke, JD, Ockenga, J, Lochs, H & Reinhold, T 2011, 'Cost-effectiveness of a 3-month intervention with oral nutritional supplements in disease-related malnutrition: a randomised controlled pilot study', *European Journal of Clinical Nutrition*, vol. 65, no. 6, pp. 735-42.

O'Flynn, J, Peake, H, Hickson, M, Foster, D & Frost, G 2005, 'The prevalence of malnutrition in hospitals can be reduced: results from three consecutive cross-sectional studies', *Clinical Nutrition*, vol. 24, no. 6, pp. 1078-88.

O'Neill, TW & Roy, DK 2005, 'How many people develop fractures with what outcome?', *Best Practice & Research Clinical Rheumatology*, vol. 19, no. 6, pp. 879-95.

Ohsfeldt, RL, Borisov, NN & Sheer, RL 2006, 'Fragility fracture-related direct medical costs in the first year following a nonvertebral fracture in a managed care setting', *Osteoporosis International*, vol. 17, no. 2, pp. 252-8.

Omsland, TK, Holvik, K, Meyer, HE, Center, JR, Emaus, N, Tell, GS, Schei, B, Tverdal, A, Gjesdal, CG, Grimnes, G, Forsmo, S, Eisman, JA & Sogaard, AJ 2012, 'Hip fractures in Norway 1999-2008: time trends in total incidence and second hip fracture rates: a NOREPOS study', *European Journal of Epidemiology*, vol. 27, no. 10, pp. 807-14.

Orwig, DL, Hochberg, M, Yu-Yahiro, J, Resnick, B, Hawkes, WG, Shardell, M, Hebel, JR, Colvin, P, Miller, RR, Golden, J, Zimmerman, S & Magaziner, J 2011, 'Delivery and outcomes of a yearlong home exercise program after hip fracture a randomized controlled trial', *Archives of Internal Medicine*, vol. 171, no. 4, pp. 323-

31.

Paillaud, E, Bories, PN, Le Parco, JC & Campillo, B 2000, 'Nutritional status and energy expenditure in elderly patients with recent hip fracture during a 2-month follow-up', *British Journal of Nutrition*, vol. 83, no. 2, pp. 97-103.

Papaioannou, A, Kennedy, CC, Ioannidis, G, Sawka, A, Hopman, WM, Pickard, L, Brown, JP, Josse, RG, Kaiser, S, Anastassiades, T, Goltzman, D, Papadimitropoulos, M, Tenenhouse, A, Prior, JC, Olszynski, WP, Adachi, JD & CaMos Study, G 2009, 'The impact of incident fractures on health-related quality of life: 5 years of data from the Canadian Multicentre Osteoporosis study', *Osteoporosis International*, vol. 20, no. 5, pp. 703-14.

Parker, M, Myles, J, Anand, J & Drewett, R 1992, 'Cost-benefit analysis of hip fracture treatment', *Journal of Bone & Joint Surgery, British Volume*, vol. 74-B, no. 2, pp. 261-4.

Pasco, JA, Brennan, SL, Henry, MJ, Nicholson, GC, Sanders, KM, Zhang, Y & Kotowicz, MA 2011, 'Changes in hip fracture rates in southeastern Australia spanning the period 1994-2007', *Journal of Bone and Mineral Research*, vol. 26, no. 7, pp. 1648-54.

Perneger, TV, Combescure, C & Courvoisier, DS 2010, 'General population reference values for the French version of the Euroqol EQ-5D health utility instrument', *Value in Health*, vol. 13, no. 5, pp. 631-5.

Peters, LL, Boter, H, Buskens, E & Slaets, JPJ 2012, 'Measurement properties of the Groningen Frailty Indicator in home-dwelling and institutionalized elderly people', *Journal of the American Medical Directors Association*, vol. 13, no. 6, pp. 546-51.

Peterson, LE, Goodman, C, Karnes, EK, Chen, CJ & Schwartz, JA 2009, 'Assessment of the quality of cost analysis literature in physical therapy', *Physical Therapy*, vol. 89, no. 8, pp. 733-55.

Pham, B, Stern, A, Chen, WD, Sander, B, John-Baptiste, A, Thein, HH, Gomes, T, Wodchis, WP, Bayoumi, A, Machado, M, Carcone, S & Krahn, M 2011, 'Preventing pressure ulcers in long-term care a cost-effectiveness analysis', *Archives of Internal Medicine*, vol. 171, no. 20, pp. 1839-47.

Philipson, TJ, Snider, JT, Lakdawalla, DN, Stryckman, B & Goldman, DP 2013, 'Impact of oral nutritional supplementation on hospital outcomes', *American Journal of Managed Care*, vol. 19, no. 2, pp. 121-8.

Pimouguet, C, Lavaud, T, Dartigues, JF & Helmer, C 2010, 'Dementia case management effectiveness on health care costs and resource utilization: a systematic review of randomized controlled trials', *Journal of Nutrition, Health and Aging*, vol. 14, no. 8, pp. 669-76.

Pinto, D, Robertson, MC, Hansen, P & Abbott, JH 2012, 'Cost-effectiveness of nonpharmacologic, nonsurgical interventions for hip and/or knee osteoarthritis: systematic review', *Value in Health*, vol. 15, no. 1, pp. 1-12.

Piscitelli, P, Iolascon, G, Gimigliano, F, Muratore, M, Camboa, P, Borgia, O, Forcina, B, Fitto, F, Robaud, V, Termini, G, Rini, GB, Gianicolo, E, Faino, A, Rossini, M, Adami, S, Angeli, A, Distante, A, Gatto, S, Gimigliano, R & Guida, G 2007, 'Incidence and costs of hip fractures compared to acute myocardial infarction in the Italian population: a 4-year survey', *Osteoporosis International*, vol. 18, no. 2, pp. 211-9.

Pretto, M, Spirig, R, Kaelin, R, Muri-John, V, Kressig, RW & Suhmd, N 2010, 'Outcomes of elderly hip fracture patients in the Swiss healthcare system: a survey prior to the implementation of DRGs and prior to the implementation of a Geriatric Fracture Centre', *Swiss Medical Weekly*, vol. 140, p. w13086.

Rabin, R, Oemar, M & Oppe, M 2011, *EQ-5D-3L user guide: basic information on how to use the EQ-5D-3L instrument version 4.0*, EuroQol Group, Rotterdam.

Randell, A, Sambrook, PN, Nguyen, TV, Lapsley, H, Jones, G, Kelly, PJ & Eisman, JA 1995, 'Direct clinical and welfare costs of osteoporotic fractures in elderly men and women', *Osteoporosis International*, vol. 5, no. 6, pp. 427-32.

Ratcliffe, J, Laver, K, Couzner, L, Cameron, ID, Gray, L & Crotty, M 2010, 'Not just about costs: the role of health economics in facilitating decision making in aged care', *Age and Ageing*, vol. 39, no. 4, pp. 426-9.

Richardson, J, Atherton Day, N, Peacock, S & Iezzi, A 2004, 'Measurement of the quality of life for economic evaluation and the assessment of quality of life (AQoL) mark 2 instrument', *Australian Economic Review*, vol. 37, no. 1, pp. 62-88.

Robertson, MC, Gardner, MM, Devlin, N, McGee, R & Campbell, AJ 2001, 'Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: controlled trial in multiple centres', *British Medical Journal*, vol. 322, no. 7288, pp. 701-4.

Rodriguez Blazquez, C, Forjaz, MJ, Prieto-Flores, M-E, Rojo-Perez, F, Fernandez-Mayoralas, G & Martinez-Martin, P 2012, 'Health status and well-being of older adults living in the community and in residential care settings: are differences influenced by age?', *Aging & Mental Health*, vol. 16, no. 7, pp. 884-91.

Rohde, G, Haugeberg, G, Mengshoel, AM, Moum, T & Wahl, AK 2008, 'Is global quality of life reduced before fracture in patients with low-energy wrist or hip fracture? A comparison with matched controls', *Health and Quality of Life Outcomes*, vol. 6, no. 90, pp. 1-11.

Rohde, G, Moum, T & Haugeberg, G 2012, 'Comparing 15D and SF-6D performance in fragility wrist and hip fracture patients in a two-year follow-up case-control study', *Value in Health*, vol. 15, no. 8, pp. 1100-7.

Rolland, Y, Kan, GAV, Benetos, A, Blain, H, Bonnefoy, M, Chassagne, P, Jeandel, C, Laroche, M, Nourhashemi, F, Orcel, P, Piette, F, Ribot, C, Ritz, P, Roux, C, Taillandier, J, Tremollieres, F, Weryha, G & Vellas, B 2008, 'Frailty, osteoporosis and hip fracture: causes, consequences and therapeutic perspectives', *Journal of Nutrition, Health and Aging*, vol. 12, no. 5, pp. 335-46.

Romijn, JA 2000, 'Substrate metabolism in the metabolic response to injury', *Proceedings of the Nutrition Society*, vol. 59, no. 3, pp. 447-9.

Roth, T, Kammerlander, C, Gosch, M, Luger, TJ & Blauth, M 2010, 'Outcome in geriatric fracture patients and how it can be improved', *Osteoporosis International*, vol. 21, no. Suppl 4, pp. S615-9.

Roulin, D, Donadini, A, Gander, S, Griesser, AC, Blanc, C, Huebner, M, Schaefer, M & Demartines, N 2013, 'Cost-effectiveness of the implementation of an enhanced recovery protocol for colorectal surgery', *British Journal of Surgery*, vol. 100, no. 8, pp. 1108-14.

Roux, C, Wyman, A, Hooven, FH, Gehlbach, SH, Adachi, JD, Chapurlat, RD, Compston, JE, Cooper, C, Diez-Perez, A, Greenspan, SL, Lacroix, AZ, Netelenbos, JC, Pfeilschifter, J, Rossini, M, Saag, KG, Sambrook, PN, Silverman, S, Siris, ES, Watts, NB & Boonen, S 2012, 'Burden of non-hip, non-vertebral fractures on quality of life in postmenopausal women: the Global Longitudinal study of Osteoporosis in Women (GLOW)', *Osteoporosis International*, vol. 23, no. 12, pp. 2863-71.

Rowell, DS & Jackson, TJ 2011, 'Additional costs of inpatient malnutrition, Victoria, Australia, 2003-2004', *European Journal of Health Economics*, vol. 12, no. 4, pp. 353-61.

Ruchlin, HS, Elkin, EB & Allegrante, JP 2001, 'The economic impact of a multifactorial intervention to improve postoperative rehabilitation of hip fracture patients', *Arthritis and Rheumatism*, vol. 45, no. 5, pp. 446-52.

Russell, CA 2007, 'The impact of malnutrition on healthcare costs and economic considerations for the use of oral nutritional supplements', *Clinical Nutrition, Supplement*, vol. 2, no. 1, pp. 25-32.

Ryan, M & Gerard, K 2003, 'Using discrete choice experiments to value health care programmes: current practice and future research reflections', *Applied Health Economics and Health Policy*, vol. 2, pp. 55-64.

Rypkema, G, Adang, E, Dicke, H, Naber, T, de Swart, B, Disselhorst, L, Goluke-Willemse, G & Olde Rikkert, M 2003, 'Cost-effectiveness of an interdisciplinary intervention in geriatric inpatients to prevent malnutrition', *Journal of Nutrition, Health and Aging*, vol. 8, no. 2, pp. 122-7.

Sahota, O, Morgan, N & Moran, CG 2012, 'The direct cost of acute hip fracture care in care home residents in the UK', *Osteoporosis International*, vol. 23, no. 3, pp. 917-20.

Sahyoun, NR, Serdula, MK, Galuska, DA, Zhang, XL & Pamuk, ER 2004, 'The epidemiology of recent involuntary weight loss in the United States population', *Journal of Nutrition, Health and Aging*, vol. 8, no. 6, pp. 510-7.

Sakuma, M, Endo, N, Oinuma, T, Miyasaka, D, Oguma, Y, Imao, K, Koga, H & Tanabe, N 2013, 'Incidence of osteoporotic fractures in Sado, Japan in 2010', *Journal of Bone and Mineral Metabolism*.

Salkeld, G, Cameron, ID, Cumming, RG, Easter, S, Seymour, J, Kurrle, SE & Quine, S 2000, 'Quality of life related to fear of falling and hip fracture in older women: a time trade off study', *British Medical Journal*, vol. 320, no. 7231, pp. 341-6.

Sanders, KM, Nicholson, GC, Ugoni, AM, Pasco, JA, Seeman, E & Kotowicz, MA 1999, 'Health burden of hip and other fractures in Australia beyond 2000. Projections based on the Geelong Osteoporosis Study', *Medical Journal of Australia*, vol. 170, no. 10, pp. 467-70.

Scandol, JP, Toson, B & Close, JC 2013, 'Fall-related hip fracture hospitalisations and the prevalence of dementia within older people in New South Wales, Australia: an analysis of linked data', *Injury*, vol. 44, no. 6, pp. 776-83.

Schott, AM, Cormier, C, Hans, D, Favier, F, Hausherr, E, Dargent-Molina, P, Delmas, PD, Ribot, C, Sebert, JL, Breart, G & Meunier, PJ 1998, 'How hip and whole-body bone mineral density predict hip fracture in elderly women: the EPIDOS Prospective Study', *Osteoporosis International*, vol. 8, no. 3, pp. 247-54.

Scottish Intercollegiate Guidelines Network 2009, *Management of hip fracture in older people: a national clinical guidelines*, Scottish Intercollegiate Guidelines Network, Edinburgh, Avaliable from: <http://www.sign.ac.uk>.

Seitz, DP, Adunuri, N, Gill, SS & Rochon, PA 2011, 'Prevalence of dementia and cognitive impairment among older adults with hip fractures', *J Am Med Dir Assoc*, vol. 12, no. 8, pp. 556-64.

Shalowitz, DI, Garrett-Mayer, E & Wendler, D 2006, 'The accuracy of surrogate decision makers: a systematic review', *Archives of Internal Medicine*, vol. 166, no. 5, pp. 493-7.

Shi, N, Foley, K, Lenhart, G & Badamgarav, E 2009, 'Direct healthcare costs of hip, vertebral, and non-hip, non-vertebral fractures', *Bone*, vol. 45, no. 6, pp. 1084-90.

Simmons, SF, Zhuo, X & Keeler, E 2010, 'Cost-effectiveness of nutrition interventions in nursing home residents: a pilot intervention', *Journal of Nutrition, Health and Aging*, vol. 14, no. 5, pp. 367-72.

Sitoh, YY, Lau, TC, Zochling, J, Cumming, RG, Lord, SR, Schwarz, J, March, LM, Sambrook, PN & Cameron, ID 2003, 'Proxy assessment of health-related quality of life in the frail elderly', *Age and Ageing*, vol. 32, no. 4, pp. 459-61.

Smedley, F, Bowling, T, James, M, Stokes, E, Goodger, C, O'Connor, O, Oldale, C, Jones, P & Silk, D 2004, 'Randomized clinical trial of the effects of preoperative and postoperative oral nutritional supplements on clinical course and cost of care', *British Journal of Surgery*, vol. 91, no. 8, pp. 983-90.

Sorensen, J, Davidsen, M, Gudex, C, Pedersen, KM & Bronnum-Hansen, H 2009, 'Danish EQ-5D population norms', *Scandinavian Journal of Public Health*, vol. 37, no. 5, pp. 467-74.

Stephens, RJ, Hopwood, P, Girling, DJ & Machin, D 1997, 'Randomized trials with quality of life endpoints: are doctors' ratings of patients' physical symptoms interchangeable with patients' self-ratings?', *Quality of Life Research*, vol. 6, no. 3, pp. 225-36.

Street, DJ & Burgess, L 2007, *The Construction of Optional Stated Choice Experiments: Theory and Methods*, John Wiley and Sons, New Jersey.

Tamulaitiene, M & Alekna, V 2012, 'Incidence and direct hospitalisation costs of hip fractures in Vilnius, capital of Lithuania, in 2010', *BMC Public Health*, vol. 12, no. 495, pp. 1-8.

Tarride, J-E, Guo, N, Hopkins, R, Leslie, W, Morin, S, Adachi, J, Papaioannou, A, Bessette, L, Brown, J & Goeree, R 2012, 'The burden of illness of osteoporosis in Canadian men', *Journal of Bone and Mineral Research*, vol. 27, no. 8, pp. 1830-8.

The Agency for Clinical Innovation Orthogeriatric Model of Care Collaborative Group 2010, *The Orthogeriatric model of care: summary of evidence 2010*, NSW Agency for Clinical Innovation, North Ryde, Australia.

Theocharis, G, Rafailidis, PI, Rodis, D, Kontopidis, I, Barbas, SG & Falagas, ME 2012, 'Outpatient parenteral antibiotic therapy (OPAT) at home in Attica, Greece', *European Journal of Clinical Microbiology and Infectious Diseases*, vol. 31, no. 11, pp. 2957-61.

Thomas, B (ed.) 2001, *Undernutrition and the principles of nutrition support*, 3rd edn, Manual of Dietetic Practice, Blackwell Science Ltd, Oxford.

Thomas, SK, Humphreys, KJ, Miller, MD, Cameron, ID, Whitehead, C, Kurrle, S, Mackintosh, S & Crotty, M 2008, 'Individual nutrition therapy and exercise regime: a controlled trial of injured, vulnerable elderly (INTERACTIVE trial)', *BMC Geriatrics*, vol. 8, no. 4, pp. 1-8.

Thompson, SG & Barber, JA 2000, 'How should cost data in pragmatic randomised trials be analysed?', *British Medical Journal*, vol. 320, no. 7243, pp. 1197-200.

Tidermark, J, Ponzer, S, Carlsson, P, Söderqvist, A, Brismar, K, Tengstrand, B & Cederholm, T 2004, 'Effects of protein-rich supplementation and nandrolone in lean elderly women with femoral neck fractures', *Clinical Nutrition*, vol. 23, no. 4, pp. 587-96.

Tidermark, J, Zethraeus, N, Svensson, O, Törnkvist, H & Ponzer, S 2002, 'Femoral neck fractures in the elderly: functional outcome and quality of life according to EuroQol', *Quality of Life Research*, vol. 11, no. 5, pp. 473-81.

Tiira, AH, Paananen, MV, Taimela, SP, Zitting, PJ, Järvelin, MR & Karppinen, JI 2012, 'Determinants of adolescent health care use for low back pain', *European Journal of Pain*, vol. 16, no. 10, pp. 1467-76.

Titler, MG, Jensen, GA, Dochterman, JM, Xie, XJ, Kanak, M, Reed, D & Shever, LL 2008, 'Cost of hospital care for older adults with heart failure: medical, pharmaceutical, and nursing costs', *Health Services Research*, vol. 43, no. 2, pp. 635-55.

Torrance, GW 1987, 'Utility approach to measuring health-related quality of life', *Journal of Chronic Diseases*, vol. 40, no. 6, pp. 593-600.

Tripuraneni, KR, Carothers, JT, Junick, DW & Archibeck, MJ 2012, 'Cost comparison of cementless versus cemented hemiarthroplasty for displaced femoral neck fractures', *Orthopedics*, vol. 35, no. 10, pp. e1461-4.

Truswell, AS 2012, 'Protein-energy malnutrition', in J Mann & AS Truswell (eds), *Essentials of Human Nutrition* 4th edn, Oxford University Press, Oxford.

Tucker, HN & Miguel, SG 1996, 'Cost containment through nutrition intervention', *Nutrition Reviews*, vol. 54, no. 4 I, pp. 111-21.

Turkington, P, McDonald, S, Elliott, J & Beringer, T 2012, 'Hip fracture in Northern Ireland, 1985-2010. Are age-specific fracture rates still rising?', *Ulster Medical Journal*, vol. 81, no. 3, pp. 123-6.

Van Someren, M, Barnard, Y & Sandberg, J 1994, *The Think Aloud Method. A Practical Guide to Modelling Cognitive Processes*, Academic Press, London.

Viney, R, Norman, R, King, MT, Cronin, P, Street, DJ, Knox, S & Ratcliffe, J 2011, 'Time trade-off derived EQ-5D weights for Australia', *Value in Health*, vol. 14, no. 6, pp. 928-36.

Viswanathan, HN, Curtis, JR, Yu, J, White, J, Stolshek, BS, Merinar, C, Balasubramanian, A, Kallich, JD, Adams, JL & Wade, SW 2012, 'Direct healthcare costs of osteoporosis-related fractures in managed care patients receiving pharmacological osteoporosis therapy', *Applied Health Economics and Health Policy*, vol. 10, no. 3, pp. 163-73.

Volkert, D 2013, 'Malnutrition in older adults - urgent need for action: a plea for improving the nutritional situation of older adults', *Gerontology*, vol. 59, no. 4, pp. 328-33.

Vu, T, Day, L & Finch, CF 2012, 'Linked versus unlinked hospital discharge data on hip fractures for estimating incidence and comorbidity profiles', *BMC Medical Research Methodology*, vol. 12.

Wade, SW, Strader, C, Fitzpatrick, LA & Anthony, MS 2012, 'Sex- and age-specific incidence of non-traumatic fractures in selected industrialized countries', *Archives of Osteoporosis*, vol. 7, no. 1-2, pp. 219-27.

Walker, A & Mollenkopf, H 2007, 'International and multi-disciplinary perspectives on quality of life in old age: conceptual issues', in H Mollenkopf & A Walker (eds), *Quality of Life in Old Age*, Springer Netherlands, vol. 31, pp. 3-13.

Ware, JE 2000, 'SF-36 Health Survey Update', *Spine*, vol. 25, no. 24, pp. 3130-9.

Watson, PF & Petrie, A 2010, 'Method agreement analysis: a review of correct methodology', *Theriogenology*, vol. 73, no. 9, pp. 1167-79.

Wells, CD, Murrill, WB & Arguedas, MR 2004, 'Comparison of health-related quality of life preferences between physicians and cirrhotic patients: implications for cost-utility analyses in chronic liver disease', *Digestive Diseases and Sciences*, vol. 49, no. 3, pp. 453-8.

Woolcott, JC, Khan, KM, Mitrovic, S, Anis, AH & Marra, CA 2012, 'The cost of fall related presentations to the ED: a prospective, in-person, patient-tracking analysis of health resource utilization', *Osteoporosis International*, vol. 23, no. 5, pp. 1513-9.

Wyers, CE, Reijven, PLM, Evers, S, Willems, PC, Heyligers, IC, Verburg, AD, van Helden, S & Dagnelie, PC 2013, 'Cost-effectiveness of nutritional intervention in elderly subjects after hip fracture. A randomized controlled trial', *Osteoporosis International*, vol. 24, no. 1, pp. 151-62.

Zethraeus, N, Borgström, F, Johnell, O, Kanis, J, Önnby, K & Jönsson, B 2002, *Costs and quality of life associated with osteoporosis related fractures: results from a Swedish survey*, SSE/EFI Working Paper Series in Economics and Finance, No. 512, The Economic Research Institute, Stockholm, Sweden, Available at: <http://hdl.handle.net/10419/56287>.

APPENDICIES

Appendix 1: Search strategy used for Medline database

1	nutrition [MeSH, all subheadings included]
2	nutri* (textword)
3	maln* (textword)
4	undernutr* (textword)
5	under-nutr* (textword)
6	undernourish* (textword)
7	under-nourish* (textword)
8	protein-energy malnutrition [MeSH, all subheadings included]
9	protein-energy malnutrition (textwod)
10	nutritional status [MeSH, all subheadings included]
11	nutrition disorders [MeSH, all subheadings included]
12	food,fortified [MeSH, all subheadings included]
13	food,formulated [MeSH, all subheadings included]
14	diet {MeSH, all subheadings included]
15	diet therap* (textword)
16	dietary supplements [MeSH, all subheadings included]
17	(diet* or nutri*) near supplement* (textword)
18	enteral nutrition [MeSH, all subheadings included]
19	dietary proteins [MeSH, all subheadings included]
20	energy intake [MeSH, all subheadings included]
21	randomized controlled trial. pt.
22	controlled clinical trial.pt.
23	randomized controlled trials.sh.
24	random allocation.sh.
25	double-blind method.sh.
26	single-blind method.sh.
27	or/21-26
28	limit 27 to animal
29	limit 27 to human
30	28 not 29
31	27 not 30
32	clinical trial.pt.
33	exp clinical trial
34	(clinic$ adj25 trial$).tw.
35	((singl$ or doub$ or treb$ or trip$) adj (mask$ or blind$)).tw.
36	placebo$.sh.
37	placebo$.tw.
38	random$.tw.

39	research design.sh.
40	(latinadj square).tw.
41	or/32-40
42	limit 41 to animal
43	limit 41 to human
44	42 not 43
45	41 not 44
46	comparative study.sh.
47	exp evaluation studies/
48	follow-up studies.sh.
49	prospective studies.sh.
50	(control$ or prospective$ or volunteer$).tw.
51	cross-over studies.sh.
52	or/46-51
53	limit 52 to animal
54	limit 41 to human
55	53 not 54
56	52 not 55
57	31 or 45 or 56
58	obesity [MeSH, all subheadings included]
59	critical care [MeSH, all subheadings included]
60	58 or 59
61	or/1-20
62	61 not 60
63	62 and 57
64	limit 63 to (newborn infant or infant <1 to 23 months> or preschool child <2 to 5 years> or child <6 to 12 years> or adolescence<13 to 18 years>
65	63 not 64
66	cancer.tw.
67	65 not 66
68	insulin.tw.
69	67 not 68
70	cardiovascular.tw.
71	69 not 70
72	"Costs and Cost Analysis"/ or Cost-Benefit Analysis/ or Economics/ or Models, Economic/ or Models, Econometric/ or Economics, Medical/
73	Quality-Adjusted Life Years/ or Health Care Costs/ or "Quality of Life"/ or "Value of Life"/
74	economic*.tw.
75	cost*.tw.
76	cost-benefit*.tw.
77	cost benefit*.tw.
78	cost –effective*.tw.
79	cost effective*.tw.

80	cost-utilit*.tw.
81	cost utility*.tw.
82	economic model*.tw.
83	model*.tw.
84	72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83
85	71 and 84

Appendix 2: Patient information sheet and consent form for INTERACTIVE trial

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Patient Information Sheet

"Improving health outcomes for patients with hip fracture using an individualised nutrition and exercise program"

Hip fractures are a common and growing problem for older Australians. Unfortunately recovery is incomplete in most people. Two factors that are believed to be important for you during recovery are exercise and nutrition. After a hip fracture your ability to walk is severely compromised, as are appetite and dietary intake. These factors are likely to contribute to the loss of muscle mass and strength. There is evidence to suggest that an individualised exercise and nutrition therapy approach to rehabilitation may improve your outcomes.

We wish to investigate the effectiveness of an individualised exercise and nutrition therapy approach to your rehabilitation.
You are invited to take part in this research project which aims to determine how effective a 6 month individualised exercise and nutrition intervention is on your rehabilitation outcomes. The Rehabilitation and Ageing Studies Unit at Flinders University is carrying out this project. Patients admitted to the Flinders Medical Centre with hip fracture between April 2007 and September 2008 will be invited to take part in the project. This information sheet explains your involvement if you choose to participate in the project.

What happens before I agree to participate?
A research therapist will discuss the project with you and will determine whether you are eligible for participation in this project. This written information sheet explains the project fully.

What happens when I agree to participate?

- If you agree to participate in the project, the research therapist will interview you and take some measurements. This will take about 90 minutes. We are asking for your permission to:
  - Access your medical case notes to collect information on admission, living arrangements, date of birth, marital status, medical history, readmissions to hospital and discharge details;
  - Weigh you after an overnight fast, first thing in the morning, in light clothes and no shoes;
  - Measure your knee height (the distance from your ankle to your knee) using a portable sliding caliper;
  - Measure your body composition using triceps skinfold measurements on your upper arm using a portable calliper;
  - Measure your body composition using a technique called bioelectrical impedance. The test requires attaching electrodes to your right wrist and ankle. It involves a small electrical current being transferred between the wrist and ankle for a period of approximately 2 minutes. This test is non-toxic, non-invasive, and safe;
  - Measure your body composition using another technique called dual energy x-ray absorptiometry, to determine the accuracy of the bioelectrical impedance technique, and

measure your bone mineral density using the same technique. This will involve 3 non-invasive scans which will take about 15 minutes. This procedure uses ionising radiation, although the dose is very small (equivalent to around 1-3 days of natural background radiation) and represents a negligible risk;
- Measure your energy expenditure using a piece of equipment called the MedGem. This test requires normal breathing into a disposable scuba-type mouthpiece for approximately 10 minutes;
- Measure your current appetite using an 8-item questionnaire (the Council on Nutrition Appetite Questionnaire);
- Measure your walking speed as you walk a 3 metre distance at a relaxed pace and at a fast pace;
- Measure how many times you can rise and return to a firm chair in 30 seconds;
- Measure your balance by getting you to maintain certain positions;
- Measure your knee strength (both legs) and **grip strength** using standard tests;
- Assess your perceived level of pain when resting in bed, rising from a chair and walking;
- Assess your level of dependence when performing activities of daily living;
- Assess your ability to participate in daily living activities, quality of life (QoL), **self reported health**, and positive affect using standard surveys.

- We are also seeking your permission to visit you at 6 and 12 months to repeat these measurements and surveys. The bone density measurement will only be repeated at 12 months.

- You will be randomly allocated to either a control or intervention group. Random allocation is commonly used in research to divide participants into groups. It is like the flip of a coin, there is equal chance of you being allocated to either group. We cannot guarantee that you will be allocated to the group you would prefer.

If you are allocated to the intervention group you will receive:
- A comprehensive nutrition assessment from a qualified dietitian;
- A 6 month individualised nutrition plan which may include recommendation of certain foods, supply of recipes, referral to community meal programs and provision of supplements (multivitamins and food supplements);
- A comprehensive physical function assessment from a qualified physiotherapist;
- A 6-month exercise therapy plan, which will include balance and strengthening exercises. You will be asked to perform these three times a week. You will also be asked to walk outside your home three times a week; and
- Weekly home visits from either the dietitian or the physiotherapist. During this time we will ask about any falls and injuries you have experienced, weigh you, measure your energy expenditure using the MedGem equipment, body composition using the bioelectrical impedance technique and assess your adherence to the program. We will also ask you about any community services you use during this time, and any hospital readmissions.

If you are allocated to the control group you will receive:
- The standard rehabilitation in the hospital you are admitted to;
- Weekly social visits by a dietitian or physiotherapist to discuss general health and well being. These visits will also involve measurement of your energy expenditure using the MedGem equipment and measurement of body composition using the bioelectrical impedance technique on a monthly basis. We will also ask you about any community services you use during this time, and any hospital readmissions.

Other
You are required to inform the investigator of any other studies you are participating in. If you require elective or emergency surgery or other medical care you are required to inform the doctor looking after you about your participation in this project.

What benefits are there from participating in this project?
We cannot guarantee that you will directly benefit from participating in this project. However, your participation in this project will provide us with valuable information to help us develop suitable nutrition and exercise therapy and programs in the future for patients undergoing rehabilitation.

What are the risks of participating in this project?
There are minimal risks associated with participating in this project, as you will be monitored closely by qualified allied health practitioners.

Confidentiality
All records containing personal information will remain confidential and kept in a locked filing cabinet or on password protected computers. No information that could lead to the identification of any individual will be released and all data will be de-identified ie all data will be identified by a number only. Members of the Research and Ethics Committee may view project records for the purposes of audit.

Use of data
The information collected in this project will be submitted for publication in a medical journal and summaries of the findings may be reported to the media or in national and international conferences.

Withdrawal from the project
Your participation in this project is entirely voluntary and you have the right to withdraw from the project at any time. If you decide not to participate in this project or if you withdraw from the project, you may do this freely without prejudice to any future treatment at Flinders Medical Centre.

This project has been reviewed by the Flinders Clinical Research Ethics Committee (FCREC). Should you wish to discuss this project with someone not directly involved or should you wish to make a confidential complaint, you may contact Carol Hakof of the FCREC on (08) 8204 4507.

Who to contact for more information about the project
This information sheet is yours to keep. If you would like more information about this project please feel free to contact Dr Michelle Miller from the Department of Nutrition and Dietetics at Flinders University on (08) 82045328. If you have any concerns or queries **after hours** you can contact Karen Humphreys on 0422071080 or Susie Thomas on 0438822264.

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CONSENT TO PARTICIPATION IN RESEARCH

I, ____ give consent to be involved in the research project

first or given names surname

Improving health outcomes for patients with hip fracture using an individualised nutrition and exercise program.

I acknowledge that the nature, purpose and contemplated effects of the research project, have been fully explained to my satisfaction by

____ and my consent is given voluntarily

first or given names surname

I acknowledge that the detail(s) of the following procedure(s):

A 90 minute, baseline assessment, including:

1. Measurement of weight, 3 metre walk, chair stand test, knee strength, **grip strength**, balance scale, body composition, and bone mineral density;
2. Assessment of appetite, levels of dependence, quality of life, **self rated health**, ability to participate in daily activities, percieved level of pain and positive affect using surveys.

A 90 minute, 6-month assessment and 12-month follow up including:

1. Measurement of weight, 3 metre walk test, chair stand test, knee strength, **grip strength**, balance scale, body composition, and bone mineral density;
2. Assessment of appetite, levels of dependence, quality of life, **self rated health**, ability to participate in daily activities, perceived level of pain and positive affect using surveys;
3. Assessment of adherence to the project using study diaries and dietary recall.

If allocated to the intervention group:

1. Comprehensive nutrition assessment from a qualified dietition including energy expenditure;
2. Comprehensive physical function assessment from a qualified physiotherapist;
3. Participation in a 6-month individualised nutrition plan which may include recommendation of certain foods, supply of recipes, referral to community meal programs and provision of supplements (multivitamins and food supplements);
4. Participation in a 6-month individualised exercise therapy plan, which will include balance and strengthening exercises three times a week, as well as walking outside the home three times a week;
5. Weekly home visits from either the dietitian (which will include monitoring of nutrition plan) or physiotherapist (which will include monitoring of exercise plan) including weekly measurement of energy expenditure, weight change and change in body composition;
6. Assessment of adherence to the project using study diaries and dietary recall;
7. Monitoring of falls, community services used, and any hospital readmissions.

If allocated to the control group:

1. Continue standard rehabilitation treatment;
2. Weekly social visits from a physiotherapist or dietitian to discuss general health and well being.
3. Monthly measurement of energy expenditure and change in body composition;
4. Monitoring of falls, community services used, and any hospital readmissions.

has/have been explained to me, including indications of risks; any discomfort involved; anticipation of length of time and the frequency with which the procedure(s) will be performed.

I have understood and am satisfied with the explanations that I have been given.

I have been provided with a written information sheet.

I understand that my involvement in this research project and/or the procedure(s) may not be of any direct benefit and that I may withdraw my consent at any stage without affecting my rights or the responsibilities of the researchers in any respect.

I acknowledge that I have been informed that should I receive an injury as a result of taking part in this study, legal action may need to be taken in order to receive compensation.

I declare that I am over the age of 18 years.

I consent to taking part in this study.

Signature of participant: ______________________________

Signature of Witness: ______________________________

Printed Name of Witness: ______________________________

I, ______________________ have described to ______________________

the research project and the nature and effects of the procedure(s) involved. In my opinion he/she understands the explanation and has freely given his/her consent.

Signature: ______________________ Date: ______________

Status in project: ______________________________

Appendix 3: Data collection forms for INTERACTIVE trial

Assessor ID **Date of survey**______________ **Study ID**

INTERACTIVE Trial
Assessment of Quality of Life

INSTRUCTIONS:
Please circle the alternative that best describes you *during the last week.*

1 Concerning my use of prescribed medicines:
- A. I do not or rarely use any medicines at all.
- B. I use one or two medicinal drugs regularly.
- C. I need to use three or four medicinal drugs regularly.
- D. I use five or more medicinal drugs regularly.

2 To what extent do I rely on medicines or a medical aid? (NOT glasses or a hearing aid.) *(For example: walking frame, wheelchair, prosthesis etc.)*
- A. I do not use any medicines and/or medical aids.
- B. I occasionally use medicines and/or medical aids.
- C. I regularly use medicines and/or medical aids.
- D. I have to constantly take medicines or use a medical aid.

3 Do I need regular medical treatment from a doctor or other health professional?
- A. I do not need regular medical treatment.
- B. Although I have some regular medical treatment, I am not dependent on this.
- C. I am dependent on having regular medical treatment.
- D. My life is dependent upon regular medical treatment.

4 Do I need any help looking after myself?
- A. I need no help at all.
- B. Occasionally I need some help with personal care tasks.
- C. I need help with the more difficult personal care tasks.
- D. I need daily help with most or all personal care tasks.

5 When doing household tasks: *(For example: preparing food, gardening, using the video recorder, radio, telephone or washing the car)*
- A. I need no help at all.
- B. Occasionally I need some help with household tasks.
- C. I need help with the more difficult household tasks.
- D. I need daily help with most or all household tasks.

6 Thinking about how easily I can get around my home and community:
- A. I get around my home and community by myself without any difficulty.
- B. I find it difficult to get around my home and community by myself.
- C. I cannot get around the community by myself, but I can get around my home with some difficulty.
- D. I cannot get around either the community or my home by myself.

7 Because of my health, my relationships (eg: with my friends, partner or parents) generally:
- A. Are very close and warm.
- B. Are sometimes close and warm.
- C. Are seldom close and warm.
- D. I have no close and warm relationships.

8 Thinking about my relationships with other people:
- A. I have plenty of friends, and am never lonely.
- B. Although I have friends, I am occasionally lonely.
- C. I have some friends, but am often lonely for company.
- D. I am socially isolated and feel lonely.

Adapted from: Hawthorn G et al. The assessment of quality of life (AQoL) instrument. Qual Life Res 1999; 8:209-24.

Assessor ID

Study ID

Dietary Adherence Assessment

Date of visit __ . __ . __   Time of arrival __ : __   Time of departure __ : __   Total time spent (mins) ___

Place of visit ____________________

Weight

___ . _ kg

BMI

__ . _ kg/m^2

CNAQ

__

Foot-to-foot BIA:

Fat Free Mass (kg)	Fat Mass (kg)	% Fat Free Mass	% Fat Mass	FFMI (kg/m^2)	FMI (kg/m^2)
__ . _	__ . _	__	__	__ . _	__ . _

Tetrapolar BIA:

Fat Free Mass (kg)	Fat Mass (kg)	% Fat Free Mass	% Fat Mass	FFMI (kg/m^2)	FMI (kg/m^2)
__ . _	__ . _	__	__	__ . _	__ . _

Energy

REE (MedGem)

_____ kJ

Estimated requirements

REE × activity factor______ = _____ kJ

Intake

_____ kJ

Met target?
○ Yes
○ No

Protein

Estimated requirements

__ . _ g

Intake

__ . _ g

Met target?
○ Yes
○ No

Any particular nutrition issues:

____
____
____
____

Previous fortnight's goals

1 ____________________

Met Goal? ○ Yes ○ No Why not?____________________

Assessor ID ☐☐☐ Visit No. ☐☐ Study ID ☐☐☐☐☐☐

Exercise Adherence Assessment

Date of visit ☐☐.☐☐.☐☐ Time of arrival ☐☐:☐☐ Time of departure ☐☐:☐☐ Total time spent (mins) ☐☐☐

Place of visit ______________________________

Exercise	Times completed weekly	Target met?
1.______________________	☐☐	○ Yes ○ No
2.______________________	☐☐	○ Yes ○ No
3.______________________	☐☐	○ Yes ○ No
4.______________________	☐☐	○ Yes ○ No
5.______________________	☐☐	○ Yes ○ No
6.______________________	☐☐	○ Yes ○ No
7.______________________	☐☐	○ Yes ○ No
8.______________________	☐☐	○ Yes ○ No
9.______________________	☐☐	○ Yes ○ No

Reasons for not meeting targets ______________________________

____

____

____

____

Walking Target met?

☐☐☐ Minutes ☐☐ x per week ○ Yes ○ No

Reasons for not meeting targets ______________________________

____

____

____

____

Possible reasons for not meeting targets:
Aggravates existing condition, New medical condition/unwell, Lost exercise folder, Doesn't see need for exercises, Too busy/lack of time, Unsafe, Forgets, Too tiring, Lack of energy, Unmotivated, Negative Beliefs about exercises, Perception that exercises unpleasant, Lack of confidence, Fear of injury/falling

Assessor ID

Weekly visit

Study ID

Date of visit . . | Time of arrival : | Time of departure : | Total time spent (mins)

Place of visit ____

Topics discussed

____
____
____
____

Activities done

____
____
____
____

Falls reported and details

○ **Serious (fracture/hospital admission)**
○ **Moderate (requiring GP assistance, bruising, sprains, cuts, abrasions, or 3 consecutive days of decreased physical function)**
○ **Mild**
○ **None reported**

Details:____
____
____
____

Adverse events (injury or treatment complication)

____
____
____
____

Community services

○ As for previous visit
○ ACAT
○ RITHOM
○ RDNS
○ CACP
○ DVA
○ Local council
○ Day Therapy Centre
○ MHLS
○ MDC/Dom care
○ TCP Residential / Community____________
○ COPS
○ MOW
○ Private services
○ Other______________________________

Outpatient appointments and reason

____
____
____
____

Appendix 4 Mini-mental examination form

Assessor ID | | | | **Date of survey** ________ **Study ID** | | | | | | |

INTERACTIVE Trial
Mini-Mental State Examination

		Score
ORIENTATION (maximum score 10). One point for each correct answer. Ask "What is today's date?" Then ask specifically for parts omitted: eg,. "Can you also tell me what season it is?"	Date	___
	Year	___
	Month	___
	Day (eg., Monday)	___
	Season	___
Ask "Can you tell me the name of this hospital/house number?"	Hospital/house number	___
"What ward/street name are we on?"	Ward/street name	___
"What suburb are we in?"	Suburb	___
"What city are we in?"	City	___
"What state are we in?"	State	___
REGISTRATION (maximum score 3). Ask the patient if you may test their memory. Then say "ball", "flag", "tree", clearly and slowly, about one second for each. After you have said all three words, ask the patient to repeat them. This first repetition determines the score (0-3) but keep saying them (up to six times) until the subject can repeat all three words. If he/she does not eventually learn all three, recall cannot be meaningfully tested.	Ball	___
	Flag	___
	Tree	___
	Record number of trials	___
ATTENTION AND CALCULATION (maximum score 5) Ask the subject to begin at 100 and count backward by 7. Stop after 5 subtractions (93, 86, 79, 72, 65). Score one point for each correct number.	93	___
	86	___
OR	79	___
If the subject cannot or will not perform this task, ask him/her to spell the word "world" backwards (D, L, R, O, W). The score is one point for each correctly placed letter eg., DLROW = 5, DLORW = 3. Record how the subject spelt "world" backwards: (DLORW).	72	___
	65	___
	OR	
	Number of correctly placed letters	___
RECALL (maximum score 3) Ask the subject to recall the three words you previously asked him/her to remember (learnt in registration).	Ball	___
	Flag	___
	Tree	___
LANGUAGE (maximum score 9) NAMING: Show the patient a wrist watch and ask "what is this?" Repeat for a pencil. Score one point for each item named correctly.	Watch	___
	Pencil	___
REPETITION: Ask the subject to repeat, "No ifs and, or buts". Score one point for correct repetition.	Repetition	___
3-STAGE COMMAND: Give the patient a blank piece of paper and say "take this paper in your right hand, fold it in half and put it on the floor". Score one point for each action performed correctly.	Takes in right hand	___
	Folds in half	___
	Puts on floor	___
READING: On a blank piece of paper write "close your eyes". Ask the patient to read the sentence and do what it says. Score one point only if he/she actually closes his/her eyes.	Closes eyes	___
WRITING: Ask the subject to write a sentence (over the page). It is to be written spontaneously. It must contain a subject and a verb and be sensible. Correct grammar and punctuation are not necessary.	Writes sentence	___
COPYING: On a piece of paper draw intersecting pentagons with each side about 1 inch and ask him/her to copy it exactly. All 10 angles must be present and two must intersect to score 1 point. Tremor and rotation are ignored	Draws pentagons	___
	TOTAL SCORE ___________	

Adapted from Folstein M et al. "Mini-mental state". J Psych Res 1975; 12: 189-98.

Appendix 5: Example of Discrete Choice Experiment and ICECAP-O and EQ-5D data collection form

A survey of individual preferences for improved mobility following hip fracture

On behalf of the Department of Rehabilitation and Aged Care at Flinders University, we would like to invite you to participate in a research project that seeks to obtain individual or their proxy family carer views concerning rehabilitation programmes designed to improve mobility following hip fracture.

The results of this survey will be used to write a report that will guide policy makers and nursing home staff in making decisions about the future planning and organisation of rehabilitation programmes.

Your participation in this survey is entirely voluntary and will not affect your current or future use of nursing home facilities or health care services. All of the information you provide will be confidential. It will be used for research purposes only and will not be used in any way in which you can be identified.

Thank you for your co-operation.

Associate Professor Julie Ratcliffe[1]
Professor Maria Crotty[1]
Dr Michelle Miller[2]
[1]Dept of Rehabilitation and Aged Care, Flinders University
[2] Dept of Nutrition and Dietetics, Flinders Medical Centre

V1

1

Section A

In this section of the questionnaire we are interested in obtaining your views about a number of statements relating to recovery following hip fracture, mobility and quality of life.

We would like you to read through each of the statements below and indicate the extent to which you agree or disagree with each statement in relation to yourself and your recovery from hip fracture by placing a tick (✓) in the relevant box next to each statement.

Please note there are no wrong or right answers to any of these statements. We are interested in your views.

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
A. I am confident that I will be able to walk again eventually					
B. I would want to be able to walk again even if there is a high risk that I could fall again and break another bone in the future					
C. I am prepared to make a large physical effort over a period of several weeks to enable me to walk again					
D. I would prefer to go into a wheelchair now and forget about walking again					
E. I am prepared to accept pain for a number of weeks whilst following an exercise programme if it would enable me to walk again					
F. I am very tired and don't want to have physiotherapy to help me with walking					
G. I would be happy to use a mechanical lifter to move me from the bed to a chair for the rest of my life					
H. I would be prepared to pay a fee to receive an 8 week rehabilitation programme in the nursing home to help me walk again					

Section B

We would like to know what choices you would make if, when receiving a rehabilitation programme to help your recovery from hip fracture, you were asked to decide between two programmes with differing characteristics and outcomes. In the rest of this section we describe 7 pairs of programmes for you to choose between. Each programme is described in terms of its characteristics and outcomes. The possible differences between the programmes are:

1. **Your risk of falling and breaking another bone** at some time point following rehabilitation

a) 25% or a 1 in 4 chance.

b) 50% or a 1 in 2 chance.

c) 75% or a 3 in 4 chance.

2. The **level of pain you would need to accept** during rehabilitation with the aim of recovering your ability to walk short distances

a) Mild pain for 6 to 8 weeks

b) Moderate pain for 6 to 8 weeks

c) Severe pain for 6 to 8 weeks

3. The **level of effort you would need to make** during rehabilitation by working hard and exercising with a physiotherapist

a) 30 minutes per day for 2 months

b) 1 hour per day for 2 months

c) 2 hours per day for 2 months

4. **Your ability to recover walking following rehabilitation**

a) Walking with a stick independently without help

b) Walking with a frame with one person close by

c) Wheelchair bound

3

Seven pairs of choices are presented below. Some of the characteristics of each choice change in every pair. Imagine you are facing the decision about which programme to choose for recovery following hip fracture and you are offered the choice between two programmes. For each of the choices below which programme would you choose?

Pair 1	Programme A	Programme B
Risk of falling and breaking another bone following the programme	25%	75%
The level of pain experienced during the programme	Mild	Severe
The level of effort needed during the program	30 minutes per day	2 hours per day
Your ability to recover walking following participation in the programme	Walking with a stick independently without help	Wheelchair bound

Which programme would you choose? *(please tick one box only)*		

Pair 2	Programme A	Programme B
Risk of falling and breaking another bone following the programme	25%	50%
The level of pain experienced during the programme	Moderate	Mild
The level of effort needed during the program	2 hours per day	30 minutes per day
Your ability to recover walking following participation in the programme	Walking with a stick independently without help	Wheelchair bound

Which programme would you choose? *(please tick one box only)*		

4

Pair 3	Programme A	Programme B
Risk of falling and breaking another bone following the programme	25%	50%
The level of pain experienced during the programme	Severe	Moderate
The level of effort needed during the program	30 minutes per day	1 hour per day
Your ability to recover walking following participation in the programme	Walking with a stick independently without help	Wheelchair bound

Which programme would you choose? *(please tick one box only)*		

Pair 4	Programme A	Programme B
Risk of falling and breaking another bone following the programme	50%	75%
The level of pain experienced during the programme	Mild	Severe
The level of effort needed during the program	1 hour per day	2 hours per day
Your ability to recover walking following participation in the programme	Walking with a frame with one person close by	Walking with a stick independently without help

Which programme would you choose? *(please tick one box only)*		

Pair 5	Programme A	Programme B
Risk of falling and breaking another bone following the programme	50%	75%
The level of pain experienced during the programme	Severe	Moderate
The level of effort needed during the program	30 minutes per day	1 hour per day
Your ability to recover walking following participation in the programme	Walking with a frame with one person close by	Walking with a stick independently without help

Which programme would you choose? *(please tick one box only)*		

Pair 6	Programme A	Programme B
Risk of falling and breaking another bone following the programme	75%	25%
The level of pain experienced during the programme	Mild	Severe
The level of effort needed during the program	1 hour per day	2 hours per day
Your ability to recover walking following participation in the programme	Wheelchair bound	Walking with a frame with one person close by

Which programme would you choose? *(please tick one box only)*		

Pair 7	Programme A	Programme B
Risk of falling and breaking another bone following the programme	75%	25%
The level of pain experienced during the programme	Moderate	Mild
The level of effort needed during the program	2 hours per day	30 minutes per day
Your ability to recover walking following participation in the programme	Wheelchair bound	Walking with a frame with one person close by

Which programme would you choose? *(please tick one box only)*		

Section C

We would be grateful if you could provide a few details about your self. All of the information you provide will be treated in complete confidence and used for research purposes only.

1. What is your age?

   ....(years)

2. Are you:

Male	
Female	

Here are some simple questions about your health and quality of life in general. By ticking one answer in each group below, please indicate which statements best describes your health and quality of life today.

Please tick one

3. Mobility
   - I have no problems in walking about ❑
   - I have some problems in walking about ❑
   - I am confined to bed ❑

4. Self-care
   - I have no problems with self-care ❑
   - I have some problems washing or dressing myself ❑
   - I am unable to wash or dress myself ❑

5. Usual Activities
   - I have no problems with performing their usual activities ❑
     (e.g. work, study, housework, family or leisure activities)
   - I have some problems with performing my usual activities ❑
   - I am unable to perform my usual activities ❑

6. Pain/Discomfort
   - I have no pain or discomfort ❑
   - I have moderate pain or discomfort ❑
   - I have extreme pain or discomfort ❑

7. Anxiety/Depression
   - I am not anxious or depressed ❑
   - I am moderately anxious or depressed ❑
   - I am extremely anxious or depressed ❑

8. Attachment
   - I can have all of the love and friendship that they want ❑
   - I can have a lot of the love and friendship that they want ❑
   - I can have a little of the love and friendship that they want ❑
   - I cannot have any of the love and friendship that they want ❑

7

9. Security

I can think about the future without any concern ❑

I can think about the future with only a little concern ❑

I can only think about the future with some concern ❑

I can only think about the future with a lot of concern ❑

10. Role

I am able to do all of the things that make them feel valued ❑

I am able to do many of the things that make them feel valued ❑

I am able to do a few of the things that make them feel valued ❑

I am unable to do any of the things that make them feel valued ❑

11. Enjoyment

I can have all of the enjoyment and pleasure that they want ❑

I can have a lot of the enjoyment and pleasure that they want ❑

I can have a little of the enjoyment and pleasure that they want ❑

I cannot have can any of the enjoyment and pleasure that they want ❑

12. Control

I am able to be completely independent ❑

I am able to be independent in many things ❑

I am able to be independent in a few things ❑

I am unable to be at all independent ❑

13. How long ago is it since you fractured you hip?

Less than 1 week	
1 week to 4 weeks	
4 to 8 weeks	
More than 8 weeks ago	

14. How long have you been living in a residential care facility?

Less than 1 month	
1 to 12 months	
Less than 2 years	
More than 2 years	

8

15. What is the highest educational qualification you have?

No qualifications	
Completed high school	
Undergraduate degree or professional qualification	
Post-graduate qualification	
Other (*please specify*)...............................	

16. Were you born in Australia?

Yes	
No	

If you answered No to Q16. please can you tell us what country you were born in?

....

17. How difficult did you find this questionnaire to complete

Very difficult	
Moderately difficult	
Slightly difficult	
Not difficult	

Do you have any comments that you would like to make about this questionnaire *(please write these in the space provided below)*

....

....

....

....

....

....

....

....

....

....

Thank you for taking the time to complete this questionnaire.

9

Appendix 6: Patient information sheet and consent form for Discrete Choice Experiment and ICECAP-O and EQ-5D Project

Patient Information Sheet.

Investigating individual or proxy family carer preferences for improved mobility

Introduction

You are invited to participate in a research study. Participation in this study is voluntary. You have been invited to participate as you have recent experience of a hip fracture.

Purpose of the study

The purpose of this study is to find out more about the preferences of people like you for participation in rehabilitation which may involve some pain and effort for you in the short term but which may lead to significant improvements in your mobility and quality of life.

Study Procedures

The study involves you answering a set of questions about your preferences for rehabilitation and your health and experiences overall which will be provided to you. We anticipate that the interview will take you no more than 1 hour to complete.

Potential benefits of the study

We cannot guarantee that you will directly benefit from participating in this study. However, it is likely to help the rehabilitation team make decisions about future treatment protocols in rehabilitation services and interventions within nursing homes.

1

Risks or adverse effects

There are no foreseeable risks or adverse effects to you through involvement in this study.

Research Statement

The researchers in this study will gain no direct financial benefit from this study.

Participation and withdrawal from the study

Your participation in this study is entirely voluntary and you have the right to withdraw from the study at any time. If you decide not to participate in this study, or if you withdraw from the study, you may do this freely without prejudice to any future treatment at the Repatriation General Hospital, Daw Park or Flinders Medical Centre, Bedford Park. If you choose to withdraw from this study, your veteran or other entitlements will not be affected.

Confidentiality

All records containing personal information will remain confidential, and no information which could lead to your identification will be released. You will not be identifiable in any publication of the results of the study. Members of the Repatriation General Hospital Research and Ethics Committee may view study records for the purposes of audit.

Additional information

Participants should advise the investigators of any other studies in which they are participating.

If you require elective or emergency surgery or any other medical care, you should inform the treating clinician of your participation in this study.

2

Should you require any further details about this study at any time, you may contact Associate Professor Julie Ratcliffe or Ms Leah Couzner from the Department of Rehabilitation and Aged Care at the Repatriation General Hospital on (08) 8275 1103 or (08) 8275 1602.

This research study has been approved by the Research and Ethics Committee of the Repatriation General Hospital, Daw Park. Should you wish to discuss the study with someone not directly involved in the study, in particular in relation to matters concerning policies or your rights as a participant, or you should wish to make a confidential complaint, you may contact: Executive Officer – Research, Ms Janet Bennett on 8275 1876, Repatriation General Hospital.

3

Government of South Australia

SA Health

REPATRIATION GENERAL HOSPITAL DAW PARK

CONSENT FORM FOR PARTICIPATION IN RESEARCH BY INTERVIEW

SURNAME:____

FIRST NAMES ____

DATE OF BIRTH___________ GENDER ______FILE NUMBER _________

I,

____
(First/or Given names) (Surname)

have had explained to me by the investigator Assoc. Professor Julie Ratcliffe (or her representative) the nature and effects of the Research Study:

Investigating individual or proxy family carer preferences for improved mobility

I have been provided with a Patient Information Sheet about the study which I have read and understood.
I understand that the study involves the following procedures:
Answering a set of questions about my preferences for rehabilitation and my health overall which will be provided and explained to me by the interviewer.

- I have understood and am satisfied with the explanations that I have been given and hereby consent to the participation in the above study.
- I understand that the results of these studies may be published, but my identity will be kept confidential.
- I understand that the procedure may not be of any benefit to myself, and that I may withdraw my consent at any stage without affecting my rights or the responsibilities of the investigator in any respect.
- I understand that representatives from the Hospital Research and Ethics Committee, from the sponsoring organisation for this study and/or from Government Drug Regulatory Authorities may need to access my medical record for information related to the study for the purpose of audit. I authorise access to my medical record for this purpose.
- I declare that I am over the age of 18 years.

Signature:________________________________ **Date**________________

Signature of Witness: ____________________ **Date:** ________________

Printed Name of Witness: __________________

Appendix 7: Permissions for inclusion of material from published papers in thesis

Professor J Ratcliffe

I have given permission for the work undertaken and published as part of co-authored papers listed below to be included in the candidate's thesis:

Milte R, Ratcliffe J, Miller M, & Crotty M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence', *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

Contribution: Conception and design, analysis and interpretation of data, drafting and critical revision of manuscript

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture? A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Contribution: Conception and design, analysis and interpretation of data, drafting and critical revision of manuscript

Signature

Associate Professor M Miller

I have given permission for the work undertaken and published as part of co-authored papers listed below to be included in the candidate's thesis:

Milte R, Ratcliffe J, Miller M,& Crotty M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence', *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

Contribution: Conception and design, analysis and interpretation of data, drafting and critical revision of manuscript

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture? A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Contribution: Conception and design, acquisition of data, Drafting and critical revision of manuscript

Signature

Associate Professor C Whitehead

I have given permission for the work undertaken and published as part of the co-authored paper listed below to be included in the candidate's thesis:

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture?A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Contribution: Conception and design, critical revision of manuscript

Signature

Professor ID Cameron

I have given permission for the work undertaken and published as part of the co-authored paper listed below to be included in the candidate's thesis:

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture? A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Contribution: Conception and design, critical revision of manuscript

Signature

Professor M Crotty

I have given permission for the work undertaken and published as part of co-authored papers listed below to be included in the candidate's thesis:

Milte R, Ratcliffe J, Miller M, & Crotty M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence', *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

Contribution: Conception and design, critical revision of manuscript

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture? A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Contribution: Conception and design, acquisition of data, analysis and interpretation of data, drafting and critical revision of manuscript

Signature

Appendix 8: Publications arising from this thesis

Milte R, Ratcliffe J, Miller M,& Crotty M 2013, 'Economic evaluation for protein and energy supplementation in adults: opportunities to strengthen the evidence', *European Journal of Clinical Nutrition*, vol. 67, pp. 1243-1250.

Milte R, Ratcliffe J, Miller M, Whitehead C, Cameron ID & Crotty M 2013, 'What are frail older people prepared to endure to achieve improved mobility following hip fracture?A discrete choice experiment', *Journal of Rehabilitation Medicine*, vol. 45, no. 1, pp. 81-6.

Milte R, Ratcliffe J, Chen G, Lancsar E, Miller M, & Crotty M 2014, ‘Cognitive overload? An exploration of the potential impact of cognitive functioning in discrete choice experiments with older people in health care’, *Value in Health*, vol. 17, no. 5, pp.655-9.

doi:10.1038/ejcn.2013.206

"ECONOMIC EVALUATION FOR PROTEIN AND ENERGY SUPPLEMENTATION IN ADULTS: OPPORTUNITIES TO STRENGTHEN THE EVIDENCE"

Running Title

Economic evaluation protein energy supplementation

Milte RK[1], Ratcliffe J[2], Miller MD[1] and Crotty M[3].

[1] Department of Nutrition and Dietetics, Flinders University

[2] Flinders Health Economics Group, Flinders University

[3] Department of Rehabilitation, Aged and Extended Care, Flinders University

ABSTRACT

Malnutrition is a costly problem for health care systems internationally. Malnourished individuals require longer hospital stays and more intensive nursing care than adequately nourished individuals and have been estimated to cost an additional £7.3 billion in health care expenditures in the United Kingdom alone. However, treatments for malnutrition have rarely been considered from an economic perspective. The aim of this systematic review was to identify the cost effectiveness of using protein and energy supplementation, as a widely used intervention to treat adults with and at risk of malnutrition. Papers were identified that included economic evaluations of protein or energy supplementation for the treatment or prevention of malnutrition in adults. While the variety of outcome measures reported for cost effectiveness studies made synthesis of results challenging, cost benefit studies indicated that the savings for the health system could be substantial due to reduced lengths of hospital stay and less intensive use of health services after discharge. In summary the available economic evidence indicates that protein and energy supplementation in

treatment or prevention of malnutrition provides an opportunity to improve patient wellbeing and lower health system costs.

Keywords

Review, Costs and Cost Analysis, Enteral Nutrition, Malnutrition, Oral nutritional supplementation

INTRODUCTION

Malnutrition is a costly problem for health care systems internationally.[1] In Australia, the additional cost of malnutrition to the Victorian public health system has been recently estimated as $10.7 million per year with the authors noting that this is likely to greatly underestimate the true costs.[2] In the UK the annual cost to the health system has been estimated at more than £7.3 billion, mostly due to increased costs of hospital and long-term care.[1] It has been identified that up to 55% of hospital patients at any one point in time are malnourished.[3-5] In addition, up to 50% of residential care and 30% of community living elderly have been found to be malnourished.[3,6-8] The consequences of malnutrition upon an individual's health are severe and impact negatively upon health care expenditure through increases in the frequency and duration of hospital episodes, and increased intensity of health and community service utilization following discharge from hospital.[9-13]

Containment of increasing health care expenditures is a global phenomenon and increasingly economic evaluation is being utilised as a tool for demonstrating the efficiency or value for money of health care expenditures. In a world of increasing resource constraints for health care expenditures, demonstrating not only the clinical effectiveness but also the cost effectiveness of nutrition interventions for the treatment of malnutrition in adult populations in hospital, residential and community settings is becoming a key evidential requirement for health care decision-makers. Whilst previous reviews[9] have highlighted the clinical effectiveness of interventions for the treatment of malnutrition, no review to date has systematically sought to identify and report upon the quality of, the economic evaluation methods used in published studies of treatments for malnutrition.

Previous studies have identified the most common treatments for malnutrition are strategies to increase energy and protein intake via the normal oral route, such as enriched diets, high energy and protein snacks and oral nutrition supplements.[14] Therefore, our primary aim was to undertake a systematic review to identify economic evaluation studies of protein and energy supplementation for the treatment of people with or at risk of malnutrition. A secondary aim was to provide an overview of the quality of the economic evidence available on this topic.

METHODS

Defining and categorising economic evaluation

Economic evaluation may be defined as the comparative analysis of alternative courses of action in terms of both their costs and consequences.[15] Therefore the fundamental requirements of any economic evaluation are to identify, measure, value and compare the costs and consequences of the alternatives being considered. There are five generally accepted forms of economic evaluation for health care interventions which are described in Table 1.[16,17] Briefly they are cost-minimisation analysis, cost-benefit analysis, cost-consequence analysis, cost-effectiveness analysis, and cost-utility analysis. It is appropriate to conduct a cost minimisation analysis of a health care intervention only where there is sound evidence (e.g. through the findings of a well conducted randomised controlled trial) to indicate that there is no difference in outcomes for both effectiveness and safety between the intervention under consideration and the most appropriate alternative intervention.[18] Within cost benefit analysis both costs and benefits are measured and valued in monetary terms to determine the net benefit of the new intervention e.g. as a consequence of reductions in future health care costs due to decreases in morbidity and/or mortality. On the other hand cost-consequence, cost-effectiveness, and cost-utility analysis all compare the benefits of interventions through a focus upon changes in clinical and/or patient focused outcomes. A cost-effectiveness analysis (CEA) involves a direct comparison of the costs associated with an intervention with a single measure of effectiveness which is usually clinically or bi-medically focused. This allows the calculation of an incremental cost effectiveness ratio (ICER) where the additional costs of the treatment are divided by additional benefits of providing the treatment e.g. cost per one unit improvement in blood cholesterol levels. Cost consequence analysis is a form of economic evaluation where the incremental costs associated with the new intervention are calculated and a series of outcomes or consequences are presented but the costs and outcomes are not presented together in the form of a ratio. Cost-utility analysis (CUA) is a particular form of CEA which warrants special consideration as it is explicitly the preferred method of economic evaluation for many health regulatory bodies in Australia (Pharmaceutical Benefits Advisory Committee (PBAC)), United Kingdom (National Institute for Health and Clinical Excellence) and many other bodies around the world.[18-19] Within CUA benefits are measured and valued using 'utility', where this reflects preference for a particular health state.[20] Once measured, the utility of a particular health state or series of health states can be combined with the quantity or number of life years a person spends in the health state to give an indicator of the Quality Adjusted Life Years (QALY) attributable to an intervention and ultimately a ICER of cost per QALY gained. There are many ways of measuring utility, but a commonly utilised method is through the use of a multi-attribute utility instrument (MAUI).[21] A MAUI is a validated instrument that provides both a framework to describe health states for valuation, and can have a developed algorithm to convert those health states into utility weights or values which indicate the preference of the population for those health states. Generally a value of one is assigned for a health state representing perfect health, zero for death, with other health states falling on a continuum between these two points. Negative values indicating a health state perceived as worse than death can be possible. It is these utility values which can be combined with the length of time a person spends in a health state to determine QALY. There are a number of MAUI which have been developed in different populations, but some of the most common include EQ-5D, Short Form 6D, Health Utilities Indexes, and Quality of Well-Being.[15] The scales have different advantages and disadvantages depending on the attributes of health included in the scale, and the number of levels of ability or impairment for each of the attributes which need to be appropriately matched to the population being studied and the expected impact of the intervention.[21] However, the advantage the MAUI share in measuring utility is they cover not only the expected effects of the intervention on mobility or pain for example, but also the flow on effects to independence, and ability to carry out your usual role within society. MAUI therefore have the opportunity to track the effects of interventions more broadly than through traditional clinical outcomes, and allow comparisons of interventions targeting different outcomes, for example providing medications for asthma compared to controlling hyperlipidaemia. This flexibility in application and interpretation has led to CUA using MAUIs being the most preferred method of economic evaluation. Many regulatory bodies for health have a threshold (either explicit or not) for the cost per QALY ICER below which interventions are likely to be considered cost effective, such as the National Institute for Health and Clinical Excellence which recommends cost per QALY ICER's below £20,000.[19]

Search Strategy

A search strategy was developed largely replicating that published by Milne et al.[9] in their review of protein and energy supplementation for treatment of malnutrition in older adults, but with additional search terms to identify studies including economic evaluation (see Appendix 1 in supplementary information). While the review published by Milne et al.[9] originally dealt with only older adults (average age 65 years and above), due to the paucity of economic evidence we widened our search strategy to include all adults (18 years and above) thereby facilitating a broader analysis of the quality of the economic literature. Inclusion criteria are as follows. We included hospitalised, residential aged care and community dwelling populations. We focused specifically upon economic evaluation studies reported either as stand-alone papers or as components of papers which also included a broader focus upon clinical effectiveness. Interventions of interest were those aiming to increase the energy and protein levels of individuals via oral administration. Interventions which included a mix of interventions such as nutrition screening and assessment, dietary advice, and feeding assistance in addition to protein and energy supplementation were included. Types of studies included were any comparative study, including randomised controlled trials, and non-randomised controlled trials. Studies employing economic modelling methods were also included. Exclusion criteria included trials purely based on patients in critical care or recovering from cancer treatment as these patients typically have highly specialised nutritional needs. In addition trials of specialised nutrition components such as specific amino acids or immunomodulatory components were excluded due to differences in the effect and cost data for these products. Relevant comparators included ‘usual practice’ (i.e. ad hoc dietary care or a different nutritional supplement with different energy and protein content) or a ‘placebo’ (such as a low energy drink).

Databases searched included Cochrane register of Controlled Trials (until December 2012), Medline (from 1946 until December 2012), Scopus (until December 2012), Web of Knowledge (until December 2012), CINAHL (until December 2012) and Australasian Medical Index (until December 2012).

In addition, any reviews of the topic that were identified through the above methods were checked for additional studies that had not been previously identified. Reference lists of identified articles or reviews of protein and energy supplementation or evaluation of nutrition therapy were also checked for additional references.

Data Collection and Analysis

Two reviewers independently identified studies from the search results for further analysis by scanning the title, abstract, and key words of the studies for evidence that they compared a protein and energy supplemented diet with no intervention, a placebo, or an alternative supplement and involved adult participants. If there was any doubt about the eligibility of the article, it was also retrieved for further investigation.

All information was extracted independently by the two reviewers. All differences in extraction were clarified with a third reviewer by going back to the original article. Information extracted included: study design, participants, intervention, sample size, follow up period, results, sensitivity analysis (which measures the variability around the base-case results), and discounting of future costs and benefits (where applicable).[15] The quality of the economic evaluations in the articles was assessed using the 35 point checklist developed by Drummond and colleagues for quality submission of economic evaluations to journals.[15] These criteria assess the quality of the economic evaluation in terms of study design, data collection, analysis and interpretation of results, and allow assessment of economic evaluations based on single trial data and combinations of data into economic models. Similarly to the previous review, we did not exclude studies based on the nutritional status of the participants, but identified studies were categorised into one of two groups according to whether they had targeted malnourished patients only (according to the criteria within the paper) or did not specify the nutritional status of their participants for entry to the study for ease of interpretation and reporting of results.

RESULTS

Description of Studies

2,750 titles were identified through the search (Figure 1). Of those titles, the vast majority could be excluded via reading the titles or the abstract (2,632 out of the 2,750), as their focus was not health care but agricultural practices or animal health or manufacturing of food, or did not include an intervention to increase dietary energy or protein. A total of 118 papers had the full text of the title accessed and of those a further 100 were excluded due to lack of an intervention to increase energy and protein intake via the normal oral route (e.g. included parental nutrition or naso-gastric, naso-enteric, or percutaneous endoscopic gastrostomy (PEG) feeding (n=15), did not include economic outcomes (n=32), did not include a dietary intervention to increase energy or protein (n=47) or were testing supplementation of immunomodulatory components within a protein and energy supplement (n=6). Two papers were protocols for studies not yet published and were therefore excluded. This left 16 papers focused upon economic evaluation which were included in the review.

Results of studies where participants were defined as malnourished

Six studies targeted malnourished patients using a variety of identification methods (e.g. Subjective Global Assessment, Mini Nutritional Assessment, BMI, history of unplanned weight loss), listed in Table 2. Of those studies three were cost utility studies,[22,23,24] with the remaining studies being cost benefit analyses[25,26] and a cost consequence analysis respectively.[27] The cost utility studies[22,23,24] and the cost consequence analysis[27] were based on the results of randomised controlled trials both with sample sizes of 100 participants or more while the cost benefit analyses[25,26] were based on modelled data. All of the studies utilized oral nutritional supplements (ONS) as their intervention, although Norman et al.[23] also provided dietary counselling to their intervention and control groups. The participants were from different clinical groups with two studies focusing on patients with gastrointestinal disease,[23,26] two with older adults admitted to hospital,[22,27] one with older adults in residential care facilities,[24] and one in community dwelling older adults.[25] The studies also differed in the costs they included in their analysis. Norman et al.[23] only included the incremental cost of the intervention in their analysis, excluding any wider effect on the health system, while most other studies took a wider view point including costs of medical treatment and social care in the community.[22,25,27] There was a great variety in outcomes measured as listed in Table 2. The cost utility analysis by Norman et al.[23] found that providing 3 months of ONS to malnourished patients with benign gastrointestinal disease was associated with between €9497-12099 per quality-adjusted life year (QALY) gained. Although in Australia no explicit guideline for determining the cost effectiveness of new healthcare technologies has been provided, the Pharmaceutical Advisory Committee appears to consider interventions with cost per QALY below $50,000 as cost effective, and this intervention is well within this threshold indicating relatively high cost effectiveness.[28] Neelemat et al.[22] neared the cost-effectiveness threshold in their CUA providing ONS to older people admitted to hospital as well as routine Vitamin D and Calcium supplementation and telephone support from a Dietitian upon discharge. The results indicated a cost per QALY gain of €26962 for the intervention group compared to the controls. Cost benefit studies conducted by Freijer et al. in the Netherlands indicated cost savings of over €200 per patient in abdominal surgery patients receiving 2 cartons of ONS per day during their hospitalisation through a reduced length of stay,[26] and reported total budget savings of over €12 million for the provision of ONS for treatment of malnutrition in community dwelling older people.[25] Pham et al.[24] found provision of ONS for the treatment of pressure ulcers in malnourished patients of residential care facilities was not cost effective in isolation, but argued that nutrition may play a wider role in supporting other prevention strategies beyond the scope of the economic model developed for their analysis. The remaining study was conducted in a community dwelling sample of older people over a 6 to 12 month follow up period and failed to demonstrate any cost savings for an 8 week intervention in a population of elderly and already malnourished subjects.[27] In summary therefore although the available economic evidence is scant, the studies which have been undertaken to date do demonstrate the potential for protein and energy supplementation in patients identified as malnourished to provide cost savings to the health system in addition to improved health outcomes for patients.

Results of studies where nutritional status not specified

Table 3 presents the results of studies including an intervention to improve nutritional status in a group of participants where their nutritional status was not specified.[29-38] Although relatively more studies were identified in this category, the studies were very diverse in terms of setting, interventions, and outcomes measured, making any direct comparisons across studies very difficult. In terms of study design, a range of designs were employed including randomised designs,[29-31,35] a number of non or quasi-randomised designs[32,33,36,37] and modelled studies.[34,38] Although sample size varied from less than 100 to over 2000, half of the studies included between 100 and 300 participants. Of the identified studies only one utilized a cost-utility approach.[29] This study assessed a multidisciplinary intervention including exercise and smoking cessation counselling in addition to ONS in community dwelling adults with chronic obstructive pulmonary disease and was found to be near the cost effectiveness threshold at AUD$39,438 per QALY gained (Table 3). Four of the studies utilized a cost-effectiveness analysis and reported upon a diverse range of outcome indicators including cost per one day reduction in length of stay, cost per kilocalorie consumed, or cost per kg of weight gained.[30-33] Findings ranged from cost of US$0.01 per kilocalorie additional consumed to cost of €76.10 per one day reduction in length of stay. Although Dangour et al.[30] found an ICER of US$4.84 per additional meter walked by their intervention group in a timed walking test, they only included the costs for the physical activity intervention not the nutrition intervention in their estimates, which could lead to an underestimate. All of these included ONS, aiming to provide between 1068kJ and 10g protein and to 2500kJ and 28g protein additional per day. Other interventions utilized included mid meal snacks, or fortified foods and five studies included a multifaceted intervention (two of which included an exercise or multidisciplinary intervention, and three which included routine early screening for nutritional status and issues). The studies also focused on different clinical groups such as patients from residential care homes,[31,37] patients with COPD discharged to the community,[29] community dwelling older adults,[30] and a large number focusing on patients from various hospital wards.[32-36,38] Follow up period was similarly varied across the studies ranging from the duration of hospital stay to a two year period, with the greatest proportion of studies (five out of nine) centred on the period of hospitalisation. In addition, the costs included in the analysis varied from the incremental costs of providing the intervention only,[30-32] compared to wider viewpoints including the costs of providing the intervention and medical treatment over the follow up time period.[29,33-37] One study focused on the changes in hospitalisation costs only.[38] Overall, while the heterogeneity of the studies makes synthesis of the outcomes difficult, they have generally indicated beneficial outcomes for the patient or health system, at a relatively low cost.

Quality of Studies

Overall when assessing the quality of the published studies, according to the widely recognised Drummond criteria the quality ranges greatly between studies, (Figure 2). Studies were of varying quality, with the number of 'yes' responses to the criteria ranging from a minimum of three to maximum of 27. Generally, the studies scored well on question 1 ("the research question is stated"), 5 ("the alternatives being compared are clearly described"), 22 ("time horizon of costs and benefits is stated"), and 32 ("conclusions follow from the data reported"). Questions completed less well included 14 ("productivity changes if included are reported separately"), 15 ("the relevance of productivity changes to the study question is discussed"), 23 ("the discount rate is stated"), and 24 ("the choice of rate is specified").

The paper which had the highest number of 'yes' responses to the criteria (n=28) was Pham et al.,[24] a recently published CUA of ONS in Residential Care patients closely followed by Norman et al.[23] (n=27) a cost utility study of ONS in malnourished patients with benign disease. This study found that ONS was cost effective. In general, it was found that the more recently published Cost Utility[22,23,29] and Cost Effectiveness studies[30-33] were of a higher quality than older published studies in terms of their adherence to the Drummond criteria. A few studies included only a partial report of healthcare costs such as general practitioner or health service visits.[27,37,38] However, these studies fail to provide a direct comparison between the costs and benefits provided by the interventions, and they therefore fail to take into consideration the value for money of the interventions from an economic perspective.[39]

DISCUSSION

In a comprehensive review of the published literature, sixteen papers were identified which included analysis of providing protein and energy supplementation for prevention or treatment of malnutrition from an economic view point. Of these, only four studies[22,23,24,29] utilised cost-utility analysis, which is currently recommended as the preferred method of economic evaluation for new health care interventions by the Pharmaceutical Benefits Advisory Committee and Medical Services Advisory Committee in Australia, and the National Institute for Health and Clinical Excellence in the UK as well as many other regulatory bodies around the world.[18-19]

Two of the cost-utility studies identified by the review concluded that the interventions under consideration (ONS for 3 months in patients with benign gastrointestinal disease who were also malnourished and ONS for 2 years in adults with Chronic obstructive pulmonary disease) were cost effective.[23,29] In both studies, the incremental cost per QALY ratios were below threshold values for determining cost effectiveness.[28] In another CUA, Neelemaat et al. 2012[22] neared the cost-effectiveness threshold for their intervention of ONS in malnourished hospitalised older adults, while Pham et al.[24] did not show cost effectiveness in prevention of pressure ulcers for in malnourished older people living in residential care facilities.

The studies identified in this review indicated an incremental cost of between -€392.00 to 478.20 (AUD$488.67- $596.12) for health outcomes such as a reduction in one day length of stay, additional metre walked, additional calories ingested, or per kg of weight gained.[30-38]. However, while these indicators appear broadly favourable, it is difficult to synthesise these outcomes due to their heterogeneous nature.[40] The utilization of the QALY, a generic measure of health outcome, for application within cost-utility analysis can be helpful in this regard in demonstrating the 'value for money' of nutrition therapy in a world of competition for scarce health budget resources.[40] The paucity of economic evidence has also been proposed as the main reason for the failure for uptake of national and international evidence based guidelines in the clinical setting.[40] Within this context, the lack of economic evaluations of protein and energy supplementation for malnutrition treatment coupled with the lack of utility-based outcomes for facilitating comparison across interventions and disease areas for decision-making is therefore a serious concern.

In addition, there were a small number of published studies targeted at the economic benefits of protein and energy supplementation to treat malnutrition in the older adult. However, this target group has received more attention recently, with three cost utility studies have been published recently within the last two years targeting the effectiveness of providing ONS to malnourished older people.[22,24,25] Of three cost effectiveness studies identified that targeted older participants, one failed to include the cost of the nutrition therapy itself in their estimation of cost effectiveness (which involved a physical function measure).[30] However, it is encouraging to see that there have been two randomised controlled trial protocols published since 2008 which include economic evaluation in their proposed evaluation of research into energy and protein supplementation as a treatment for or to prevent malnutrition.[41-42] These two studies are all focused on older adults and the study protocols all include consideration of costs of the intervention and associated health care utilisation (including costs of the nutrition intervention, specialist staff, hospital costs, community services, and medications) as well as non-medical costs (such as absenteeism and unpaid help) and health outcomes as such as QALYs, and functional status.

Many identified studies have a short follow up time of one year or less. This presents a challenge for clinicians aiming to demonstrate the benefits of nutrition support, as the short follow up time may not be long enough to allow the benefits to become apparent. When one study in community living elderly over a 6 to 12 month follow up period did not show cost savings in the intervention group compared to the control group, the authors hypothesised that their 8 week intervention was not sufficient to show improvement in their elderly and already malnourished population.[27] Also, the results of economic evaluations should be reported as an incremental cost effectiveness ratio (ICER) wherever possible. An ICER is important as it provides the decision-maker with the opportunity to determine the potential additional cost of a new health care intervention in order to achieve a given outcome. The use of a generic measure of health outcome such as the QALY in this context has the added advantage of facilitating comparisons of value for money across the health care system for example comparing investment in nutrition interventions for malnutrition in older people versus pharmacological treatments for dementia

In conclusion, to date few economic evaluations of protein and energy supplementation for treatment or prevention of malnutrition have been published and the quality of published studies is highly variable. However, the available economic evidence suggests that providing ONS of between 1068kJ and 10g protein up to 4200kJ and 23g protein is associated with positive economic benefits in both patients with malnutrition and in studies where nutritional status was not specified, and over short follow up times. Use of protein and energy supplementation in those with or at risk of malnutrition presents an opportunity for health services to reduce hospitalisation costs for a relatively small additional investment. In the absence of comprehensive economic evidence relating to its cost effectiveness, nutrition therapy is in danger of falling by the wayside in this new era of competitive health care funding. Future research should focus on the inclusion of high quality comprehensive economic evaluations alongside studies of clinical effectiveness to demonstrate the cost effectiveness of nutrition interventions for the treatment of malnutrition.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

REFERENCES

1. Elia M, Stratton R, Russell C, Green C, Pan F. The cost of disease-related malnutrition in the UK and economic considerations for the use of oral nutritional supplements (ONS) in adults 2005. Available at http://www.bapen.org.uk/pdfs/health_econ_exec_sum.pdf. Accessed 11 January 2012.

2. Rowell DS, Jackson TJ. Additional costs of inpatient malnutrition, Victoria, Australia, 2003-2004. *Eur J Health Econ* 2011; **12**: 353-361.

3. Watterson C, Fraser A, Banks M, Isenring E, Miller M, Silvester C et al. Evidence based practice guidelines for the nutritional management of malnutrition in adult patients across the continuum of care. *Nutr Diet* 2009; **66**: S1-S34.

4. Braunschweig CA. Creating a clinical nutrition registry: prospects, problems, and preliminary results. *J Am Diet Assoc* 1999; **99**: 467-470.

5. O'Flynn J, Peake H, Hickson M, Foster D, Frost G. The prevalence of malnutrition in hospitals can be reduced: results from three consecutive cross-sectional studies. *Clin Nutr* 2005; **24**: 1078-1088.

6. Fagerström C, Palmqvist R, Carlsson J, Hellström Y. Malnutrition and cognitive impairment among people 60 years of age and above living in regular housing and in special housing in Sweden: a population-based cohort study. *Int J Nurs Stud* 2011; **48**: 863-871.

7. Stratton RJ, Green CJ, Elia M. *Disease-Related Malnutrition: An Evidence-Based Approach to Treatment.* CABI Publishing: Wallingford, UK, 2003.

8. Pauly L, Stehle P, Volkert D. Nutritional situation of elderly nursing home residents. *Z Gerontol Geriatr* 2007; **40**: 3-12.

9. Milne AC, Potter J, Vivanti A, Avenell A. Protein and energy supplementation in elderly people at risk from malnutrition. *Cochrane Database Syst Rev* 2009; CD003288

10. Messner RL, Stephens N, Wheeler WE, Hawes MC. Effect of admission nutritional status on length of hospital stay. *Gastroenterol Nurs* 1991; **13**: 202-205.

11. Baumeister SE, Fischer B, Döring A, Koenig W, Zierer A, John J, et al. The Geriatric Nutritional Risk Index predicts increased healthcare costs and hospitalization in a cohort of community-dwelling older adults: results from the MONICA/KORA Augsburg cohort study, 1994–2005. *Nutrition* 2011; **27**: 534-542.

12. European Nutrition for Health Alliance. *Malnutrition among Older People in the Community: Policy Recommendations for Change*. European Nutrition for Health Alliance: London, UK 2006.

13. Nikkel LE, Fox EJ, Black KP, Davis C, Andersen L, Hollenbeak CS. Impact of comorbidities on hospitalization costs following hip fracture. *J Bone Joint Surg Am* 2012; **94**: 9-17.

14. Yaxley A, Miller, MD. The challenge of appropriate identification and treatment of starvation, sarcopenia, and cachexia: a survey of Australian dietitians. *J Nutr Metab* 2011; **2011**: 603161.

15. Drummond MF, Sculpher MJ, Torrance GW, O'Brien BJ, Stoddart GL. *Methods for the Economic Evaluation of Health Care Programmes*, 3rd edn. Oxford University Press: Oxford, UK, 2005.

16. Peterson LE, Goodman C, Karnes EK, Chen CJ, Schwartz JA. Assessment of the quality of cost analysis literature in physical therapy. *Phys Ther* 2009; **89**: 733-755.

17. Gold MR, Siegel JE, Russell LB, Weinstein MC. (eds). *Cost-Effectiveness in Health and Medicine*. Oxford University Press: New York, NY, 1996.

18. Commonwealth Department of Health and Ageing. *Guidelines for the Pharmaceutical Industry on Preparation of Submissions to the Pharmaceutical Benefits Advisory Committee: Including Major Submissions Involving Economic Analyses*. Commonwealth of Australia: Canberra, Australia, 2002.

19. National Institute for Health and Clinical Excellence. *Guide to the Methods of Technology Appraisal.* National Institute for Health and Clinical Excellence: London, UK, 2008.

20. Torrance GW. Utility approach to measuring health-related quality of life. *J Chronic Dis* 1987; **40**: 593-600.

21. Richardson J, Atherton Day N, Peacock S, Iezzi A. Measurement of the quality of life for economic evaluation and the assessment of Quality of Life (AQoL) Mark 2 Instrument. *Aust Econ Rev* 2004; **37**: 62-88.

22. Neelemaat F, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Oral nutritional support in malnourished elderly decreases functional limitations with no extra costs. *Clin Nutr* 2012; **31**: 183-190.

23. Norman K, Pirlich M, Smoliner C, Kilbert A, Schulzke JD, Ockenga J, Lochs H, Reinhold T. Cost-effectiveness of a 3-month intervention with oral nutritional supplements in disease-related malnutrition: a randomised controlled pilot study. *Eur J Clin Nutr* 2011; **65**: 735-742.

24. Pham B, Stern A, Chen W, Sander B, John-Baptiste A, Thein H, Gomes T, Wodchis WP, Bayoumi A, Machado M, Carcone S, Krahn M. Preventing pressure ulcers in long-term care: a cost-effectiveness analysis. *Arch Intern Med* 2011; **171:** 1839-1847.

25. Freijer K, Nuijten MJC, Schols JMGA. The budget impact of oral nutritional supplements for disease related malnutrition in elderly in the community setting. *Front Pharmacol* 2012, **3**: 78.

26. Freijer K, Nuijten MJC. Analysis of the health economic impact of medical nutrition in the Netherlands. *Eur J Clin Nutr* 2010; **64**: 1229-1234.

27. Edington J, Barnes R, Bryan F, Dupree E, Frost G, Hickson M, et al. A prospective randomised controlled trial of nutritional supplementation in malnourished elderly in the community: clinical and health economic outcomes. *Clin Nutr* 2004; **23**: 195-204.

28. Harris AH, Hill SR, Chin G, Li JJ, Walkom E. The role of value for money in public insurance coverage decisions for drugs in Australia: a retrospective analysis 1994-2004. *Med Decis Making* 2008; **28**: 713-722.

29. Hoogendoorn M, Van Wetering CR, Schols AM, Rutten-van Mölken MPMH. Is INTERdisciplinary COMmunity-based COPD management (INTERCOM) cost-effective? *Eur Respir J* 2010; **35**: 79-87.

30. Dangour AD, Albala C, Allen E, Grundy E, Walker DG, Aedo C, et al. Effect of a nutrition supplement and physical activity program on pneumonia and walking capacity in Chilean older people: a factorial cluster randomized trial. *PLOS Med* 2011; **8**: e1001023.

31. Simmons SF, Zhuo X, Keeler E. Cost-effectiveness of nutrition interventions in nursing home residents: a pilot intervention. *J Nutr Health Aging* 2010; **14**: 367-372.

32. Kruizenga HM, Van Tulder MW, Seidell JC, Thijs A, Ader HJ, Van Bokhorst-de Van der Schueren MA. Effectiveness and cost-effectiveness of early screening and treatment of malnourished patients. *Am J Clin Nutr* 2005; **82**: 1082-1089.

33. Rypkema G, Adang E, Dicke H, Naber T, de Swart B, Disselhorst L, et al. Cost-effectiveness of an interdisciplinary intervention in geriatric inpatients to prevent malnutrition. *J Nutr Health Aging* 2003; **8**: 122-127.

34. Russell CA. The impact of malnutrition on healthcare costs and economic considerations for the use of oral nutritional supplements. *Clinical Nutrition, Supplements* 2007; **2**: 25-32.

35. Smedley F, Bowling T, James M, Stokes E, Goodger C, O'Connor O, et al. Randomized clinical trial of the effects of preoperative and postoperative oral nutritional supplements on clinical course and cost of care. *Br J Surg* 2004; **91**: 983-990.

36. Lawson RM, Doshi MK, Barton JR, Cobden I. The effect of unselected post-operative nutritional supplementation on nutrition status and clinical outcome of orthopaedic patients. *Clin Nutr* 2003; **22**: 39-46.

37. Lorefält B, Andersson A, Wirehn AB, Wilhelmsson S. Nutritional status and health care costs for the elderly living in municipal residential homes - an intervention study. *J Nutr Health Aging* 2011; **15**: 92-97.

38. Tucker HN, Miguel SG. Cost containment through nutrition intervention. *Nutr Rev* 1996; **54**: 111-121.

39. Brown J. Economic evaluation of health care. In: Bowling A, Ebrahim S (eds.) *Handbook of Health Research Methods: Investigation, Measurement, and Analysis*. Open University Press, Maidenhead, UK, 2008, pp 314-328.

40. Darmon P, Lochs H, Pichard C. Economic impact and quality of life as endpoints of nutritional therapy. *Curr Opin Clin Nutr* 2008; **11**: 452-458.

41. Wyers CE, Breedveld-Peters JJ, Reijven PL, Van Helden S, Guldemond NA, Severens JL, et al. Efficacy and cost-effectiveness of nutritional intervention in elderly after hip fracture: design of a randomized controlled trial. *BMC Public Health* 2010; **10**: 212.

42. Thomas SK, Humphreys KJ, Miller MD, Cameron ID, Whitehead C, Kurrle S, Mackintosh S, Crotty M. Individual nutrition therapy and exercise regime: a controlled trial of injured, vulnerable elderly (INTERACTIVE trial). *BMC Geriatrics.* 2008; **8**: 4.

Conflict of Interest

The authors declare no conflict of interest.

Table 1. Types of Economic Evaluation

Type of Evaluation	*Abbreviation*	*Aim*	*Variables*	*Outcomes*	*Example*
Cost-utility analysis	CUA	Compares the costs associated with an intervention with a measure of utility which combines the life years gained by an intervention with a measure of the quality of those life years	Resource costs Measure of utility (e.g. Quality Adjusted Life Year (QALY))	Ratio of cost per QALY gained	Cost per QALY for a fish oil intervention which reduces joint pain in patients with arthritis.
Cost-effectiveness analysis	CEA	Compares the costs associated with an intervention with a measure of clinical effectiveness	Resource costs Measure of clinical effectiveness	Cost per unit of clinical effectiveness	Cost of a unit reduction in blood cholesterol levels for a nutrition education intervention
Cost-consequence analysis	CCA	Compares the costs associated with an intervention with the consequences neither without combining these inputs nor without indicating the relative importance of the consequences.	Resource costs Consequences	List of costs List of possible outcomes Up to the reader to make judgements about the benefits and drawbacks of the intervention	Cost of providing a nutrition education intervention, and a reported reduction in blood cholesterol levels in an intervention group, but without combining these outcomes into a ratio.
Cost –benefit analysis	CBA	Compares the benefits of the intervention in monetary terms with the costs of the intervention	Resource Costs Benefits of the intervention in money	Net benefit of the intervention expressed in monetary terms	Commonly used for when a new treatment might involve an initial expenditure for treatment, but overall results in savings over time through reduce healthcare utilization.

Cost-minimisation analysis	CMA	Determine the least costly intervention where outcomes for two interventions are assumed to be equal	Resource costs	Difference in resource costs between two interventions	Measure the costs of providing hospital in the home program when the outcomes in morbidity, function, quality of life have been shown to be the same for as for inpatient care.

Table 2: Design and cost outcomes of included studies when participants defined as malnourished

Citation	*Design*	*Intervention*	*Population*	*n Subjects*	*Follow Up*	*Method*	*Sensitivity Analysis*	*Discounting*	*Unit*	*Cost per unit*	*Cost Intervention*	*Cost Comparison*
Neelemaat et al. 2012[22]	RCT	ONS (2520kJ and 24g protein) and malnutrition treatment protocol	Hospitalised older adults (Malnourished according to BMI or weight loss)	210	3 months	CUA	Yes	N/A	Additional QALY	€26962 $US33703	€9129 (1227)[1,2] $US11411 (1534)	€8684 (1361)[1,2] $US10855 (1701)
Norman et al. 2011[23]	RCT	ONS 3/12 (2505kJ and 23g protein)	Benign GI disease (Malnourished according to SGA)	120 I=60 C=54	3 months	CUA	Yes	N/A	Additional QALY	€9497-12099 $US11904-15164	€561 (514-609)[3,4] $US703 (644-763)	€22 (0-73)[3,4] $US28 (0-92)
Pham et al. 2011[24]	Model	ONS (1 carton per day, 8.4kJ/mL formula)	Residential Care (Malnourished according to weight loss)	N/A	3.8 years	CUA	Yes	Yes	Additional QALY	$CAN7824747 $US74306502	-	-

Freijer et al. 2012[25]	Model	ONS (2 cartons per day, NFS)	Community dwelling older people	720223	1 year	CBA	Yes	N/A	Total budget savings	€12986000 $US16232500	€262657000[5] $US328321250	€275643000[5] $US344553750
Freijer et al. 2010[26]	Model	ONS (2 cartons per day, NFS)	Abdominal surgery	N/A	Per admission	CBA	Yes	N/A	Mean cost of hospitalisation	-€252 $US316	-	-
Edington et al. 2004[27]	RCT	ONS from hospital (2500 – 4200kJ)	Recently hospitalised older adults (Malnourished according to BMI or weight loss)	100 I=51 C=49	6 months	CCA	No	N/A	-	-	£2989 (4418)[2,6] $US4752 (7024)	£2146 (2238)[2,6] $US3412 (3558)

Abbreviations: BMI=Body Mass Index, C=Control, GI=Gastrointestinal, I=Intervention, N/A=Not applicable, NFS= Not further specified, ONS=Oral nutritional supplements, QALY=Quality adjusted life year, RCT=Randomised controlled trial, SGA=Subjective global assessment, 95%CI=95% Confidence intervals

1a Standard Error

2 Costs included for providing medical treatment and social services only

3 Costs included for providing intervention only

4 95% CI

5 Costs included for medical treatment and social services related to treatment of DRM

6 Standard Deviations

Table 3: Design and cost outcomes of included studies where nutritional status not specified

Citation	*Design*	*Intervention*	*Population*	*n Subjects*	*Follow Up*	*Method*	*Sensitivity Analysis*	*Discount*	*Unit*	*Cost per Unit*	*Cost Intervention*	*Cost Comparison*
Hoogendoorn et al. 2010[29]	RCT	ONS 4/12 (2351kJ and 28g protein) plus multi-disciplinary intervention	COPD	199 I=102 C=97	2 years	CUA	Yes	No	Additional QALY	€32425 $US40400	€13565[1] $US16901	€10814[1] $US13474
Dangour et al. 2011[30]	Randomised factorial trial	ONS (1068kJ and 10g protein) and/or physical activity	Community-dwelling older adults	1669 ONS = 414, ONS+PA=452 PA=403 C[d]=400	2 years	CEA	Yes	Yes	Additional meter walked in 6 minute walking test	$US4.84[2]	Nutrition intervention $US91[3]	-
Simmons et al. 2010[31]	RCT	Snacks or ONS (NFS)	Residential Care	63 ONS=18 Snacks=24 C=19	6 weeks	CEA	Yes	N/A	Additional kCal consumed	$US0.01	ONS $US2.13 (0.37)[3,4]	-

Kruizenga et al. 2005[32]	Historical controlled trial	Malnutrition treatment protocol including high energy and protein meals (2500kJ and 12g protein additional)	Mixed ward patients	588 I=297 (HEHP =98) C[d]=291	Per admission	CEA	Yes	N/A	Mean cost per 1 days reduction in LOS (96%CI)	€35 (-1239-109) $US44 (-1544-136)	€37 (15-58)[3,5] $US46 (19-73)	-
Rypkema et al. 2003 [33]	Quasi-randomised controlled trial	Malnutrition protocol including treatment with high energy diet or ONS (NFS)	Geriatric ward patients	298 I=140 C = 158	Per admission	CEA	Yes	N/A	Kg gained	-€392 -$US489	€7516[6] $US9366	€7908[6] $US9854
Russell 2007[34]	Model	ONS (NFS)	Surgical patients	N/A	Per admission	CBA	N/A	N/A	Mean difference in cost of hospitalisation intervention vs control	-£849 -$US1340	-	-

Smedley et al. 2004[35]	RCT	ONS (6.3kJ and 0.05g protein per ml drink ad libitum) before and after surgery (SS group) vs ONS before (SC group) vs ONS after (CS group) vs control (CC group)	Surgical patients	152 CC=44 SS=32 CS=35 SC=41	Up to 96 days	CBA	Yes	N/A	Mean difference in cost of hospitalisation intervention vs control	-£300 -$US473	SS £2289 (2034-2717)[4,6] $US3612 (3209-4287)	£2618 (2272-3181)[4,6] $US4131 (3585-5019)
Lawson et al. 2003[36]	Prospective controlled trial	ONS (2500kJ and 20g protein)	Emergency and elective orthopaedic surgery	181 I=84 C=97	Per admission	CBA	No	N/A	Mean difference in cost of hospitalisation intervention vs control	-£16 -$US25	£2069[6] $US3264	£2199[6] $US3470
Lorefält et al. 2011[37]	Non-randomised controlled trial	Malnutrition protocol including high energy high protein meal	Residential Care	109 I=42 C=37	1 year	CCA	No	N/A	-	-	€1005[6] $US1253	€921[6] $US1148

		options (NFS) for 3 months										
Tucker and Miguel 1996[38]	Model	ONS (NFS)	Hospital patients	2485	Per admission	CCA	N/A	N/A	Mean difference in cost of hospitalisation per year intervention vs control	-$US8294	-	-

Abbreviations: C=Control, COPD=Chronic obstructive pulmonary disease, GI=Gastrointestinal, HEHP=High energy high protein diet, I=Intervention, LOS=Length of stay, N/A=Not applicable, NFS=Not further specified, ONS=Oral nutritional supplements, PA=Physical activity, QALY=Quality adjusted life year,

1 Costs included for providing intervention plus medical treatment and loss of income for participant

2 Costs included for providing physical activity intervention only

3 Costs included for providing intervention only

4 Standard deviations

5 95% Confidence intervals

6 Costs included for providing intervention and medical treatment

Legend for Figure 1. Flow diagram of study selection process

Legend for Figure 2. Results of the quality analysis of the study designs.

Bars indicate the number of studies for which the quality criteria was met (black bar), not met (white bar), or not applicable for this study (grey bar). Quality criteria taken from the 35 item checklist by Drummond et al.[14] Quality criteria divided into items referring to study design (A), data collection (B), and analysis and interpretation of the results (C). Criteria questions are as follows: Q1, the research question is stated; Q2, the economic importance of the research is stated; Q3, the viewpoint(s) of the analysis are clearly stated and justified; Q4, the rationale for choosing the alternative programmes or interventions compared is stated; Q5, the alternatives being compared are clearly described; Q6, the form of economic evaluation used is stated; Q7, the choice of form of economic evaluation is justified in relation to the questions addressed; Q8, the source(s) of effectiveness estimates used are stated; Q9, details of the design and results of the effectiveness study are given (if based on a single study); Q10, details of the method of synthesis or meta-analysis of estimates are given (if based on an overview of a number of effectiveness studies); Q11, the primary outcome measure(s) for the economic evaluation are clearly stated; Q12, methods to value health states and other benefits are stated; Q13, details of the subjects from whom valuations were obtained are given; Q14, productivity changes (if included) are reported separately; Q15, the relevance of productivity changes to the study question is discussed; Q16, quantities of resources are reported separately from their unit costs; Q17, methods for the estimation of quantities and unit costs are described; Q18, currency and price data are recorded; Q19, details of currency of price adjustments for inflation or currency conversion are given; Q20, details of any model used are given; Q21, the choice of model used and the key parameters on which it is based are justified; Q22, time horizon of costs and benefits is stated; Q23, the discount rate(s) is stated; Q24, the discount rate(s) is justified; Q25, an explanation is given if costs or benefits are not discounted; Q26, details of statistical tests and confidence intervals are given for stochastic data; Q27, the approach to sensitivity analysis is given; Q28, the choice of variables for sensitivity analysis is justified; Q29, the ranges over which the variables are varied are stated; Q30, relevant alternatives are compared; Q31 incremental analysis is reported; Q32, major outcomes are presented in a disaggregated as well as aggregated form; Q33, the answer to the study question is given; Q34, conclusions follow form the data reported; Q35, conclusions are accompanied by the appropriate caveats.

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ORIGINAL REPORT

WHAT ARE FRAIL OLDER PEOPLE PREPARED TO ENDURE TO ACHIEVE IMPROVED MOBILITY FOLLOWING HIP FRACTURE? A DISCRETE CHOICE EXPERIMENT

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Objective: **To investigate the preferences of frail older people for individualised multidisciplinary rehabilitation to promote recovery from a hip fracture.**
Design: **Discrete Choice Experiment.**
Setting: **Acute and Rehabilitation Hospitals in Adelaide, South Australia.**
Subjects**: Eighty-seven patients with recent hip fracture (16 living in residential care facilities prior to fracture).**
Methods: **Patients providing informed consent (or consenting family carer proxies in cases where patients were unable to provide informed consent (*n*=10)) participated in a face to face interview following surgery to repair a fractured hip to assess their preferences for different configurations of rehabilitation programs.**
Results: **Overall, participants expressed a strong preference for improvements in mobility and a willingness to participate in rehabilitation programs involving moderate pain and effort. However, negative preferences were observed for extremely painful interventions involving high levels of effort (2 h per day for 2 months). Subgroup analysis revealed consistently similar preferences according to place of residence (residential care vs community).**
Conclusions: **Improvements in mobility are highly valued by frail older people recovering from hip fracture, including those living in residential care. Further research should be directed towards achieving greater equity in access to rehabilitation services for the wide spectrum of patients attending hospital with hip fractures.**

Key words: discrete choice experiment; hip fracture; older people; residential care; rehabilitation.

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INTRODUCTION

Hip fractures are amongst the most devastating consequences of osteoporosis and injurious accidental falls with around 25% of patients dying in the first year after fracture (1, 2), with only 40% returning to pre-fracture levels of mobility (2), and annual expenditures exceeding 400M AUD (3). Rehabilitation strategies for frail older people following hip fractures are still evolving. However, there is evidence to suggest that an individualised multidisciplinary rehabilitation programme is associated with improvements in mobility relative to usual orthopaedic care (4). A previous study by Salkeld and colleagues (5) to assess the preferences for health of older women at risk of hip fracture living in the community indicated that even a small improvement in mobility was very highly valued and could have a large positive impact on quality of life. Whilst a rehabilitation programme has the ability to achieve large improvements in mobility (6), typically this also involves a period of substantial effort and endurance by the individual participant, as well as the endurance of significant levels of pain. In addition, paradoxically this type of intervention may also increase the risk of further falls and injuries principally because the individual achieves greater mobility as a consequence. Presently, scant evidence is available concerning the preferences of older people for an individualised multidisciplinary rehabilitation programme to promote recovery from a hip fracture.

Discrete Choice Experiment (DCE) is a stated preference technique originating in mathematical psychology which is designed to establish the relative importance and impact of individual attributes, or characteristics, upon the overall utility of a good or service (7). Within health economics there has been an exponential increase in the number of DCE studies undertaken within the last decade, with the majority focused upon the assessment of patient preferences within a wide variety of health care programmes and services (8, 9). However, DCE studies specifically designed for and conducted with older people (aged 65 years and over) remain rare in comparison with those conducted with general adult samples (8, 9). A recent commentary highlighted the potential for the application of discrete choice experiments in promoting patient choice for older people (8) and a recently published study in this jorurnal has demonstrated the potential for DCEs to engage older people in eliciting their views and preferences about alternative stroke specific rehabilitation services (10).

DCEs are typically administered through a questionnaire in which the respondent is presented with a series of choices between alternative health or rehabilitation programs and asked to choose the program that they would prefer. The alternative programs are described in terms of their attributes and associated levels (for example waiting time, location of treatment, type of treatment and staff providing the treatment). DCEs therefore provide information about the acceptability of different characteristics of programs, the trade-offs that patients are willing to make between these characteristics, and the relative importance of each of these characteristics in determining overall utility or value (11). This study sought to apply discrete choice experiment methodology to investigate the preferences of older people for rehabilitation to promote recovery from a hip fracture. Specifically, the DCE sought to investigate what older people would be prepared to endure in terms of levels of pain, physical effort and the risk of further falls and injury to recover the ability to mobilise independently following hip fracture through participation in an individualised multidisciplinary rehabilitation programme.

METHODS

Questionnaire design

A DCE questionnaire was developed for completion via a face to face interview between the consenting participant and a trained interviewer. The questionnaire contained two main sections. Section A comprised a series of attitudinal statements relating to recovery following hip fracture, mobility, and quality of life. Respondents were asked to indicate the degree to which they agreed or disagreed with each statement on a 5 point Likert scale ranging from completely agree to completely disagree. Section B of the questionnaire contained the DCE questions. The scenarios presented for consideration in the DCE were based upon 4 salient attributes identified by the research team in consultation with rehabilitation clinicians based upon increasing levels of pain, effort, risk of further falls and mobility. The full factorial options resulted in 81 possible scenarios for presentation (=3^4). A fractional factorial design was employed to reduce this to a more practical total of 36 scenarios, generating 18 binary choice sets, which were 100% efficient for the estimation of main effects (7). This design was divided into 3 versions and 6 binary choice sets were presented within each version. Within each binary choice set, participants were asked to indicate their preferred choice between a pair of hypothetical scenarios reflecting the characteristics of an individualised multidisciplinary rehabilitation programme they would receive at two alternative locations. Given that patients were already currently participating in a rehabilitation program, a "forced choice" experiment was considered appropriate and no opt out option was provided.

Administration of questionnaire

Participants were recruited from Flinders Medical Centre, and the Repatriation General Hospital in Adelaide, South Australia. The study was approved by the Flinders Clinical Research Ethics Committee (approval no. 4609, approval granted february 2009). Patients were approached sequentially between May 2009 and November 2010 following referral to the research team by a key contact staff member at each hospital. Inclusion criteria were admission with a falls related proximal femur fracture, 60 years old and above, and not currently receiving palliative care. All patients who gave informed consent to participate took part in a face to face interview with one of two study researchers. The interviews were completed approximately 7 days following their surgery, either at the patient bedside or at their home.

Consenting family carer preferences were elicited by proxies directed to answer from the patient's perspective in cases where significant cognitive impairment (defined in terms of a score less than 19/30 on the Mini-Mental State Examination (MMSE)) prevented an individual from giving informed consent and responding directly to the questionnaire. Whilst previous DCE studies in health care have tended to include participants with a reasonably high level of cognitive function (defined in terms of a MMSE score of 24 or above) for this study we attempted to be more inclusive in order to reflect more fully the views and preferences of older people themselves (including those from a residential care background), as opposed to obtaining proxy responses from a family member. There is evidence that the preferences of proxies often do not correspond well with the preferences of the patients themselves (12). The DCE was initially piloted with a small sample of patients ($n=10$) with a range of levels of cognitive function to check respondents level of understanding of the questions and to indicate that they were providing meaningful responses. The findings from the pilot study indicated that patients with mild cognitive impairment (MMSE 19–23) were able to complete the questionnaire and were also able to provide meaningful responses. Minor changes to question layout and phraseology were made as a consequence of the findings of the pilot study to improve participant understanding.

Data analysis

The data from the DCE were analysed within a random utility theory framework using a conditional logit regression model (13). The function to be estimated was of the following form:

V = β75%risk_fall + β50%risk_fall + β25% risk_fall + βmild_pain + βmoderate_pain + βsevere_pain + β30_mins + βone_hour + βtwo_hours + βmobility-Independant + βmobility_frame + βmobility-wheelchair + *e* + *u*

V is the utility or satisfaction associated with the different rehabilitation programs.

β_x are the estimated parameters of the model. *e* is the error term for the difference in observations. *u* is the error term for the differences between responses.

The estimated coefficients and their statistical significance (or otherwise) indicate the relevant importance of the different attributes on individual preferences. A positive sign on a coefficient indicates that as the level of the attribute increases so does the utility derived and the converse applies for a negative sign on a coefficient. The base levels of the coefficients could then be calculated using the formula that they were equal to the negative one multiplied by the sum of the coefficients for the two other levels. For every respondent, tests were also carried out to determine if any of the attributes were dominant (14). A dominant response implies that the scenario with the preferred direction of preference for one particular attribute is always chosen, irrespective of the levels of the remaining attributes presented. For example, a participant who always chooses the best level for mobility in every choice situation (irrespective of falls risk and the levels of pain or effort presented) has a dominant response pattern for mobility. Sub group analyses were undertaken by estimating two separate DCE models for [1] residential status: living in residential care versus living in the community, [2] education level: completed high school versus no qualifications, [3] age: 79 years and below versus 80 years and above, and the results were compared.

In order to estimate marginal rates of substitution (MRS), a conditional logit model was estimated including the risk of falling and the duration of effort required in the rehabilitation session as continuous variables. The MRS were then calculated by dividing the estimated coefficient for the attribute by the estimated coefficient for the selected value attribute (risk of falling or duration of effort).

RESULTS

A total of 149 patients with a recently proximal femoral fracture were approached of whom 87 (58%) consented to participate

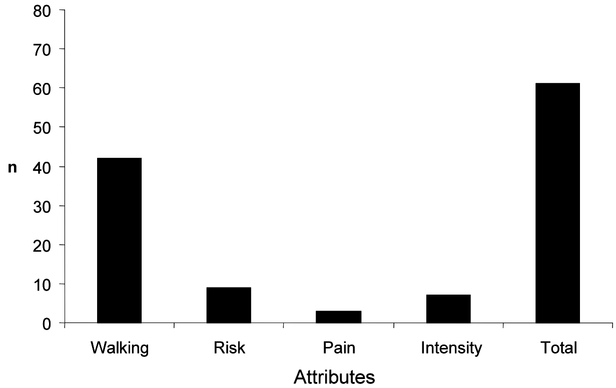

Fig. 1. The proportion of participants exhibiting dominant choice patterns from the total sample.

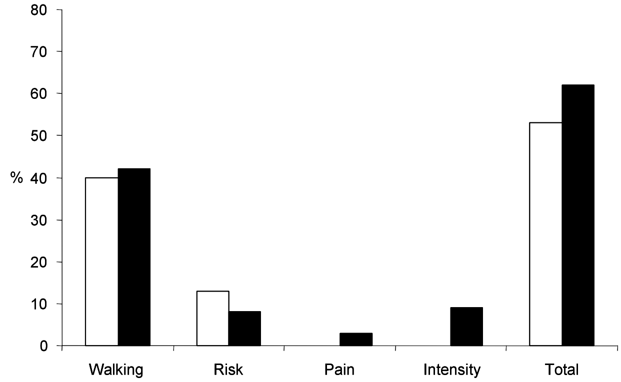

Fig. 2. The proportion of participants exhibiting dominant choice patterns within the residential care and community subgroups. Black columns represent the community subgroup and white columns represent the residential care subgroup.

in the study. The majority $n=61$ (70%) of the participants were women and were between 71 and 80 years of age, $n=64$ (74%). A small proportion were living in residential care prior to fracture [n=16 (18%)], the majority were living independently in the community prior to admission, n= 71 (82%). A total of 34 (39%) participants had a MMSE of 23 or below, of whom 10 (11%) had an MMSE of 19 or lower and therefore the questionnaire was completed on their behalf by a proxy family carer. For those participants with a MMSE of 23 and below, the results were found to be similar to those with a MMSE of 24 and above (results not shown), and therefore the results of these two groups were combined in a pooled analysis. Six (60%) of those participants whose questionnaire was completed by a proxy family carer were from residential care, the remainder were from the community.

The number of respondents who were dominant for each attribute and the total number of participants who were dominant for any attribute is presented in Fig. 1, along with the breakdown of dominant respondents for each attribute by sub group: living in residential care vs. the community prior to fracture in Fig. 2. Fig. 1 shows that 42 out of 81 (52%) participants who completed the this section of the questionnaire were dominant for the mobility attribute, this being much more common than dominance for any other attribute. Sub-group analysis revealed that the proportion of dominant respondents was largely similar for those living in residential care vs. the community prior to fracture.

Table I presents the results from the conditional logit model for the total sample. Both of the higher attribute levels relating to mobility (walking with a stick independently and walking with a frame) and the attribute level relating to the lowest risk of further falls (25%) were found to be highly important in determining positive preferences for an individualised multidisciplinary rehabilitation programme and were highly statistically significant ($p<0.001$). Participants also exhibited negative preferences for the attribute levels relating to severely painful interventions and levels of effort involving rehabilitation intervention durations of two hours or more per day and both of these attribute levels were statistically significant.

Table II presents the results from the conditional logit model for the subgroups according to place of residence prior to the hip fracture. It can be seen that both groups exhibited strong positive preferences for higher levels of the mobility attribute. However in contrast to those participants living in the community those living in residential care prior to hip fracture were less averse to severely painful interventions and levels of effort involving rehabilitation intervention durations of two hours or more per day. Both of these attribute levels were statistically significant in influencing the preferences of the community group but were uninfluential for the residential care group. The responses to the attitudinal questions for the total sample, and also for each subgroup can be found in

Table I. *Conditional logit model results (total sample). Data shown as coefficients with 95% confidence intervals (CI)*

Attributes	Attribute level	Coefficient (95% CI)	*p*
FALLS: Your risk of falling and breaking another bone at some time point following rehabilitation	50% or a 1 in 2 chance	0.0354 (–0.1670 to 0.2378)	0.732
	25% or a 1 in 4 chance	0.5450 (0.3316 to 0.7583)	0.000
PAIN: The level of pain you would need to accept during rehabilitation with the aim of recovering your ability to walk short distances	Moderate pain for 6 to 8 weeks	0.2097 (–0.0004 to 0.4199)	0.051
	Severe pain for 6 to 8 weeks	–0.4036 (–0.6111 to –0.1962)	0.000
EFFORT: The level of effort you would need to make during rehabilitation by working hard and exercising with a physiotherapist	1 h per day for 2 months	0.0088 (–0.1985 to 0.2162)	0.933
	2 h per day for 2 months	–0.4916 (–0.7020 to –0.2812)	0.000
MOBILITY: Your ability to recover walking following participation in the programme	Walking with a frame with 1 person close by	0.4032 (0.2063 to 0.6001)	0.000
	Walking with a stick independently without help	1.3807 (1.1697 to 1.5916)	0.000

Table II. *Results of conditional logit model for subgroups based on living in the community or in residential care*

Attributes	Attribute levels	Residential care (n=16) Coefficient (95% CI)	p	Community (n=71) Coefficient (95% CI)	p
FALLS: Your risk of falling and breaking another bone at some time point following rehabilitation	50% or a 1 in 2 chance	–0.0684 (–0.5481 to 0.4113)	0.780	0.0583 (–0.1672 to 0.2837)	0.613
	25% or a 1 in 4 chance	0.7499 (0.2344 to 1.2653)	0.004	0.4999 (0.2629 to 0.7369)	0.000
PAIN: The level of pain you would need to accept during rehabilitation with the aim of recovering your ability to walk short distances	Moderate pain for 6 to 8 weeks	0.2129 (–0.2808 to 0.7066)	0.398	0.2175 (–0.0168 to 0.4519)	0.069
	Severe pain for 6 to 8 weeks	–0.1673 (–0.6592 to 0.3247)	0.505	–0.4675 (–0.6991 to –0.2359)	0.000
EFFORT: The level of effort you would need to make during rehabilitation by working hard and exercising with a physiotherapist	1 h per day for 2 months	–0.4692 (–0.9482 to 0.0096)	0.055	0.1287 (–0.1036 to 0.3609)	0.277
	2 h per day for 2 months	–0.1620 (–0.6513 to 0.3273)	0.516	–0.5774 (–0.8138 to –0.3411)	0.000
MOBILITY: Your ability to recover walking following participation in the programme	Walking with a frame with 1 person close by	0.8300 (0.3556 to 1.3045)	0.001	0.3062 (0.0871 to 0.5253)	0.006
	Walking with a stick independently without help	1.2330 (0.7463 to 1.7197)	0.000	1.4322 (1.1949 to 1.6695)	0.000

CI: confidence interval.

Table III. The responses to the attitudinal statements broadly reinforce the findings from the DCE, indicating a strong preference to undertaking rehabilitation programmes with a view to increasing mobility, in both the residential and community care subgroups and the total sample.

Table IV presents the results of the conditional logit model for the sample with risk of falling and duration of effort for rehabilitation included as linear, continuous variables and the results of the marginal rates of substitution using risk of falling (risk) and duration of effort (duration) as value attributes. Plotting of the coefficient values attached to alternative levels of these two value attributes indicated that the assumption of a linear relationship was appropriate. The results indicate that, in general, participants would be prepared to accept a 22% increase in the risk of falling and breaking another bone to avoid enduring severe pain from participating in a rehabilitation programme. In general participants would also be prepared to accept an increase in the duration of the rehabilitation programme of over 2 h in a 2 month period (132 min) in order to achieve the highest mobility outcome of walking with a stick unaided.

The results of the conditional logit model were also analysed split for subgroups based on education level (no qualification

Table III. *Responses to attitudinal questions for total sample and by subgroup: living in residential care vs the community prior to fracture*

		A n (%)	B n (%)	C n (%)	D n (%)	E n (%)	F n (%)	G n (%)	H n (%)
Total	Strongly agree	51 (58.6)	32 (36.8)	40 (46.0)	0 (0)	27 (31.0)	3 (3.4)	0 (0)	9 (10.3)
	Agree	31 (35.6)	44 (50.6)	38 (43.7)	0 (0)	55 (63.2)	11 (12.6)	5 (5.7)	39 (44.8)
	Neither agree nor disagree	3 (3.4)	7 (8.0)	6 (6.9)	0 (0)	2 (2.3)	5 (5.7)	1 (1.1)	20 (23.0)
	Disagree	1 (1.1)	4 (4.6)	3 (3.4)	23 (26.4)	2 (2.3)	37 (42.5)	24 (27.6)	11 (12.6)
	Strongly disagree	1 (1.1)	0 (0)	0 (0)	64 (73.6)	0 (0)	31 (35.6)	57 (65.5)	4 (4.6)
	Did not answer	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.1)	0 (0)	0 (0)	4 (4.6)
Residential care	Strongly agree	6 (37.5)	3 (18.8)	3 (18.8)	0 (0)	3 (18.8)	0 (0)	0 (0)	3 (18.8)
	Agree	7 (43.8)	10 (62.5)	8 (50.0)	0 (0)	11 (68.8)	2 (12.5)	0 (0)	10 (62.5)
	Neither agree nor disagree	1 (6.3)	2 (12.5)	3 (18.8)	0 (0)	1 (6.3)	2 (12.5)	0 (0)	1 (6.3)
	Disagree	1 (6.3)	1 (6.3)	2 (12.5)	7 (43.7)	1 (6.3)	5 (31.3)	6 (37.5)	2 (12.5)
	Strongly disagree	1 (6.3)	0 (0)	0 (0)	9 (56.3)	0 (0)	7 (43.8)	10 (62.5)	0 (0)
Community based	Strongly agree	45 (63.4)	29 (40.8)	37 (52.1)	0 (0)	24 (33.8)	3 (4.2)	5 (7.0)	6 (8.5)
	Agree	24 (33.8)	34 (47.9)	30 (42.3)	0 (0)	44 (62.0)	9 (12.7)	0 (0)	29 (40.8)
	Neither agree nor disagree	2 (2.8)	5 (7.0)	3 (4.2)	0 (0)	1 (1.4)	3 (4.2)	1 (1.4)	19 (26.8)
	Disagree	0 (0)	3 (4.2)	1 (1.4)	16 (22.5)	1 (1.4)	32 (45.1)	18 (25.4)	9 (12.7)
	Strongly disagree	0 (0)	0 (0)	0 (0)	554 (77.5)	0 (0)	24 (33.8)	47 (66.2)	4 (5.6)
	Missing					1 (1.4)			4 (5.6)

A: I am confident that I will be able to walk again eventually; B: I want to be able to walk again even if there is a high risk that I could fall again and break another bone in the future; C: I am prepared to make a large physical effort over a period of several weeks to enable me to walk again; D: I would prefer to go into a wheelchair now and forget about walking again; E: I am prepared to accept pain for a number of weeks whilst following an exercise programme if it will enable me to walk again; F: I am very tired and I don't want to have physiotherapy to help me with walking; G: I would be happy to use a mechanical lifter to move me from the bed to a chair for the rest of my life; H: I would be prepared to pay a fee to receive an 8-week rehabilitation programme in the nursing home to help me walk again.

Table IV. *Marginal rates of substitution using risk of falls and duration of effort as value attributes*

Attribute	Level	Coefficient (SE)	MRS risk, %	MRS duration of effort, min
FALLS	Risk	–0.0160*** (0.0057)	–	2.000
PAIN	Mild	0.138	–8.625	–0.005
	Moderate	0.209** (0.104)	–13.063	–26.125
	Severe	–0.347*** (0.010)	21.688	43.375
EFFORT	Duration	–0.0078*** (0.0020)	0.500	–
MOBILITY	Wheelchair bound	–1.361	85.063	170.125
	Walking with a frame	0.304*** (0.091)	–19.000	–38.000
	Walking with a stick	1.057*** (0.105)	–66.063	–132.125

*$p<0.1$, **$p<0.05$, ***$p<0.01$.
SE: standard error; MRS: marginal rates of substitution.

vs high school completion and above) and age (79 years and below vs 80 years and above). There were no significant differences between the results split according to subgroup and the main results (data not shown).

DISCUSSION

To our knowledge this is the first time DCE methodology has been applied to ascertain patient preferences for an individualised multidisciplinary rehabilitation programme following hip fracture. The findings from this DCE study indicate that mobility outcomes and the achievement of independent mobility have significant and positive impacts for frail older people recovering from hip fracture. This study also provides important preliminary evidence for the feasibility and future potential for DCE methodology to be applied to elicit the treatment preferences of frail older people, a sub-group of the population traditionally excluded from studies of this nature (9).

Although our sub-sample of participants from residential care was small (n=16), we found that the preferences of participants from a residential care background were broadly similar to those from a community background. Participants from both residential care and the community exhibited strongly positive preferences for improved mobility following hip fracture and these differences were found to be statistically significant. This finding is reinforced by the responses to the attitudinal questions whereby all participants from both residential care and the community (100%) expressed they disagreed or strongly disagreed with the statement 'I would prefer to go into a wheelchair now and forget about walking'. Presently in Australia, patients from high care residential aged care facilities (nursing homes) are denied the same opportunities in relation to rehabilitation care as compared to people from community or low care residential aged care settings, an approach which is increasingly being questioned (15). Recently updated hip fracture guidelines from the National Institute of Health and Clinical Excellence (NICE) in the UK have recommended that priority research be undertaken into the provision of rehabilitation strategies for rehabilitating residential care patients following a hip fracture through their care facilities (16). A recent systematic review and an editorial have also highlighted the likely clinical benefit to this group (17). The findings from this study concur with these recommendations.

The DCE study represents a snapshot study of patient preferences at one time point only, following surgery for hip fracture. It may be the case that patients could change their preferences for rehabilitation over time, for example, if optimal rehabilitation is not achieved, or if their health declines further. We elected to survey patients about their preferences for rehabilitation early after their surgery when they were first commencing rehabilitation as it has been demonstrated that it is at this time-point that their engagement with a rehabilitation program is most important as rehabilitation must commence early following surgery to achieve the best outcomes (16). The chosen attributes and levels were developed with health professionals engaged in the provision of rehabilitation programmes and piloted with patients receiving rehabilitation for relevance, language and coverage. However, it is important that future research includes a comprehensive and client-focused method of defining attributes and levels for DCEs. The selection criteria recently presented by Coast et al. (18) recommending more methodologically rigorous methods of attribute selection based on qualitative methods would be useful in this regard.

This study provides important preliminary evidence relating to the preferences of frail older people for improved mobility as a consequence of an individualised multidisciplinary rehabilitation intervention following hip fracture. The findings indicate that, in general, the desire to recover mobility through a rehabilitation intervention is tempered by an aversion to high levels of risk of further falls and pain. This finding is important to note, given the current NICE recommendations to investigate the effectiveness of higher intensity rehabilitation programs, which may result in increased pain and fatigue for patients (16). If these guidelines were implemented in Australia, our study provides evidence that frail older adults are willing to participate in programmes requiring increasing effort and resulting in increasing pain during rehabilitation. However, a significant proportion is averse to programmes of severe pain and very long duration. Therefore, while higher intensity rehabilitation programmes are likely to be acceptable to this group, especially if they provide the chance of improved mobility outcomes for participants, it would be important for those designing such programmes to consider process outcomes such as the level of effort involved. It will be important in the future for both researchers and clinicians to determine novel strategies to design rehabilitation programmes which provide the intensity required to gain the mobility outcomes that older people so highly value but within levels of effort and pain which are acceptable. Physical exercise programmes are not only of interest for hip fracture rehabilitation, but are also of interest in older adults as a way of reducing the functional decline associated with hospitalisation (19) and in older community dwelling adults to reduce functional decline to maintain health and independence (20). Particularly Liu & Latham (20) in their Cochrane review of the effects of resistance strength training on physical function in older adults found effects on strength and vitality with higher intensity interventions, although the number of published studies was small. It would be interesting to consider whether the findings we have reported in hip fracture patients would also apply to other groups of older adults. While this may be the case, the preferences of older adults in other groups receiving rehabilitation programs needs further examination.

The study also adds to the bourgeoning literature highlighting the potential for the wider application of DCE methodology as a valuable tool for engaging with, and eliciting the views and preferences of, frail older people in relation to their health and health care (8, 10, 21), a group traditionally excluded from studies of this nature (8, 9). We attempted to be inclusive with the DCE by not excluding older adults with mild cognitive impairment. The preferences of those with mild cognitive impairment are particularly important given the increasing awareness that those with cognitive difficulties should not be excluded from rehabilitation programmes (16). The preliminary finding from our study are generally positive and indicate the potential for DCE's to be conducted in samples of older people with mild cognitive impairment. However it is important that further work is conducted to assess the practicality and feasibility of this approach in older people with cognitive impairment. The application of qualitative research methods, including think aloud approaches (22), may be particularly helpful in this regard to investigate the process of DCE decision making in this group. Further research should also be directed towards achieving greater equity in access to rehabilitation services for the wide spectrum of patients attending hospital with hip fractures.

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REFERENCES

1. Braithwaite RS, Col NF, Wong JB. Estimating hip fracture morbidity, mortality and costs. J Am Geriat Soc 2003; 51: 364–370.
2. Koval KJ, Zuckerman JD. Functional recovery after fracture of the hip. J Bone Joint Surg Am 1994; 76: 751–758.
3. Pasco JA, Henry MJ, Gaudry TM, Nicholson GC, Kotowicz MA. Identification of incident fractures: the Geelong Osteoporosis Study. Aust N Z J Med 1999; 29: 203–206.
4. Crotty M, Whitehead C, Miller M, Gray S. Patient and caregiver outcomes 12 months after home-based therapy for hip fracture: a randomized controlled trial. Arch Phys Med Rehabil 2003; 84: 1237–1239.
5. Salkeld G, Cameron ID, Cumming RG, Easter S, Seymour J, Kurrle SE, et al. Quality of life related to fear of falling and hip fracture in older women: a time trade off study. BMJ 2000; 320: 341–346.
6. Halbert J, Crotty M, Whitehead C, Cameron ID, Kurrle SE, Graham S, et al. Multi-disciplinary rehabilitation after hip fracture is associated with improved outcome: A systematic review. J Rehabil Med 2007; 39: 507–512.
7. Street DJ, Burgess L. The construction of optimal stated choice experiments: theory and methods. Hoboken, New Jersey: John Wiley and Sons; 2007.
8. Ratcliffe J, Laver K, Couzner L, Cameron ID, Gray L, Crotty M. Not just about costs: the role of health economics in facilitating decision making in aged care. Age Ageing 2010; 39: 426–429.
9. de Bekker-Grob EW, Ryan M, Gerard K. Discrete choice experiments in health economics: a review of the literature. Health Economics 2010 Dec 19 [Epub ahead of print].
10. Laver K, Ratcliffe J, George S, Lester L, Walker R, Burgess L, et al. Early rehabilitation management after stroke: what do stroke patients prefer? J Rehabil Med 2011; 43: 354–358.
11. Ryan M, Gerard K. Using discrete choice experiments to value health care programmes: current practice and future research reflections. Appl Health Econ Policy 2003; 2: 55–64.
12. Shalowitz DI, Garrett-Mayer E, Wendler D. The accuracy of surrogate decision makers: a systematic review. Arch Intern Med 2006; 166: 493–497.
13. Ryan M, Gerard K, Amaya-Amaya M, editors. Using discrete choice experiments to value health and health care. Dordrecht: Springer; 2006.
14. Lancsar E, Louviere J. Deleting 'irrational' responses from discrete choice experiments: a case of investigating or imposing preferences? Health Economics 2006; 15: 797–811.
15. Crotty M, Ratcliffe J. If Mohammed won't come to the mountain, the mountain must go to Mohammed. Age Ageing 2011; 40: 290–292.
16. National Clinical Guideline Centre. The management of hip fracture in Adults. London: National Clinical Guidelines Centre; 2011.
17. Forster A, Lambley R, Young J. Is physical rehabilitation for older people in long-term care effective? Findings from a systematic review. Age Ageing 2010; 39: 169–175.
18. Coast J, Al-Janabi H, Sutton EJ, Horrocks SA, Vosper AJ, Swancutt DR, et al. Using qualitative methods for attribute development for discrete choice experiments: issues and recommendations. Health Economics 2012; 21: 730–741.
19. de Morton N, Keating JL, Jeffs K. Exercise for acutely hospitalised older medical patients. Cochrane Database Syst Rev 2007: CD005955.
20. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. Cochrane Database Systs Rev 2009: CD002759.
21. Laver K, Ratcliffe J, George S, Burgess L, Crotty M. Is the Nintendo Wii Fit really acceptable to older people? A discrete choice experiment. BMC Geriatr 2011; 1: 1–6.
22. van Someren MW, Barnard, YF, Sandberg, JAC. The Think aloud method. A practical guide to modelling cognitive processes. London: Academic Press; 1994.

Cognitive overload? An Exploration of the Potential Impact of Cognitive Functioning in Discrete Choice Experiments with Older People in Health Care.

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Cognitive overload? An Exploration of the Potential Impact of Cognitive Functioning in Discrete Choice Experiments with Older People in Health Care.

ABSTRACT

Objectives: This study sought to investigate the impact of cognitive functioning on the consistency of individual responses to a DCE study conducted exclusively with older people.

Methods: A DCE to investigate preferences for multidisciplinary rehabilitation was administered to a consenting sample of older patients following surgery to repair a fractured hip (N=84). Conditional logit, mixed logit, heteroscedastic conditional logit and generalised multinomial logit regression models were utilised to analyse the DCE data and to explore the relationship between the level of cognitive functioning (specifically the absence or presence of mild cognitive impairment as assessed by the mini-mental state, MMSE) and age with preference and scale heterogeneity.

Results: Both the heteroscedastic conditional logit and generalised multinomial logit models indicated that the level of cognitive functioning did not impact significantly upon the consistency of the responses to the DCE. However age was found to have an impact, with the oldest old (aged 86 years and above) generally making less consistent choices relative to their younger counterparts.

Conclusions: This study provides important preliminary evidence relating to the impact of cognitive functioning upon DCE responses for older people. It is important that further research is conducted in larger samples and more diverse populations to further substantiate the findings from this exploratory study and to assess the practicality and validity of the DCE approach with older populations.

Introduction

There has been an exponential increase in the number of DCE studies undertaken within health economics during the last two decades since the first seminal paper by Propper and colleagues to assess the disutility of time spent on NHS waiting lists [1]. Despite the increase in their proliferation, DCE studies specifically designed for and conducted with older people remain relatively rare in comparison with those conducted and reported upon with general adult samples. Examples of published DCE studies focused exclusively in populations of older people (aged 65 years and over) include the valuation of the newly developed ICECAP-O capability instrument developed using best worst attribute scaling, a particular type of DCE [2] and DCE studies to assess older people's preferences for transition care and rehabilitation services [3,4]. The findings indicate that these studies were generally well received by their respective participants and point towards the practicality and validity of the application of DCE methodology in older populations. However, to date, older people with mild cognitive impairment have typically been excluded from DCE studies conducted in health and aged care.

Whilst it is well documented within health economic and health services research that individual choice behaviour often exhibits substantial heterogeneity, until recently the central premise of the investigation of heterogeneity has focused almost exclusively on the existence of preference or taste heterogeneity. A number of published DCE studies in health economics have accounted for preference or taste heterogeneity [5-8]. However, Louviere and colleagues [9,10] have argued that much of the heterogeneity in DCEs may actually be better described as scale heterogeneity (where scale is the inverse of the variance of the error term) reflecting the observation that for some individuals their choice behaviour is simply more random than others. Such scale heterogeneity can be explored using heteroscedastic error variance models [11] as recently performed in the health care sector by Lancsar et al. [12] who modelled scale as a function of education level. This observation has also generated the desire to simultaneously model both preference and scale heterogeneity in estimation of choice models and led to the development of specialised model structures, most notably the generalised multinomial logit regression (G-MNL) model [13,14].

Studies have been conducted with adults within health economics to assess the impact of the complexity of the DCE task, including the number of choice sets presented and the degree of overlap in the attribute levels chosen for comparison within choice sets [15,16]. These studies have included a proportion of older people within their study samples but have not been based exclusively in populations of older people. The findings have generally been inconclusive in identifying a definitive relationship between cognitive burden and task complexity. Intuitively, however it is reasonable to expect that such a relationship exists and this hypothesis is supported by evidence from behavioural decision research indicating that people tend to trade accuracy against effort in formulating decisions [17]. It has also been noted that what is commonly referred to as the 'capacity-difficulty gap' may actually matter more than the complexity of the DCE task [18,19]. The emphasis in this case is not on the impact of the task environment *per se* but on the innate cognitive capacity of the participant and his/her level of engagement with the DCE task. Scale heterogeneity could therefore be the result of some participants not understanding the task at hand, not being able to relate to the choice scenarios presented or not taking the experiment seriously. Hence differences in DCE study engagement and the resulting scale heterogeneity may be related (at least in part) to measurable characteristics of the participant e.g. the level of cognitive functioning or ability, or age (e.g. youngest old versus oldest old).

Given future patterns of socio-demographic change and the aging of the population it is reasonable to expect that the development of DCE studies designed specifically for application with older people across health and aged care sectors are likely to increase markedly during the coming decades. The reliability of DCE responses from older people with varying levels of cognition and the threshold level of cognitive ability required for an older person to reliably complete a DCE are therefore highly important but currently under-researched areas of investigation. This exploratory study sought to investigate this issue empirically by assessing the potential impact of cognitive functioning upon DCE generated responses from a sample of older people recovering from hip fracture. Specifically we employed mixed logit, heteroskedastic conditional logit and generalised multinomial logit regression models to more formally investigate the potential for preference and scale heterogeneity in responses for the total sample and by sub-groups classified according to the absence or existence of mild cognitive impairment.

Methods

Questionnaire design and administration

A DCE questionnaire was developed for administration with a population of older people recovering from surgery to repair a fractured hip. The design and administration of the DCE questionnaire is discussed in detail in a separate paper [20]. The DCE comprised four salient attributes relating to rehabilitation therapy following hip fracture including levels of pain and effort endured, the risk of further falls and injury from participating in rehabilitation therapy and the level of mobility achieved. The attributes and levels included in the DCE are presented in Table 1. The 81 possible scenarios resulting from the full factorial options were reduced to 18 binary choice sets each containing two options using a fractional factorial design which was 100% efficient for the estimation of the main effects [21]. To reduce participant burden, this design was blocked into three versions each with six binary choice questions presented. An additional binary choice set contained a clearly dominant choice through comparison of the best and worst levels of each attribute was included as a seventh choice set to provide a test of internal consistency. For each choice question participants were asked to indicate their preferred programme from two hypothetical multidisciplinary rehabilitation programmes with different levels of the attributes presented within each programme.

[Insert Table 1 about here]

Following approval granted from the relevant research ethics committee, participants were recruited from two hospitals in Adelaide, South Australia, sequentially over an 18 month period between May 2009 and November 2010. Patients were approached for participation if they had been admitted to hospital with a falls related proximal femur fracture, were 60 years old or above, and were not currently receiving palliative care.

Cognitive functioning was assessed by the Mini-Mental State Examination (MMSE). The MMSE was developed in 1975 as a brief tool to measure global cognitive function [22]. The MMSE has since proven to be valid and reliable across a variety of clinical, epidemiological, and community survey studies [23]. The MMSE is now widely applied and recognized in many countries as an effective test for detecting and quantitatively estimating the severity of cognitive impairment and for documenting cognitive changes over time in individuals residing in health, aged care and community settings. It contains 19 items relating to orientation, registration, attention and calculation, recall, language and praxis, and is scored from 0 to 30 where 0 indicates the most severe level of cognitive impairment and 30 indicates the highest level of cognitive functioning. MMSE scores were categorized according to the three group categorization criteria adopted by Tombaugh and McIntyre's seminal review whereby a score of 17 or below indicates severe cognitive impairment, a score of 18 to 23 indicates mild cognitive impairment and a score of 24 or above indicates no cognitive impairment [23]. For patients classified with severe cognitive impairment informed consent was sought from a proxy family member who was also asked to complete the DCE questionnaire on behalf of the patient and from the patient's perspective.

The DCE questionnaire was administered using an interviewer mode of administration, post-operatively at approximately one to two weeks following surgery to repair the fractured hip. Previous DCE studies conducted exclusively in older populations and a recent study in patients exhibiting cognitive impairments due to a diagnosis of schizophrenia have indicated that an interview mode of administration is preferable to self-completion postal or on-line surveys as this helps to aid respondent understanding and promotes completion rates. In advance of the main study, the DCE questionnaire was piloted with a small sample of patients (N=10) with a range of levels of cognitive function to check respondents understanding of the questions and to indicate that they were providing meaningful responses. The findings from the pilot study indicated that patients with mild cognitive impairment (MMSE 19-23) were able to fully complete the questionnaire and were also able to provide meaningful responses. Minor changes to question layout and phraseology were made as a consequence of the findings of the pilot study to improve participant understanding.

Data analysis

The data from the DCE were analysed within the framework of random utility theory which assumes that respondents choose the alternative that maximizes their utility. Let U_{itj} be the utility individual *i* derives from choosing alternative *j* in choice scenario *t*. Utility is given by:

$$U_{itj} = x'_{itj}\beta_i + \varepsilon_{itj},$$

where x_{itj} is a vector of observed attributes of alternative *j*, β_i is a vector of individual specific coefficients reflecting the desirability of the attributes, and ε_{itj} is a stochastic term. For a traditional linear-index model (i.e. $x'_{itj}\beta_i$), the probability of respondent *i* choosing alternative *j* in choice situation *t* can be specified as:

$$\Pr(choice_{it} = j \mid \beta_i) = \frac{\exp(\sigma_i x'_{itj}\beta_i)}{\sum_{k=1}^{J}\exp(\sigma_i x'_{itk}\beta_i)},$$

where σ_i is an individual specific scale of the idiosyncratic error, which is inversely proportional to the error variance.

The data were analysed using four key econometric model specifications suitable for the analysis of DCE data ranging in their respective levels of model sophistication including (1) the simple conditional logit (which is unable to take account of either preference of scale heterogenity), (2) the heteroskedastic conditional logit (which can take account of scale heterogeneity), (3) the mixed logit (accounting for taste or preference heterogeneity) and (4) the advanced generalised multinomial logit (which takes account of both preference and scale heterogeneity simultaneously).

Firstly, assuming ε_{itj} is independent and identically distributed (IID) with Gumbel (type 1 extreme value) distribution, a conditional logit model is adopted under the assumptions that $\beta_i=\beta$ and $\sigma_i=\sigma=1$ [24]. Although conditional logit models have been widely utilised in the analysis of DCE data, such models contain a strong assumption relating to homoscedasticity or constant error variance, amongst others [25]. Within this data-set it is reasonable to hypothesize that the existence of the 'capacity-difficulty gap' may mean that participants in the lower cognitive functioning sub-group tend to make choices that are considerably less consistent (or with a larger error variance) than those in the higher cognitive functioning sub-group. A heteroscedastic conditional logit model was then employed to test whether error variances differed according to lower or higher cognitive functioning [26-28]. According to the heteroscedastic conditional logit model framework, the scale parameter can be parametrised as $\sigma_i = \exp(\theta z_i)$, where z_i is a vector of individual characteristics (e.g. level of cognitive functioning, age) and θ is a vector of parameters capturing the influence of those characteristics on the error variance).

The traditional conditional logit model also assumes that each individual specific coefficient β, reflecting the desirability of a particular attribute, is a fixed parameter representing homogeneous preferences. To relax this assumption, a mixed logit model was employed, by specifying β_i to follow a distribution of which the mean and standard deviation are estimated (i.e. $\beta_i = \beta + \eta_i$, where η_i is a vector of individual *i*-specific deviations from the mean) [29].

Finally, the recently operationalized G-MNL model which can accommodate both preference and scale heterogeneity in a single model was employed [14]. Following Fiebig et al. [14] and Gu et al. [30] β_i is defined generally as: $\beta_i = \sigma_i\beta + [\gamma + \sigma_i(1-\gamma)]\eta_i$, where γ governs how the variance of preference heterogeneity varies according to the level of scale heterogeneity, σ_i is distributed log-normal with standard deviation τ and mean $\overline{\sigma} + \theta z_i$, i.e.

$\sigma_i = \exp(\bar{\sigma} + \theta z_i + \tau\varepsilon_0)$. Fiebig et al. [14] show that γ lies between 0 and 1. In one extreme case where γ=1, β_i can be written as $\beta_i = \sigma_i\beta + \eta_i$. This is referred to as the G-MNL-I model. It can be clearly demonstrated that: firstly this setting incorporates both scale and preference heterogeneity, and secondly η_i is independent of σ_i. In another extreme case where γ=0, β_i can be written as $\beta_i = \sigma_i\beta + \sigma_i\eta_i$. This is referred to as the G-MNL-II model. In this case, preference heterogeneity is impacted by both η_i and σ_i.

Information criterion are commonly utilised to choose the overall fit of DCE models with the Bayesian Information Criterion (BIC) being increasingly utilised as the preferred measure [31]. All econometric analyses were conducted in Stata version 12.1 (StataCorp LP, College Station, Texas, USA) using clogit, clogithet [32], mixlogit [33], and gmnl [30] commands.

Comparisons between choice models that have been generated from two groups of respondents, for example, a sample of patients with higher levels of cognitive functioning and a sample of patients with lower levels of cognitive functioning, need to take account of differences in unobserved variability, or scale, between the data sources [34]. The Swait and Louviere test was used to formally test for such differences across the two sub-samples [35].

Results

A total of 149 patients who had recently undergone surgery to repair a hip fracture were approached of whom 87 (58%) consented to participate in the study. A total of 84 individuals (56%) fully completed the DCE questionnaire of whom 74 were patients and 10 were proxy family members. Table 2 presents a summary of the characteristics of the participants. For the self-completing participants, the majority N=52 (70%) were women and the mean age was 80 years of age. Whilst a small proportion, N=10 (14%) were living in residential care prior to fracture, the vast majority were living independently in the community prior to admission, N=64 (86%). The majority of self-completing participants (68%) were classified with normal cognitive function and were born in Australia (73%). In addition the vast majority

(84%) indicated that they found the DCE task either ‘not’ or ‘slightly’ difficult to complete and all 84 participants (100%) passed the test of internal consistency.

[Insert Table 2 about here]

The results from the conditional logit regression model based upon the total self-reporting sample and for sub-samples partitioned according to cognitive functioning (higher cognitive functioning and, lower cognitive functioning) and age (85 years and below or 86 years and above) are presented in Table 3. Column (1), comprising the total sample, indicates that participants exhibited statistically significant positive preferences for the lowest risk of future falls (25%) and for improvements in mobility (walking with a frame with one person close by and walking with a stick independently without help) and statistically significant negative preferences for the highest level of pain during rehabilitation (severe pain) and the longest duration of rehabilitation intervention (two hours per day for two months).

Columns (2) and (3) in Table 3 present the results from the sub-samples partitioned according to cognitive functioning. For respondents without cognitive impairment (i.e. MMSE≥24), the conditional logit estimates are broadly consistent with the total sample. However, for individuals with minor cognitive impairment (i.e. MMSE ranged between 19 and 23), the pain attribute became insignificant. When partitioned according to age (see Columns (4) and (5)) a notable difference is that whilst the younger old exhibited statistically significant positive preferences for the lowest level of risk of falls (25%) the falls attribute was insignificant for the oldest old age group. These results are supported by application of the Swait and Louviere test which confirmed that splitting the sample based on cognitive functioning, the null hypothesis of equal preferences could not be rejected at the 10% level while splitting the sample on age, lead to reject of the null hypothesis of equal parameters.

[Insert Table 3 about here]

The results from the heteroscedastic conditional logit model to investigate whether respondents' characteristics impacted on the error variance are presented in Table 4. The MMSE score was included as a dummy variable reflecting higher or lower cognitive functioning (Column (1)). The coefficient relating to cognitive functioning was positive indicating that respondents with higher level of cognitive functioning tended to exhibit higher scale and thus lower error variance, however this was not found to be statistically significant. In contrast, a stronger relationship was found for age; the coefficient relating to age indicated that the oldest old exhibited lower scale and higher error variance and this relationship was found to be highly statistically significant ($P<0.01$) (Column (2)). Although not reported here, when including both MMSE and age dummies simultaneously, the results were found to be similar in that only the age dummy was found to be statistically significant ($P<0.05$). In addition, the impact of education level was also tested and found to be statistically insignificant ($P>0.10$).

[Insert Table 4 about here]

Preference heterogeneity was investigated through application of a mixed logit regression model by specifying the coefficients attached to each attribute level (β_i) to follow a normal distribution with associated mean and standard deviation. The results are reported in Table 5, firstly assuming random coefficients are independent and secondly assuming random coefficients are correlated. Comparing the mixed logit estimates for the standard deviations reported in Columns (1) and (2), it can be seen that in both cases only the attribute levels relating to mobility were found to be statistically significant. The BIC values support the conclusion that the model in Column (2) is preferred compared to the one in Column (1). Based on the same information criterion, the model in Column (4) is preferred when assuming random coefficients are correlated. Regarding whether random coefficients should be assumed to be independent or not, the likelihood ratio test can be adopted. To this end, comparing Columns (2) and (4), the likelihood ratio statistic under the null of uncorrelated coefficients is -2×[-161.172-(-160.303)]=1.738. Since the 95% critical value from the chi-squared distribution with 1 degree of freedom is 3.84, the null hypothesis cannot be rejected. We therefore conclude that the mixed logit estimates reported in Column (2) represent the preferred model. Since coefficients of attribute levels are assumed to be normally distributed, the mixed logit estimates relating to the mean coefficient and standard deviation for the mobility attribute (Column (2), Table 5) can be utilised to calculate the distribution of preference heterogeneity. For example, the proportion of respondents exhibiting a preference for the ability to recover walking with a frame with one person close by following rehabilitation (relative to being wheelchair bound) is calculated as $100\times\Phi(0.644/1.106)=72\%$, where Φ is the cumulative standard normal distribution. Similarly, 88% of respondents ($100\times\Phi(2.907/2.454)=88\%$) would prefer walking with a stick independently without help relative to being wheelchair bound.

[Insert Table 5 about here]

Table 6 reports results from application of the G-MNL model which accounts for both scale and preference heterogeneity simultaneously. Following the conclusions from the data analysis using the mixed logit model, the coefficients attached to the attribute levels relating to mobility were assumed to be random and independent. The parameter γ (which governs how the variance of residual preference heterogeneity varies with scale) was estimated both without any boundary restriction and also on two special cases (i.e. γ=0 and γ=1). For the sake of simplicity, only the preferred G-MNL estimates (selected based on the BIC values) are reported. In all non-reported results, the estimates of γ were consistently insignificant. Furthermore, comparing the BIC values in the corresponding columns in Table 4 and Table 6, it can be clearly seen that in all cases, all G-MNL models were preferred. In comparison with the heteroscedastic conditional logit model results, the G-MNL model also indicates that the dummy variable attached to cognitive functioning is statistically insignificant (Column (1), Table 6) whilst the oldest old dummy variable (in Column (2), Table 6) remains statistically significant but the relationship is weaker (p<0.10). All other conclusions remain the same across both heteroscedastic conditional logit and G-MNL models principally that: MMSE score is statistically insignificant and only the mobility attribute exhibits robust statistically significant standard deviations. Conditional on including the personal characteristics that may influence scale, the estimated τ in all columns were insignificant and close to 0, implying that scale heterogeneity is mainly related to age.

[Insert Table 6 about here]

Discussion

This paper investigated the potential role of cognitive functioning in DCE using a sample of older patients following surgery to repair a fractured hip. Preference heterogeneity was found to be significant only for the mobility attribute. Whilst no evidence of a relationship between scale heterogeneity and the level of cognitive functioning was found, the results indicate that there may be a relationship between scale heterogeneity and age, with the oldest old (86 years and above) tending to exhibit larger error variance/lower scale.

There are several possible explanations for our findings. Although it is presently the most widely applied instrument internationally for assessing cognitive impairment, the MMSE may not be the most appropriate test of cognitive functioning for application with DCE studies. In a comprehensive review of screening tests for cognitive impairment Cullen et al. [36] noted that although a total of 39 screening tests were identified which had been designed for this purpose clinician surveys indicate that the MMSE is “overwhelmingly ubiquitous in practice”. The review described the content of all tests according to a comprehensive checklist of six key abilities or domains including attention/working memory, verbal recall, expressive language, verbal fluency, visual construction and reasoning/judgement. The MMSE was found to lack coverage of both the verbal fluency and reasoning/judgement domains. However, the ability to apply logical reasoning and judgement is clearly an important requirement for a participant to provide meaningful responses to a discrete choice experiment. Therefore although the MMSE appears reasonable at categorising individuals with higher and lower cognitive functioning, it may not provide a good measure of a person's ability to carry out logical reasoning [37]. This may provide at least a partial explanation as to why we failed to observe a consistent relationship between cognitive impairment and scale heterogeneity. The review identified two tests, 3MS (Modified Mini-Mental State Examination) [38] and the CASI (Cognitive Abilities Screening Instrument) [39] which covered all six abilities or domains. Future research is needed to further assess the discriminative abilities of the MMSE in relation to other more comprehensive screening tests in categorising individuals with higher and lower cognitive functioning for the purposes of participation and data analysis for DCE studies.

The finding that the oldest age group (aged 86 years and above) tended to exhibit larger error variance/lower scale relative to the young old may also be related to the lack of discriminative ability of the MMSE in relation to reasoning and judgement. Evidence indicates that the prevalence of cognitive impairment and dementia rises markedly in the oldest old age group [40,41]. Hence, it may be the case that the oldest old group were more adversely impaired in the reasoning/judgement domain of cognitive functioning but the utilisation of the MMSE as the screening test for this study failed to identify this. As a consequence the oldest age group may have been less engaged with the DCE task than their younger counterparts leading to an increase in the error variance and therefore lower scale for this group. Further research including qualitative 'think aloud' approaches would be helpful in this regard in determining a detailed examination of older participants understanding and level of engagement with the DCE task.

In practice the impact of the task environment, the complexity of the DCE task and the cognitive capacity of the participant are likely to be highly inter-dependent. Within this study we deliberately sought to simplify the DCE design and minimise the complexity of the DCE task in two main ways. Firstly, by focusing upon four salient attributes with three levels attached to each attribute and secondly, by blocking the design into three versions to reduce the number of choice sets required for presentation. The simplification of the task may therefore have contributed to the main finding of the insignificance of the level of cognitive functioning on scale heterogeneity and it is possible that scale heterogeneity may be more evident where more complex DCE tasks are conducted. Previous studies conducted exclusively in populations of older people have tested the impact of the complexity of the DCE task, in terms of the mode of administration and the number of choice sets presented [3,4,42]. These studies found that participant understanding and completion rates were significantly elevated using an interviewer mode of administration with visual props (in the form of choice sets handed one at a time to the participant for consideration) as opposed to a traditional self-completion format with all choice sets presented simultaneously in a single questionnaire. Additionally participant fatigue precluded the presentation of more than 6 or 7 binary choice sets within a single interview.

This exploratory study involved face to face interviews which are more expensive than other forms of data collection and hence the sample size was relatively small when compared to samples achieved from online panels, for example. However, it is important to note that other modes of administration (such as online completion) would not be appropriate for this cohort of respondents. However, our sample size is larger than many DCE studies reported in the literature that have also incorporated more advanced modelling approaches [4,6,43,44]. Further research is needed in larger samples and more diverse populations to substantiate these preliminary findings and to investigate the reliability and validity of the DCE approach in populations of older people, including those with mild cognitive impairment.

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References

1. Propper C. **Contingent valuation of time spent on NHS waiting lists**. *Econ J.* 1990;100:193-199.
2. Coast J, Flynn T, Natarajan L, Sproston K, Lewis J, Louviere J, Peters, T. **Valuing the ICECAP capability index for older people**. *Soc Sci Med.* 2008;67:874-882.
3. Laver K, Ratcliffe J, George S, Burgess L, Crotty M. **Is the Nintendo Wii Fit really acceptable to older people?: A discrete choice experiment**. *BMC Geriatr.* 2011;11:64.
4. Laver K, Ratcliffe J, George S, Lester L, Walker R, Burgess L, Crotty M. **Early rehabilitation management after stroke: what do stroke patients prefer?** *J Rehabil Med. 2011;*43:354-358.
5. Hall J, Fiebig DG, King MT, Hossain I, Louviere JJ. **What influences participation in genetic carrier testing?: Results from a discrete choice experiment**. *J Health Econ. 2006;*25:520-537.
6. Lancsar EJ, Hall JP, King M, Kenny P, Louviere JJ, Fiebig DG, et al. **Using discrete choice experiments to investigate subject preferences for preventive asthma medication**. *Respirology.* 2007;12:127-136.
7. Eberth B, Watson V, Ryan M, Hughes J, Barnett G. **Does one size fit all? Investigating heterogeneity in men's preferences for benign prostatic hyperplasia treatment using mixed logit analysis**. *Med Decis Making. 2009;*29:707-715.
8. Mentzakis E, Ryan M, McNamee P. **Using discrete choice experiments to value informal care tasks: exploring preference heterogeneity**. *Health Econ.* 2011;20:930-944.
9. Louviere J, Eagle T. **Confound it! That pesky little scale constant messes up our convenient assumptions**. *Proceedings of the Sawtooth Software Conference*, Delray Beach, Florida, US; 2006.

10. Louviere J, Meyer R. **Formal choice models of informal choices: what choice modeling research can (and can't) learn from behavioural theory**. *Rev Market Res.* 2008;4:3-32.
11. Swait J, Adamowicz W. **Choice environment, market complexity, and consumer behavior: a theoretical and empirical approach for incorporating decision complexity into models of consumer choice**. *Organ Behav Hum Dec.* 2001;86:141-167.
12. Lancsar E, Louviere J, Donaldson C, Currie G, Burgess L. **Best worst discrete choice experiments in health: Methods and an appliation**. *Soc Sci Med.* 2013;76:74-82.
13. Keane M. **The generalized logit model: preliminary ideas on a research programme**. *Presentation at the Motorola-CenSoc Hong Kong Meeting*, Hung Horn, Kowloon, Hong Kong; 2006.
14. Fiebig D, Keane M, Louviere J, Wasi N. **The generalized multinomial logit model: accounting for scale and coefficient heterogeneity**. *Market Sci.* 2010;29:393-421.
15. Maddala T, Phillips KA, Johnson FR. **An experiment on simplifying conjoint analysis designs for measuring preferences**. *Health Econ.* 2003;12:1035-1047.
16. Bech M, Kjaer T, Laurisden J. **Does the number of choice sets matter? Results from a web survey applying discrete choice experiment**. *Health Econ.* 2011;**20**:273-286.
17. Payne J, Bettman J, Johnson E. **The Adaptive Decision Maker**. Cambridge University Press: Cambridge; 1993.
18. Heiner RA. **The origin of predictable behavior**. *Am Econ Rev*. 1983;73:560-595.
19. Hess S, Stathopoulos A. **Linking response quality to survey engagement: a combined random scale and latent variable approach**. *Presentation at the International Choice Modelling Conference*, Leeds, UK; 2011.
20. Milte R, Ratcliffe J, Miller MD, Crotty M, Whitehead C, Cameron ID. **What are frail older people prepared to endure to achieve improved mobility following hip fracture? A discrete choice experiment**. *J Rehabil Med.* 2013;45:81-86.

21. Street DJ, Burgess L. **The Construction of Optional Stated Choice Experiments: Theory and Methods**. John Wiley and Sons: New Jersey, USA; 2007.

22. Folstein MF, Folstein SE, McHugh PR. **“Mini-mental state”: a practical method for grading the cognitive state of patients for the clinician**. *J Psychiat Research.* 1975;12:189-198.

23. Tombaugh TN, McIntyre NJ. **The Mini-Mental State Examination: a comprehensive review**. *J Am Geriat Soc. 1992;*40:922-935.

24. McFadden D. Conditional logit analysis of qualitative choice behaviour. In **Frontiers in Econometrics***,* Zarembka P (ed.). Academic Press: New York, USA; 1974.

25. Louviere J, Hensher D, Swait J. **Stated Choice Methods: Analysis and Interpretation***.* Cambridge University Press: Cambridge; 2000.

26. Swait J, Awamowicz W. **The Effect of Choice Environment and Task Demands on Consumer Behavior: Discriminating Between Contribution and Confusion**. *Staff Paper Series: No. 24091.* Department of Resource Economics and Environmental Sociology University of Alberta, Alberta, Canada; 1997.

27. Hensher D, Louviere J, Swait J. **Combining sources of preference data**. *J Economet.* 1999;89:197-221.

28. de Shazo J, Fermo G. **Designing choice sets for stated preference methods: the effects of complexity on choice**. *J Env Econ Ma.* 2002;44:123-143.

29. McFadden D, Train K. **Mixed MNL models for discrete choice**. *J Appl Econom.* 2000;5:447-470.

30. Gu Y, Hole A, Knox S. **Estimating the generalized multinomial logit model in Stata**. *Stata J.* 2013;13:382-397.

31. Hensher DA. **Accounting for scale heterogeneity within and between pooled data sources**. *Transport Res A-Pol.* 2012;46:480-486.

32. Hole AR. **Small-sample properties of tests for heteroscedasticity in the conditional logit model**. *Econ Bull.* 2006;3:1-14.

33. Hole AR. **Fitting mixed logit models by using maximum simulated likelihood**. *Stata J.* 2007;7:388-401.
34. Lancsar E, Louviere J. **Conducting discrete choice experiments to inform Healthcare decision making**. *Pharmacoeconomics.* 2008;26:661-677.
35. Swait J, Louviere J. **The role of the scale parameter in the estimation and comparison of multinomial logit models**. *J Market Res.* 1993;30:305-314.
36. Cullen B, O'Neill B, Evans J, Coen R, Lawlor B. **A review of screening tests for cognitive impairment**. *J Neuro Neurosur Ps.* 2007;78:790-799.
37. Marioni RE, Chatfield M, Brayne C, Matthews FE. **The reliability of assigning individuals to cognitive states using the Mini Mental-State Examination: a population-based prospective cohort study**. *BMC Med Res Methodol.* 2011;11:127.
38. Teng EL, Chui HC. **The modified mini-mental state (3MS) examination**. *J Clin Psychiat.* 1987;48:314-318.
39. Teng EL, Hasegawa K, Homma A, Imai Y, Larson E, Graves A, et al. **The Cognitive Abilities Screening Instrument (CASI): a practical test for cross-cultural epidemiological studies of dementia**. *Int Psychogeriatrics.* 1994;6:45-62.
40. Johansson B, Zarit SH. **Prevalence and incidence of dementia in the oldest old: a longitudinal study of a population-based sample of 84–90-year-olds in Sweden**. *Int J Geriatr Psych.* 1995;10:359-366.
41. Llibre Rodriguez JJ, Ferri CP, Acosta D, Guerra M, Huang Y, Jacob KS, et al. **Prevalence of dementia in Latin America, India, and China: a population-based cross-sectional survey**. *Lancet.* 2008;372:464-474.
42. Ratcliffe J, Laver K, Couzner L, Crotty M. Health economics and geriatrics: challenges and opportunities. In **Geriatrics**, Atwood CS (ed.). ISBN: 978-953-51-0080-5, InTech; 2012. Available from: http://www.intechopen.com/articles/show/title/health-economic-evaluation-and-geriatrics-challenges-and-opportunities. [Accessed: 28 January 2013].

43. Hall J, Kenny P, King M, Louviere J, Viney R, Yeoh A. **Using stated preference discrete choice modelling to evaluate the introduction of varicella vaccination**. *Health Econ.* 2002;11:457-465.

44. Schellings R, Essers BAB, Kessels AG, Brunner F, van de Ven T, Robben PBM. **The development of quality indicators in mental healthcare: a discrete choice experiment**. *BMC Psychiat.* 2012;12:103.

Table 1 - Attributes and Attribute Levels

Attributes	Description	Attribute levels	Variable name
Risk	Your risk of falling and breaking another bone at some time point following rehabilitation	75% or a 3 in 4 chance	Seventy
		50% or a 1 in 2 chance	Fifty
		25% or a 1 in 4 chance	Twentyfive
Pain	The level of pain you would need to accept during rehabilitation with the aim of recovering your ability to walk short distances	Mild pain for 6 to 8 weeks	Mild
		Moderate pain for 6 to 8 weeks	Moder
		Severe pain for 6 to 8 weeks	Severe
Effort	The level of effort you would need to make during rehabilitation by working hard and exercising with a physiotherapist	30 minutes per day for 2 months	Thirtymins
		1 hour per day for 2 months	Onehour
		2 hours per day for 2 months	Twohours
Mobility	Your ability to recover walking following rehabilitation	Wheelchair bound	Wheelchair
		Walking with a frame with one person close by	Frame
		Walking with a stick independently without help	Stick

Note: Effects coding is used.

Table 2 - Participant Characteristics

	Self-reported N=74 N (%)[b]	Proxy[a] N=10 N (%)[b]
Mean age (Std. Dev.) years	80 (8.5)	82 (6.9)
Female	52 (70%)	7 (70%)
MMSE[c]		
Normal (24-30)	48 (68%)	0
Mild (18-23)	23 (32%)	0
Education[c]		
No qualifications	32 (44%)	5 (50%)
High school	35 (48%)	5 (50%)
Degrees/professional qualification	6 (8%)	0
Live in community	64 (86%)	4 (40%)
Live in residential care	10 (14%)	6 (60%)
Born in Australia[c]	53 (73%)	8 (80%)
Difficulty[c]		
Not	39 (56%)	4 (40%)
Slightly	20 (28%)	4 (40%)
Very or Moderately	11 (16%)	2 (20%)

[a] Characteristics reflect patients in proxy group with exception of MMSE score which is attributable to the proxy

[b] Unless otherwise indicated

[c] MMSE missing = 3, Education missing = 1, Born in Australia missing = 1, Difficulty missing = 4

Table 3 - Conditional Logit Estimates

Attribute levels	(1)	(2)	(3)	(4)	(5)
	Full sample	MMSE ≥ 24	MMSE 19~23	Age ≥ 86	Age ≤ 85
Fifty	0.121	0.009	0.282	-0.322	0.228*
	[0.103]	[0.136]	[0.185]	[0.215]	[0.125]
Twentyf	0.373***	0.404***	0.518***	0.385	0.485***
	[0.110]	[0.152]	[0.200]	[0.236]	[0.148]
Moder	0.214*	0.327**	0.120	0.588**	0.139
	[0.112]	[0.152]	[0.194]	[0.240]	[0.136]
Severe	-0.332***	-0.378**	-0.209	-0.603**	-0.310**
	[0.108]	[0.150]	[0.185]	[0.235]	[0.131]
Onehour	0.021	-0.114	0.193	-0.311	0.139
	[0.100]	[0.133]	[0.180]	[0.231]	[0.124]
Twohours	-0.417***	-0.297**	-0.650***	-0.465**	-0.457***
	[0.114]	[0.151]	[0.214]	[0.235]	[0.141]
Frame	0.266***	0.341***	0.122	0.525**	0.204*
	[0.098]	[0.129]	[0.176]	[0.220]	[0.118]
Stick	1.118***	1.282***	1.094***	0.514**	1.399***
	[0.116]	[0.158]	[0.220]	[0.214]	[0.159]
LL	-191.096	-112.877	-60.792	-47.935	-130.905
BIC	432.114	272.194	162.186	133.473	309.802
N	74	48	23	16	58
Obs.	513	332	160	110	403

Notes: Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. LL: log likelihood; BIC: Bayesian Information Criterion.

Table 4 - Heteroscedastic Conditional Logit Estimates

Attribute levels	(1)	(2)
Fifty	0.078	0.168
	[0.096]	[0.118]
Twentyf	0.369***	0.492***
	[0.112]	[0.138]
Moder	0.208**	0.195
	[0.103]	[0.128]
Severe	-0.270***	-0.344***
	[0.103]	[0.124]
Onehour	-0.019	0.059
	[0.091]	[0.116]
Twohours	-0.349***	-0.469***
	[0.120]	[0.133]
Frame	0.241***	0.271**
	[0.091]	[0.112]
Stick	1.023***	1.351***
	[0.169]	[0.157]
HET		
MMSE: 24-30 (dummy)	0.206	
	[0.192]	
The oldest old (dummy)		-0.636***
		[0.225]
LM test statistics	1.16	8.75***
LL	-177.783	-186.450
BIC	411.352	429.062
N	71	74
Obs.	492	513

Notes: Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. LL: log likelihood; BIC: Bayesian Information Criterion. HET: variables used to model error variance. The null hypothesis for LM test is that the error variance is constant across respondents.

Table 5 - Mixed Logit Estimates

	Random coefficients: independent		Random coefficients: correlated	
Attribute levels	(1)	(2)	(3)	(4)
Fifty	0.048	0.044	0.056	0.117
	[0.217]	[0.212]	[0.449]	[0.218]
Twentyf	1.114***	1.069***	1.415**	0.997***
	[0.334]	[0.313]	[0.613]	[0.284]
Moder	0.503**	0.490**	0.555	0.464**
	[0.218]	[0.208]	[0.406]	[0.209]
Severe	-0.647***	-0.640***	-0.811**	-0.632***
	[0.203]	[0.196]	[0.402]	[0.193]
Onehour	-0.045	-0.048	-0.089	0.071
	[0.179]	[0.175]	[0.370]	[0.183]
Twohours	-0.918***	-0.881***	-1.231*	-0.910***
	[0.268]	[0.243]	[0.710]	[0.248]
Frame	0.645***	0.644***	0.752*	0.370
	[0.244]	[0.239]	[0.434]	[0.243]
Stick	3.019***	2.907***	3.878***	2.814***
	[0.688]	[0.627]	[1.187]	[0.607]
SD				
Fifty	-0.024		0.439	
	[0.451]		[0.588]	
Twentyf	-0.109		0.786	
	[0.429]		[0.540]	
Moder	0.018		0.480	
	[0.364]		[0.519]	
Severe	0.003		1.104*	

	[0.536]		[0.604]	
Onehour	-0.004		0.476	
	[0.342]		[0.464]	
Twohours	-0.231		0.809	
	[0.502]		[0.586]	
Frame	1.131***	1.106***	1.739***	1.147***
	[0.354]	[0.338]	[0.600]	[0.330]
Stick	2.542***	2.454***	3.493***	2.503***
	[0.645]	[0.603]	[1.153]	[0.592]
LL	-160.552	-161.172	-151.961	-160.303
BIC	420.948	384.746	578.493	389.250
N	74	74	74	74
Obs.	513	513	513	513

Notes: Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. LL: log likelihood; BIC: Bayesian Information Criterion. SD: standard deviation. Number of Halton draws: 500.

Table 6 - Generalized multinomial logit estimates, random coefficients are assumed to be independent

Attribute levels	(1)	(2)
Fifty	0.045	0.091
	[0.254]	[0.232]
Twentyf	1.331***	1.262***
	[0.456]	[0.398]
Moder	0.585**	0.510**
	[0.264]	[0.234]
Severe	-0.693***	-0.688***
	[0.247]	[0.226]
Onehour	-0.064	-0.031
	[0.205]	[0.194]
Twohours	-1.115***	-0.946***
	[0.372]	[0.280]
Frame	0.752**	0.661**
	[0.304]	[0.267]
Stick	3.594***	3.308***
	[1.014]	[0.781]
SD		
Frame	1.330***	1.103***
	[0.432]	[0.344]
Stick	3.163***	2.366***
	[0.820]	[0.561]
HET		
MMSE: 24-30 (dummy)	0.021	
	[0.219]	
The oldest old (dummy)		-0.424*

		[0.253]
τ	0.032	0.101
	[0.139]	[0.198]
γ	<u>**1**</u>	<u>**1**</u>
LL	-144.593	-159.881
BIC	363.567	394.645
N	71	74
Obs.	492	513

Notes: Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. γ is set to be one. LL: log likelihood; BIC: Bayesian Information Criterion. SD: standard deviation. HET: variables used to model error variance. Number of Halton draws: 500.