The Economics of Hip Fracture Re-Considered: The Case of Tayside

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And though the truth will not be discovered
by such means – never can that stage be
reached – yet they throw light on some of
the profounder ramifications of falsehood.

Franz Kafka, *Investigations of a dog.*

Declaration

I, Elisabeth M.C. Brock, hereby certify that this thesis, which is approximately 70,000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date: 4-10-04 Signature:

I was admitted as research student under Ordinance No. 12 in September 1995 and as a candidate for the degree of Doctor of Philosophy in September 1996; the higher study for which this is a record was carried out in the University of St Andrews between 1996 and 2002.

Date: 4-10-04 Signature:

I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of Doctor of Philosophy in the University of St Andrews and that the candidate is qualified to submit this thesis in application for that degree.

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Abstract

Hip fracture has long been associated with significantly increased morbidity as well as mortality. A review of the published global knowledge of the resource implications of hip fracture revealed widely divergent estimates of the costs associated with this condition, even after adjusting for differences in purchasing power between different countries. Cost estimates could be shown to vary with the timeframe of a study, the use of any type of control group and the length of acute stay. Cost estimates could not be shown to be directly related to many other differences in the epidemiological characteristics of the patient sample, unit costs or methodological choices made in the modelling process. This might have been partly due to the difficulty of comparing studies' modelling inputs, processes and results because of heterogeneous standards of reporting.

A model was therefore constructed to estimate the costs associated with hip fracture for the health and social services of Tayside in the year following the fracture. It was attempted to gain additional insight into the question which costs can be directly attributed to hip fracture (rather than other co-morbid conditions) by linking each individual's data on resource consumption with data of that individual's physical functioning during the same time period. It was suggested that costs needed to be accompanied by corresponding changes in physical functioning in order to establish that these costs were directly attributable to the sustained hip fracture. The analysis revealed that assessed in this way, only a minority of patients incurred long-term costs due to changes in accommodation needs. Even fewer patients attributed any changes that did occur in this respect to the sustained fracture. Using physical functioning data in this way appeared to suggest that the corresponding cost estimate using standard methods of cost assessment overestimates the true costs of hip fracture by between 25% and 33% per case. This study's individualised patient-level data on physical functioning in hip fracture patients suggests that outcomes data may be able to play an important role in refining current knowledge of the costs of different diseases far beyond those of hip fracture.

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1. Introduction

Far from eradicating illness, Aneurin Bevan's vision of universal health care free at the point of delivery has in fact led not to less but more consumption of health care. Those charged with the health of contemporary Britain find themselves in an environment of spiralling healthcare costs as well as increased demand (Normand, 1999, p. 226). One of the ways in which the NHS had sought to address this is by attempting to maximise the value its population derives from each pound spent on healthcare (Ashmore, 1989, p.2). This involves the comparison of the costs and outcomes associated with particular health care programmes to identify which programme might deliver the greatest benefit at the least cost. When considering for example which programme would deliver the best value-for-money in hip fracture prevention and treatment, the costs of hip fracture and the costs of undertaking the programme in question need to be identified, measured and valued. These then need to be compared to the expected outcome or benefits of that particular programme. Much of the attention and controversy has so far been concentrated on the question of how outcomes ought to be measured. The question of how costs should be measured does not appear to have received the same amount of scrutiny. For example, one of the main textbooks of economic evaluations in healthcare devotes one chapter to issues of cost assessment and three to that of the assessment of outcomes (Drummond, 1997). The issue of cost measurement, however, provides the foundation without which no comparison between costs and outcomes is possible. Without this comparison, efforts to make the implications of decisions more transparent and thereby improve the value gained from funds spent on health care and other public services must remain relatively ineffective.

In this context of identifying and increasing value for money, the prevention and management of osteoporosis as the main risk factor for hip fracture has received much attention. Amongst others, it was incorporated into the Department of Health's National Service Framework for Older People (2001). Osteoporosis is a condition known to many people as 'brittle bones'. It appears to lead to an increased risk of fractures at different sites. Fractures of the hip have received the lion's share of attention in this, although fractures of the wrists and vertebrae have also been identified as common. One of the reasons for hip fractures having a more prominent profile is that their effect is acutely debilitating. The fact that they require hospitalisation makes them a relatively easy disease target to identify and quantify.

The management of hip fracture is one of the more serious problems facing the health care systems of most industrialised countries today. It is one of the most common diagnoses behind admission to an orthopaedic hospital ward. On average one hip fracture takes up around 29 inpatient bed days. For a substantial number of patients the hip fracture seems to trigger the move from independent living in the community to living within a more or less supported institutional setting. This trend may well be exacerbated by the fragmentation of the traditional family and the increasing number of women in the full-time workforce, by choice or by necessity. Hip fracture is most common in the elderly. The average age at which a fracture is sustained is around 80 years.

Although the increase in hip fractures for each age range seems to have stabilised, the fact that Britain's population is getting older in itself looks set to lead to a substantial increase in hip fractures.

In accordance with the principles of increasing value for money in health care spending, in order to decide what, if anything can and should be done about hip fractures in any given population, it is a necessity to understand the impact this condition has on resource consumption. It is the aim of this thesis to further decision-makers' understanding of this.

To do so, the parameters of the disease or condition in question need to be set out first. Chapter 2 provides this in the form of a survey of current knowledge concerning the epidemiology of hip fracture and its most common underlying cause, osteoporosis. Having defined what it means to speak about a 'fractured hip', the chapter continues by looking at causes and treatments for hip fracture. This necessitates a brief excursion into the area of biology to acquire a rudimentary understanding of the complexity and current state of knowledge of bone anatomy and the process of bone remodelling. Thus equipped, light can be shed on selected aspects of the condition of osteoporosis. Evidence on the risk of fracture in different population groups is given, as well as information on the clinical risk factors which can lead to fractures.
An outline of the incidence rates of osteoporosis, hip and other fractures across the world concludes the second chapter. The main finding of this introduction to the condition under investigation is that hip fracture patients across the world appear to differ with respect to many epidemiological criteria, such as age, which

may have an impact on resource consumption. In order to increase transparency and transferability of results, it is argued that any study of the resource implications of this condition thus ought to provide a description of the study sample with respect to these criteria.

Having established what a hip fracture is and who gets it, the question then becomes what is the effect of a hip fracture? The answer to this question is spread across two chapters. Chapter 3 sets out current knowledge of how the burden of this condition or disease should be assessed. This starts with a brief outline of the key concepts which underpin such an assessment. It is followed by an exposition of the guiding principles behind the methodological choices faced by an investigation of the impact of a hip fracture prevention or treatment programme. These cover all aspects of an investigation, from the identification of the consequences of the condition, through their measurement to their valuation in monetary units. It involves choices with respect to the inputs as well as processes of modelling the impact of a disease. It includes choices as to the perspective of the study and its geographical location. It further includes the choice of the type and time horizon of the study and finally the type of costs included in the assessment and the way they were assessed.

Having thus set out the criteria on which an assessment should be based in order to give a reasonably true picture of the impact of a disease, chapter 4 then proceeds to examine how the impact of hip fracture has been studied by the existing literature. Chapter 3 and 4 thus used the generic as well as the disease-specific literature to identify which issues are of particular importance in ensuring that a study assesses the impact of hip fracture most faithfully. This forms the basis for chapter 5, which sets out the methodological issues involved in performing an assessment of the impact of hip fracture in Tayside. The chapter describes the way data was collected on patients' resource use, unit costs and functional ability. It then depicts how these model inputs were combined to yield an estimate of the impact of hip fracture in Tayside in the twelve months following the fracture.

Having described how this model was constructed, chapter 6 then presents the results of this model. The sensitivity analysis sought to complement the best estimate of the monetary costs of hip fracture in Tayside mainly with the construction of a lower and an upper estimate by varying key assumptions of the model.

Chapter 7 examines how the costs associated with hip fracture in Tayside compare with those identified by the existing literature on the subject. Since cost estimates appeared to vary widely, the variables identified in chapter 2 and 3 relating to patient characteristics and methodological modelling choices were used to investigate whether cost estimates appeared to be in any way systematically influenced by either what was measured or how it was measured. Three criteria, patients' length of stay in acute care, the use of a control group and the timeframe of the analysis appeared to bear a significant impact on many studies' cost estimates. However, the fact that, for example, a study's estimate is higher due to a longer timeframe of analysis does not in itself pass judgment on whether the resulting costs can be directly attributed to the disease being investigated.

Chapter 8 thus attempts to shed additional light on this issue by drawing on data relating to patients' physical functioning. This is based on the idea that it may not be appropriate to attribute all patients' change of accommodation in the year following a hip fracture directly to the sustained fracture. Many elderly patients might have moved to accommodation offering a higher level of support with or without the fracture. Existing case-control study designs though find it difficult to incorporate such considerations, since many hip fracture patients already suffer from relatively worse health before their fracture compared to their age and sex-matched counterparts. Chapter 8 therefore explores in what way hip fracture cost estimates might be affected by the idea that only those follow-up costs may be directly attributed to the hip fracture which are accompanied by a change in physical functioning.

The thesis aims to contribute to current knowledge on several fronts. The thesis presents the first comprehensive review of the costs associated with hip fracture in the global literature. This is furthermore the first time that a comprehensive assessment of the costs of hip fracture in Tayside in the year following the fracture has been produced. The main contribution of the thesis though aims to be its contribution to the methodology of cost assessment for economic evaluations of health care programmes. It seeks to get a better understanding of which costs may be directly attributed to a condition by utilising information about patients' physical outcomes.

2. The Nature and Epidemiology of Hip Fractures and Osteoporosis

In order to investigate the economic aspects of any disease a basic understanding of the disease or condition in question is needed. This second chapter sets out to provide just that. The first section details what a hip fracture is, who fractures their hip and why. The second section aims to give a basic idea of bone anatomy and the process of bone turnover. The subsequent four sections are concerned with osteoporosis, the major risk factor for hip fracture that is also amenable to health care intervention. These sections in turn detail what osteoporosis is, who gets it and why. Ultimately, the purpose of the chapter is also to identify those characteristics of hip fracture patients which may have an impact on the costs associated with the condition, an association which will be explored in later chapters.

There is a substantial body of literature concerned with the epidemiology of hip fracture and osteoporosis. The 'golden age' of osteoporosis research started in the 1980s and continues into the present day. Much of the earlier literature of the 1970s and 1980s is concerned with establishing some of the fundamental disease processes, North American and Northern European prevalence and incidence rates. The 1990s saw an explosion of literature on the condition. The main focus of concentration during this decade was on extending the geographic reach of the literature, identifying prevalence and incidence rates beyond North America and Northern Europe. These concerns organically extended the research into the

quest for identifying risk factors predisposing individuals or ethnicities towards the conditions. This body of literature has been added to and extended during the last few years. This research as yielded few findings which have directly contradicted the fundamental earlier results on the aforementioned topics. The more recent literature has furthermore shifted focus somewhat by taking advantage of the rapidly evolving methods of diagnosis, including genetics.
The relevant literature was identified by searches of the most common databases containing medical literature such as Medline, Bids and First Search. The references of the retrieved articles were also examined. This was supplemented by hand-searching journals identified as consistently relevant in this way in several medical libraries in Scotland, as well as Switzerland.[1]

2.1. Hip Fractures

2.1.1. Definition of Hip Fracture

A hip fracture is defined as a fracture of the femur (the thigh bone) above a point 5 cm below the distal part of the lesser trochanter (Parker and Pryor, 1993). This broad definition includes a number of different subdivisions and classification methods, such as intra- and extracapsular fractures, displaced and undisplaced fractures, which refer to the location or the type of fracture sustained (Gillespie, 2001). The time taken to recuperate from these different types of hip fracture

[1] The first draft of this chapter was written in 1998. This is reflected in the referenced literature. The aim of the chapter is to give a reasoned account for establishing certain broad categories of patient characteristics which might impact cost assessments. Given the size of the relevant literature, the existing references were updated up to the summer of 2003 mainly where studies were published later contradicting the earlier findings or offering substantial new insights into the condition relevant to cost assessment.

appears to differ and in some cases differ substantially (Jensen and Tondevold, 1980). When comparing between different studies of the resource implications of hip fracture, it may thus be important to consider explicitly the way the disease entity was defined by the study.

2.1.2. Causes of Hip Fracture

Hip fractures in the young are most often associated with high energy trauma such as motor vehicle accidents. More typically, however, hip fractures result in older people from a fall from standing height or less. The two main risk factors which have been identified are an increased risk of falling and the loss of skeletal strength resulting from osteoporosis. Both of these risk factors have been primarily associated with ageing and are explained in more detail in section 2.4. (Gillespie, 2001). There are few estimates in the published literature of how many hip fractures are the direct result of osteoporosis. The reason for this is probably that it is difficult by nature to disentangle these two factors, falling and osteoporosis. Osteoporotic bone is unlikely to fracture without the impact of a fall. At the same time, a fall from standing height or less would be unlikely to result in a fractured hip unless the bone was made more fragile by the presence of osteoporosis. However, Weinstein estimates that over 90% of hip fractures are the result of osteoporosis (Lane, 1996). Osteoporosis thus seems to be the main driving factor behind low trauma hip fractures which is potentially amenable to health care intervention. The biological processes involved in this degenerative bone disease will be examined in more detail in the next section.

2.1.3. Treatment of Hip Fractures

Hip fractures are mainly treated surgically today. The exact type of treatment depends on the location and type of fracture sustained, specific patient characteristics and to a certain extent the preferences of the individual surgeon in a given country. A hip fracture can happen to anyone, at any age. However, the risk of sustaining such a fracture increases exponentially with age (see section 2.5).

2.1.4. Mortality Following a Hip Fracture

Hip fractures have been associated with an increased risk of mortality. This ranges anywhere between 6% and 37%, depending on patient characteristics such as age and pre-fracture health status (Cauley JA, Thompson DE, Ensrud KC, et al., 2000; Meyer HE, Tverdal A, Falch JA, et al., 2000).

2.2. The Anatomy of Bone and the Process of Bone Remodelling

2.2.1. Bone Types

The average adult's skeleton consists of about 206 bones. Each bone has a particular shape suited to its specific function. There are several different types and shapes of bones. The two main types are spongy bone and compact bone. There are no sharp boundaries between these two. The differences between them depend on the relative amount of solid matter and the number and size of the spaces in each of them. All bones have an outer shell of compact bone (also called os compactum, substantia corticalis, cortical bone or substantia compacta) surrounding a central mass of cancellous bone (substantia spongiosa, os spongiosum or trabecular bone) (Pschyrembel, 1994). Cancellous bone consists of thin, irregular trabeculae[2] (bars) of compact bone which branch and unite with one another to form intercommunicating spaces that are filled with bone marrow (medulla ossium). These trabeculae of spongy bone are arranged in lines of pressure and tension. Trabecular bone has a greater surface area and its metabolism is a lot more active than that of cortical bone. It is thus more responsive to changes in mineral homeostasis.

2.2.2. Patterns of Bone Loss

Over their lifetimes, women lose about 35 % of their cortical bone and 50 % of their trabecular bone. Men lose about two thirds of these amounts (Mazess, 1982; Riggs 1981). There are two phases of bone loss for both types of bone. There is a protracted slow phase of bone loss for both sexes and a transient accelerated phase in post-menopausal women. The slow phase of loss of **cortical bone** starts around the age of 40 in both sexes initially at a rate of 0.3 to 0.5% per year. This increases with aging until it slows or ceases late in life (Mazess, 1982; Smith, 1975). Postmenopausal women experience a phase of accelerated bone loss of the cortical bones in addition to the trabecular bone loss. Immediately after menopause 2 to 3 % of bone is lost. This decreases exponentially until it becomes asymptotic with the slow phase 8 to 10 years after menopause (Lindsay, 1980).

[2] This is defined as "supporting strands of connective tissue constituting part of the framework of an organ" (Youngson, 1992).

Evidence of **trabecular bone** loss from the axial[3] skeleton is conflicting (Riggs and Melton, 1986). What seems certain is that the pattern of bone loss of trabecular bone is different from that of cortical bone in several respects. In both sexes, the onset of trabecular bone loss occurs at least a decade earlier than the onset of cortical bone loss; in women, the extent of premenopausal trabecular bone loss is much greater than the extent of cortical bone loss; and the accelerated postmenopausal phase of trabecular bone loss may have an initial rate that is greater than that for cortical bone loss but a duration that is shorter. The accelerated phase is more difficult to demonstrate after natural menopause than after oophorectomy because the onset of sex-steroid deficiency is more variable and more gradual (Riggs and Melton, 1986).

It has been suggested that women's bone loss is due more to a reduction in the number of trabeculae. In men a fall in trabecular width predominates . Mean wall thickness decreases more markedly in men. In women perforation or total resorption of trabeculae is more common, especially during the high-turnover phase after menopause (Seeman, 1995). These differences may contribute to a lower fracture rate in males and may also be advantageous when treating male osteoporosis (Ringe, 1996).
Concerning the risk of hip fracture, differences in age-related changes in cortical bone between sexes may be even more important. The diminution in cortical bone is less in men because there is less endocortical resorption and more periosteal bone apposition[4] (Ruff, 1988). The latter may be a more important

[3] spine and skull
[4] periosteum : " the tissue that surrounds bone" (Youngson, 1992)

factor in preserving bone strength because placing bone tissue distant from the long axis of bone increases biomechanical stability. Ringe (1985) showed that in the radius (one of the two forearm bones) a clear increase in bone diameter with advancing age could be recognized only in men. This greater increase in periosteal bone formation in men is also true for the spine, leading to increases in vertebral body size and a reduction in fracture risk (Mosekilde and Mosekilde, 1990).

The patterns of bone loss in men thus seems to be different than that of women. The implications of this are that the age and sex distribution of the patient sample may well have an impact on any estimate of the resource use associated with hip fracture. This will be explored in chapter 4. The reasons for this difference in the patterns of bone loss between the sexes are to be found in the complex processes and controls involved in bone remodelling.

2.2.3. Bone Remodelling

The process of bone resorption and bone formation does not occur randomly throughout the skeleton. Once an area of bone is activated, bone remodelling units called 'osteons' take over. These osteons comprise osteoclasts which demolish the existing bone which has been tagged, reversal cells, also called mononuclear cells, which clean up the bone demolished by the osteoclasts and osteoblasts which are responsible for building new bone. The latter fill in the now cleared area with a new organic matrix, called osteoid. This is a jelly-like substance that frames the new bone. After about 25 to 30 days this osteoid

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apposition : " a placing of structures side by side" (ditto) becomes mineralised and turns to bone. This remodelling cycle takes several months to complete and continues throughout the entire lifetime.

2.2.4. Determinants of bone remodelling

The rate of bone turnover is mainly determined by the frequency of activation of new osteons (Parfitt, 1979). What varies is the balance between bone formation and demolition. During the twenties and thirties bone formation outstrips bone demolition until peak bone mass is reached around the age of 30 to 35. After a transient period of stability, the process is reversed. Bone is lost when the two phases of bone remodelling become uncoupled, with a relative or absolute increase in resorption over formation. When this occurs, an increase in bone turnover leads to increased bone loss (Riggs and Melton, 1986). In the slow phase of bone loss, the bone loss is caused mainly by impaired bone formation. Osteoclasts build resorption cavities of normal or even decreased depth but osteoblasts fail to fill them completely. The accelerated phase of bone loss which occurs in women shortly after menopause is characterised by a high rate of bone turnover. More osteoclasts create more and deeper resorption cavities. There is an increase in bone growth but this is outstripped by bone resorption.

There are still large gaps in the knowledge of the coupling mechanism. It has been suggested that future research should aim at identifying the key factors influencing the interaction between resorptive and formative cell populations. This may make it possible to design more effective regimens for the treatment of osteopenia (low bone mass) (Eriksen and Kassem, 1992).

A cross-sectional study of mono- and dizygotic twins suggests that there are significant familial influences on the distribution of femoral bone mass and on the structural strength of the proximal femur, but not on femoral neck length. Should the assumptions of the twin model be correct, this is evidence for genetic factors influencing these traits (Slemenda, 1996). However, the influence of environmental factors has also been shown. Bone adaptation is dynamically controlled by the mechanical environment through the processes of growth, modelling and remodelling. It is not yet clear which factors of the strain environment influence the remodeling system, whether the effects are direct or indirect, or how the mechanical signal is transduced into a cellular signal (Burr and Martin, 1992).

Evidence suggests that many defects in skeletal development, skeletal diseases like osteoporosis and the effects of many agents on bone mass may be caused by changes in the way in which skeletal tissue perceives and adapts to typical mechanical usage (Jee and Frost, 1992).

2.2.5. Section Summary

Although the basics in the process of bone remodelling have been established, much is still unknown. Both nature and nurture seem to play an important role in the renewal of bone tissue. The next section builds on the understanding of bone anatomy and remodelling gained in this section to establish what is currently known about the epidemiology of the degenerative bone disease osteoporosis which underlies the majority of hip fractures.

2.3. Osteoporosis

2.3.1. Historical Overview

The term osteoporosis was first used in French in the early 1820s (Schapira and Schapira, 1992). The term combines the Greek for 'bone' and 'porous'. Since that time understanding of this term has altered significantly to reflect the increasing knowledge of the disease. The definition has always attempted to maintain a difficult balance between physiological and clinical criteria. Initially, the disease definition centred on the physical description of the pathological state of the bone. From the mid-nineteenth century onwards the definition becomes more rigorous. Two major causes of osteoporosis are given: 1) the absolute decrease in bone tissue and 2) the abnormal draining of mineral, earthy and calcium salts. Bone porousness as a risk factor for fracture has only been added to these criteria in the 1980s due to the development of new technology enabling us to measure bone mass (Schapira and Schapira, 1992).

2.3.2. But is it a disease?

Schapira and Schapira (1992) argue that osteoporosis ceased to be merely a bone porosity when treatment began to be offered to osteoporotic patients sometime in the 20th century. It became known as a 'bone disease', a 'disorder', or a 'condition'. The three terms are defined differently in a medical dictionary[5] but

[5] (a) 'disease' is defined as 'a definite morbid process having a characteristic train of symptoms' (Dorlands Medical Dictionary, 1988; Larousse Medical Illustre, 1971)
(b) 'disorder' is defined as 'a derangement or abnormality of function; a morbid physical or mental state' (Dorlands Medical Dictionary, 1988)
(c) 'condition' is defined as 'a state or mode of being, especially state of health' (Churchill's Illustrated Medical Dictionary, 1989)
as quoted by Schapira D. and Schapira C. (1992)

are often used as synonyms in the osteoporosis literature. This leads Schapira and Schapira to ask the question whether osteoporosis should be regarded a disease. This is a matter of importance because it is essential to the question of policy for two reasons. First, the very word 'disease' implies that something is amiss. A 'disease' by its very nature requires treatment. Secondly, it is necessary to establish a common baseline of what is to be discussed for discussion to have any chance of leading to good policy. In other words, it is necessary to have a clear and shared view of what osteoporosis is before making any decision whether something should be done about it. To return to the question of whether osteoporosis should be regarded as a disease, the answer may be less clear-cut than it first appears. De Seze and Rickewaert argued that in the absence of at least one spontaneous vertebral compression osteoporosis is an anatomical syndrome, not a disease in the clinical sense (see Schapira and Schapira, 1992). This leads them to distinguish between 'probable osteoporosis' (without compression) and 'osteoporosis' (with evidence of fracture). Nordin (1987) challenged this distinction and argues that a definition of osteoporosis should be based solely on high-precision densitometric measurements and a calculation of risk factors. The current World Health Organization's definition is in the same spirit (Anon. Consensus Development Conference, 1993). They define osteoporosis as

> *" a skeletal disease characterised by low bone mass, microarchitectural deterioration of bone tissue leading to enhanced bone fragility and a consequent increase in fracture risk".*

There is currently no consensus regarding the quantification of the contribution of microarchitectural deterioration to fracture risk. As a result, in practice, osteoporosis is assessed indirectly through non-invasive measurements of bone mineral density only.

2.3.3. Bone Mineral Density and Fracture Risk

There does appear to be a strong association between bone mineral density and the probability of sustaining a fracture. Bone density appears to account for 75-85% of the variance in bone tissue strength (Melton, 1988). It also appears to be closely associated with the load-bearing capacity of the skeleton in vitro (Mosekilde, 1989; Spadaro, 1994; Courtney, 1995).

As a result, the present WHO criteria thus define osteoporosis for both sexes as a T-score equal to or lower than 2.5 standard deviations below the average bone mineral density of the young healthy female population as measured by DXA (dual x-ray absorptiometry) at the proximal femur. A T-score between –1 and –2.5 which is associated with a moderate increase in fracture risk is classified as low bone mass or osteopenia (World Health Organization, 1994). Siris (2001) found that by this definition, osteoporosis was associated with a fracture rate of approximately four times that of normal bone mineral density. Osteopenia was associated with a 1.8 times higher rate. The data to show whether this relationship holds also in general for non-Caucasians has been limited (Delmas, 2000).

In effect, osteoporosis as a disease is thus defined by an intermediate outcome (bone mineral density), rather than a health outcome (fracture). In this respect, osteoporosis can be compared to hypertension or diabetes mellitus (National Osteoporosis Foundation, 1998). But as the WHO definition indicates, research has also shown that fragility depends on various factors apart from bone mass, for example arrangement and correctedness (architecture), the loading history of the member and unrepaired excess fatigue damage (Parfitt, 1987; Heaney, 1991). This means that low bone mass is but one risk factor for developing osteoporotic fractures. This aspect has recently received more attention. Elffors (1998) has pointed out the importance of frailty for hip fractures. This might act as an involutionary phenomenon or as comorbidity, especially neurological. He shows how frailty affects fracture risk through several different causal pathways. The implication to arise from this is that since frailty is age-related, existing projections of future fracture occurrence may be significantly underestimating the problem (Elffors, 1998).

2.3.4. Section Summary

It has been shown that the definition of osteoporosis is not cast in stone and has evolved considerably over time. It seems likely that it will continue to evolve as new knowledge of the causes of fragility emerges as well as our ability to measure and treat them. In the light of recent evidence on the importance of frailty it is not entirely clear whether the present WHO definition of osteoporosis based on bone mineral density is an adequate measure for estimating how many people are at risk from developing hip fractures as well as other fractures linked to the ageing of the skeleton.

2.4. Clinical Risk Factors for Osteoporosis

It was established that osteoporosis is the major risk factor for developing a hip fracture. This section will look in more detail at the clinical risk factors predisposing a person to developing osteoporosis. In general, fracture risk increases as the degree of stress which is put on the bone increases and as the ability of the bone to withstand it decreases or a combination of both (Riggs and Melton, 1986).

2.4.1. Determinants of Bone Strength

The last sections have shown that bone strength depends on both the material characteristics and the geometrical configuration of bone tissue. The geometrical arrangement of bone tissue has implications for bone strength and stiffness at the molecular, micro- and macro-anatomical level (Geusens, 1996). The most important material characteristic of bone strength is bone density, the amount of calcified matrix within a certain bone volume. In the absence of severe trauma, fractures do not occur until bone density has fallen below the values found in young adults (Riggs and Melton, 1986).

Empirically, this fragility results in a fracture threshold at about 1.0 g per square centimetre for both vertebrae and femur (Riggs, 1981). With further decreases in bone density below the fracture threshold, the incidence of hip fractures and the prevalence of vertebral fractures increase. The relationship between bone mineral density and fracture risk is thus not linear. This suggests that osteoporosis may lead to qualitative changes in bone. This could be the result of the loss of structural elements (Parfitt, 1983) or the accumulation of trabecular microfractures which weaken the skeleton (Frost, 1985).

These explanations seem to be in accordance with intermediary results obtained in an ongoing longitudinal cohort study by the Study of Osteoporotic Fractures Research Group (SOF). They looked at 9703 non-black women aged 65 and older. After one and a half years, 53 women suffered fractures. As expected, women with lower bone density had more hip fractures. The study also showed though the complex interaction of various risk factors which lead to fractures. Even after the differences in bone density were adjusted for, it was found that the risk of hip fractures doubled for each 10 years of a woman's age (Cummings, 1995). However, the same study also revealed that a large proportion of functional decline, itself is a risk factor for fractures, can be attributed to risk factors which are amenable even to relatively short-term intervention. These include slow gait, short-acting benzodiazepine use, depression, low exercise level, and obesity (Sarkisian, 2000).

It has been suggested that the disruption of skeletal microarchitecture associated with postmenopausal bone loss might be irreversible (Aaron, 1987; Parfitt, 1983; Parfitt, 1987). The selective destruction of trabeculae seems to lead to a loss of mechanical competence which is disproportionate to the amount of material removed. At present there is no widely applicable method of restoring skeletal strength once is has been lost (Kanis, 1994). This is one of the main arguments brought forward in favour of assessment and intervention as early as possible in the natural history of the condition: Of the various factors influencing skeletal competence only bone mass can currently be measured as a predictor of future fracture risk. At this stage only bone mass can be manipulated in mid-life in the hope of preventing fractures decades later (Kanis, 1994).

It has been suggested that BMD (bone mineral density) is not sufficiently predictive of fracture risk to justify widespread use in the general population (Law, 1991). This is based on studies which show that even though BMD values for fracture cases usually lie below that of the controls, there is still considerable overlap between the two groups. Six studies, however, all show a statistically significant link between bone density at baseline and fracture risk (Wasnich, 1991, Siris, 2001). The relative risk of hip fracture triples for each standard deviation decline in spinal bone density (Cummings, 1993). Another paper reports an even stronger association between future hip fracture risk and proximal femoral bone density (Melton, 1993).

Nevertheless, other evidence strongly suggests that other factors influencing fracture risk should not be neglected. It has been suggested that bone mineral density is higher in Chinese and other Oriental populations than in Caucasians (Garn, 1964; Hagiwara, 1989; Kin, 1991; Norimatsu, 1989). However, more recent studies found that both hip and spine bone mineral density did not differ between Chinese, Japanese and Caucasian Americans after adjustments for height and weight (Cundy, 1995; Kin, 1993; Russell-Aulet, 1993). This seems to indicate that the lower hip fracture incidence in the Oriental population is not due to a higher bone mineral density. The explanation probably lies in bone's other biomechanical properties. It has been suggested that the bones of Oriental populations may be stronger than that of Caucasians (Nakamura, 1993). Another explanation focuses on geometric differences in hip anatomy between Orientals and Caucasians. A long hip axis seems to be an independent risk factor for hip fracture in women (Faulkner, 1993). This may in part explain the differences in hip fracture incidence between females of different ethnic groups found by other studies. A comparative study of the differences in hip geometry between Caucasian and women of African origin suggested that racial characteristics, such as the latter's thicker cortical bone of the hip, shorter hip axis length and smaller intertrochanteric widths might contribute to an approximately 25%

reduced hip fracture risk among black women (Theobald, 1998). A comparative study of bone loss in British and Japanese men and women though argues that differences in peak bone mass and hip geometry do not fully explain the differences in hip fracture incidence between the two countries. Instead, the decisive factor appeared to be that the rate of bone loss in the Japanese study subjects was slower (Dennison, 1998). Luckey (1996) found similar results with respect to bone loss in African-American women. Another factor which appears promising in explaining differences in fracture rates lies outside the realm of anatomy. Roy (2002) found that variations in fall rates explained a significant proportion of differences in fracture rates across Europe. Fall rates were also lower among women of Japanese origin compared to Caucasian women. However, Davis (1999) was not able to explain this with reference to specific neuromuscular advantages enjoyed by Japanese women.

The issue of comparing different studies is complicated by the fact that different measurement techniques for establishing bone mineral density may yield very different results. Del Puente (1998) found that a large proportion of the women in their study would not have been diagnosed as having osteoporosis if they had relied on a single DEXA measurement site. As low a percentage as 4% among women between 50 and 59 years of age were diagnosed with osteoporosis at both the lumbar spine and the right femoral neck. It would be fascinating to find out whether osteoporosis cases diagnosed in different ways lead to substantially different disease and resource consumption patterns.

2.4.2. Causes of Secondary Osteoporosis

A variety of conditions are known to influence skeletal competence both in women and men. Secondary osteoporosis can be the result of endocrine and metabolic disorders such as

- Cushing Syndrome
- Hyperthyreosis
- Hypogonadism
- Hyperthyroidism
- Acromegaly
- Diabetes mellitus
- Homocystinuria.

Osteoporosis can also be a side-effect of various medications, such as

- glucocorticoids
- heparins
- thyroid hormones
- GnRH agonists
- laxatives and others.

Osteoporosis can furthermore be a side-effect of various forms of cancer. It can be parainfectious or immunogenic (rheumatoid arthritis, Enteritis regionalis Crohn) or caused by hereditary diseases of the connective tissue such as Osteogenesis imperfecta, Marfan-syndrome and Ehlers-Danlos-syndrome. Last but not least it can be a part of complex osteopathies (renal osteoporosis, intestinal osteoporosis) (Pschyrembel, 1994).

2.4.3. Prevalence of Secondary Osteoporosis

In women there is only a 5-10% prevalence of secondary osteoporosis. In men 64% of cases are secondary forms (Ringe, 1994; Seeman, 1983; Francis, 1988). Ringe and Dorst (1993) found a high proportion of male secondary osteoporosis to have secondary risk factors or underlying diseases. Of the 24 different possible contributing factors identified by the authors, the most common were corticoid therapy, high alcohol consumption, heavy smoking, hypogonadism, hypercalciuria, kidney stones and liver disease. The osteoporotic men of the study were found to have on average 1.8 risk factors. Although numerous risk factors for secondary osteoporosis are relevant to both sexes, some are more typical for males. These include alcohol consumption, smoking, hypercalciuria and male hypogonadism. The pathogenetic relevance of differences in prevalence of secondary osteoporosis and differences in risk factor pattern between sexes for the risk of hip fractures in later life remains to be clarified. (Ringe and Dorst, 1993).

2.4.4. Clinical Risk Factors in Practice

One of the problems currently encountered with risk factor analysis is that often the links between the risk factor, another disease and osteoporosis are not well understood, which may limit the risk factor's potential usefulness as part of a prevention strategy. An example of research on the direct link between a risk factor and osteoporosis is Ensrud (2000). They found that an age-related decrease in the ability to absorb calcium was a directly significant risk factor in developing type 2 osteoporosis in women with low calcium intake. The research attempting to identify more indirect risk factors for osteoporosis faces more obstacles. Roux' prospective study of 35 patients observed an increased risk of lumbar and femoral bone loss in patients with inflammatory bowel disease (Roux, 1995). It is estimated that 31-59% of patients with Inflammatory Bowel Disease have osteopenia (Compston, 1987; Vogelsang, 1989; Pigot, 1992).[6] But the pathogenic link between inflammatory bowel disease and osteopenia is not completely understood. Corticosteroid therapy is likely to be a contributory factor at least in some patients (Roux, 1995). Also, it is again worth bearing in mind that, as has been illustrated earlier, osteopenia itself is not necessarily to be equated with osteoporosis, which in turn is not necessarily to be equated with hip fracture.

There has been positive evidence in favour of the practical use of clinical risk factor analysis despite some of these problems. A study of hip fracture risk factors in Southern European women found that differences in lifestyle factors are associated with significant differences in the risk of hip fracture and may enable the prediction of high risk individuals (Johnell, 1995).

2.4.5. Section Summary

Osteoporotic fractures are caused by skeletal as well as extraskeletal factors. The skeletal factors include bone mass, the spatial organisation of bone, the turnover of bone and the quality of bone (plasticity). Extraskeletal factors are the frequency, type and severity of falls and neuromuscular coordination because it influences the response to trauma and the available soft tissue cushion (Kanis, 1994). Until a way is found of reliably measuring bone microarchitecture and its

[6] depending on the definition of osteopenia, the site of bone measurements, the technique used for bone density measurement and the proportion of the patients studied with small bowel resection and vitamin D deficiency

plasticity, bone density (apart from attempting to limit the number and severity of falls) will in all likelihood remain the main factor public health intervention for the prevention of the majority of hip fractures will be geared towards. A number of risk factors have been identified in men and women which seem to place the affected at risk from low bone density and increased risk of fracture. It appears then that many hip fracture patients suffer from ailments apart from the fracture. In addition, the age-related nature of hip fracture indicates that the characteristics of the patient as well as the control group may bear an impact on a study's estimate of the resource consumption associated with hip fracture.

2.5. Incidence of Hip Fractures and Osteoporosis

These excursions into the anatomy of bone, the remodelling process and the definitional issues surrounding the diagnosis have served to illustrate the extent of the knowledge of what causes hip fractures and who is at risk from them. Bearing these issues in mind, it is now possible to appreciate the level of certainty or uncertainty underlying this section's estimates of the prevalence and incidence of hip fracture and osteoporosis.

Based on incidence rates derived in North America, it has been estimated that the lifetime risk of a hip fracture in Caucasian women is 17.5%. The comparable risk in men is 6% (Cooper, 1996).

For the UK, it has been estimated that 60 000 hip, 50 000 distal forearm, and 40 000 clinically diagnosed vertebral fractures occur per year in postmenopausal women (Cooper, 1993; Royal College of Physicians, 1989).

2.5.1. Hip Fracture Incidence Rates Across the World

Up until very recently, the data available suggests that there was a distinct variation in hip fracture incidence rates across the world. The table shows that the rates were highest for Caucasians living in Northern Europe and North America, intermediate in Orientals and lowest in the black population *(Table 2.1.)*.

Table 2.1. International Hip Fracture Incidence Rates

International pattern for the incidence of hip fracture (Lau, 1996)		
Location	Rate/10 000[a]	
	women	men
Norway (1983-4)	129	55
Stockholm (1972-81)	62	29
California whites (1983-4)	56	21
Rochester, Minn. (1965-74)	51	17
Hong Kong (1965-7)	15	10
Hong Kong (1985)	35	18
Singapore (1955-62)	8	10
California Asians (1983-4)	34	10
California blacks (1983-4)	22	14
California Hispanics (1983-4)	20	9
Beijing, China (1990-2)	9	10

[a] All rates are age-standardized to the United States population.

The table also shows the rapid increase in hip fracture rates in Hong Kong. There is evidence to suggest that this increase may be replicated in other Asian countries. This led the authors to conclude that the majority of hip fractures in this coming century would be found in Asia, not Northern Europe. They estimated that by 2050 more than 50% of all hip fractures will occur in Asia compared to 30% in 1990 (Cooper, 1992). This conclusion was also confirmed by other authors. In 1960, Chalmers and Ho (1970) surveyed Hong Kong's hip fracture incidence rate. They found that Hong Kong's Chinese population had an age-adjusted incidence rate of only approximately 13-30% of that of Caucasians. In addition, Hong Kong Chinese men and women were equally likely to fracture their hip, whereas Caucasian females were three times more likely to fracture their hip than men. However, a more recent study showed that the disease pattern of the community has now turned to that of the developed world (Lau, 1988). The reason given for this is the rapid urbanization which has occurred in Hong Kong over the last three decades.

According to WHO projections, by the year 2050 there will be a total of 900 million men and women aged 65 and over (Cooper, 1992). Lau estimates that at that time, the total number of people with hip fracture on the Asian continent will be approximately 3.2 million per year (Lau, 1996).

2.5.2. Hip Fracture Incidence Rates Across Europe

Within the European context studies have found a significant difference in hip fracture incidence rates between different communities. Prior to the MEDOS study, published data shows that there was only scattered and incomplete retrospective information about hip fracture incidences in Europe (Johnell, 1992). However, retrospective studies suggest that rates may vary 10-fold or more across Europe (Agnusdei, 1993). *(Table 2.2.)*

Table 2.2. Lifetime Risk of Hip Fracture

Lifetime Risk of Hip Fracture at 80 years of age in some European Countries (Johnell, 1992)		
Country	**Women**	**Men**
Sweden	19%	13%
Switzerland	8%	5%
Netherlands	6%	3%
Portugal	3%	3%

The MEDOS study was a prospective, multicentre (14) study of the incidence and risk factors of hip fractures in men and women over 50 carried out in six countries on the shores of the northern Mediterranean (Portugal, Spain, France, Italy, Greece and Turkey) (Lyritis, 1996). A significant positive correlation was found between the age-standardized incidence rates in men and women from the same country. A larger difference occurred in incidences between countries. This suggests that genetic and /or environmental factors play an important role in causing hip fractures.

Several other studies confirm this. For example, in France, the risk of a women who reaches the age of 80 fracturing her hip was estimated to be 5.1%. The equivalent risk for men was 3.1 %. At the age of 95, the risk rose to 33.4% in women and 17.4% in men (Baudoin, 1996). The same study also estimated the distribution of hip fractures in France. There were 81 385 declarations of hip fractures in women and 28 382 in men between 1979 and 1990. This translated into a crude hip fracture incidence of 5.73 per 10 000 women-years and 2.56 per 10 000 man-years as estimated by the data from this particular database. This would make France one of the countries with the lowest observed hip fracture incidences in Europe. The interesting point about the data presented in this study is that it seemed to partition France into regions. The regions with the highest incidences were mainly situated in the west and centre of the country. In addition the study noted a north-south decreasing gradient. As no decrease in the north-south incidence was observed in the US, the hypothesis that deficiencies in vitamin D due to sunlight exposure were responsible was rejected by the authors. Nutritional, morphometric and genetic factors may explain this gradient. Compared to other countries, very high hip fracture rates were reported in Scandinavian countries (Maggi, 1991; Johnell, 1992; Melton, 1988). These studies have generally been limited to data from small sub-regions and from different time periods. One exception is a study by Johnell (1992) which used discharge data from national registers for several European countries, including three (Finland, Sweden, Switzerland) which were also examined by Bacon (1996). In contrast to Johnell who concedes the possibility of double counting, Bacon did not find higher rates in Sweden than in other European or North American countries. Fracture rates for women in Sweden were lower than in North American or other European countries. However, since it is difficult to completely adjust for differences among national registers or in methods of case selection, Bacon points out that it is risky to draw conclusions about the small variations observed among Western countries. But fracture rates in north European and North American countries do appear to be more similar than previously thought.

2.5.3. Section Summary

Even after methodological differences in data sources are minimized, variations in hip fracture rates among countries were still observed. This suggests that differences in environment and biology also play a part. These factors include bone mass (Cummings, 1993; Hui, 1989; Kelsey, 1987), body weight

(Cummings, 1985; Kreiger, 1982; Grisso, 1991), degree of industrialization or level of physical labour (Lewinnek, 1980; Ray, 1990; Paganini-Hill, 1991), latitude (Jacobsen, 1990), diet (Cumming, 1990; Johnston, 1992), reproductive history (Hoffman, 1993; Alderman, 1986), and femur anatomy (Cummings, 1994; Nakamura, 1994; Waher, 1994). The role of these factors in fracture rate variability among countries can only be determined through a coordinated, standardized international study. Due to these unresolved issues, any analysis or comparison between different studies of resource consumption associated with hip fracture would thus do well to consider not only the relative age and sex distribution of different study populations, but also factors such as the origin of the patient with respect to geography, ethnicity as well as living circumstances prior and post fracture and different countries treatment patterns.

2.6. Epidemiology of Fractures other than Hip Fractures

Even though hip fractures appear to be the most serious, debilitating and expensive fracture associated with osteoporosis and also the one on which the best statistics are available, the frequency and impact of the other two major fractures associated with osteoporosis, vertebral and Colles (wrist) fractures, is not to be forgotten. This is of importance when considering the benefits of any health programme aimed at preventing hip fractures. Because the majority of hip fractures have been associated with osteoporosis, the prevention of osteoporosis would not only prevent hip fractures but also a whole host of other fractures which although less serious are much more common. Jones' (1994) Australian

DOES study found that in the 60-80 year age group, only 10% of fractures involved the hip. This rose to 41% in the study subjects over the age of 80.
The European Vertebral Osteoporosis Study (EVOS) (Reeve, 1996) collected data on vertebral fractures in a prevalence study in 17 000 men and women over 50 in 18 countries. They found that approximately 12% of both men and women have vertebral deformities. The surprise was that the overall impact of vertebral deformity was roughly equal in the two sexes. Regardless of this, however, vertebral fracture rates differed between men and women. The age-standardised incidence of morphometric fracture was 10.7/ 1,000 person years in women. The same rate for men was only roughly half of that at 5.7/ 1,000 person years. As assessed qualitatively by a radiologist, the age-standardised incidence of vertebral fracture was broadly similar at 12.1/ 1,000 person years in women and 6.9/ 1,000 person years in men (EPOS, 2002). The prevalence of vertebral deformity among women at least varies considerably across Europe (O'Neill, 1996; Ismail, 2002).
Concerning forearm fractures, it has been estimated that 50,000 fractures of the distal forearm occur in the UK each year in post-menopausal women (Cooper, 1993). Again, incidence figures suggest that there may be significant variation in fracture rates for this type of fracture across Europe (Ismail, 2002).

2.7. Chapter Summary

Having examined the literature concerning the nature and epidemiology of hip fracture and osteoporosis, it has become apparent that there are still large gaps in our knowledge of the bone remodelling process. It does appear certain though that osteoporosis is the major underlying risk factor for hip fractures. The definition of what constitutes osteoporosis has changed and continues changing. Technological requirements currently more or less force the medical practitioner and policy makers to equate the disease to a large extent with low bone mass. Differences among fracture rates across countries emphasize though that this is by no means the only determinant of fracture risk. Differences in environment and biology also play their part. These uncertainties surrounding osteoporosis as the single most important cause of hip fractures have significant implications for the expected impact of hip fractures and the likely impact of any policy concerning prevention or treatment. They also highlight the importance of taking into account numerous characteristics of studies' patient population and the control group, such as age, sex and inclusion criteria, when comparing the results of different studies. Although it may be disputed how high a risk for hip fracture is in a given population, what is not disputed, however, is that hip fractures do take a toll on society's resources when they do happen. Just how this toll should be assessed in economic terms will be the question addressed in the following chapter.

3. Methodological Aspects of Hip Fracture Cost Assessment

3.1. Introduction

As the previous chapter has shown why the condition of hip fracture ought to be studied, this chapter now attempts to show how its impact should be studied. The aim of this chapter is not to provide a comprehensive discussion of the methodological issues inherent in economic evaluations in general. Its aim, instead, is to provide an overview of issues which need to be considered when setting out to assess the specific impact and costs of hip fracture.

The aim of any such assessment must be to reflect the underlying effects of the disease as faithfully as possible. This chapter thus aims to set out what is currently known of how to ensure that a model of the impact of hip fracture is constructed in such as way as to best approximate the real underlying effects of the disease. The guiding principles behind the methodological choices underpinning a model's inputs, processes and outputs will thus be scrutinised. As such, they cover all aspects of constructing a model of the costs and impact of a disease or indeed any health care programme. These principles cannot be subdivided into those affecting exclusively model inputs, processes or outputs. They were thus categorised into principles guiding the choice of

- Study perspective
- Geographical location
- Type of study
- Time horizon
- Population group
- Type of costs
- Method of costing
- Future costs
- Censoring, and
- End-of-Life costs.

Each of these are discussed in separate sections. The hip fracture cost literature is then investigated as to its treatment of these issues in the next chapter.
But first, clarification of some basic theoretical concepts on which economic comparisons of the costs and benefits of programmes are based is required. It is then shown how these are used to form the health economic toolbox.

3.2. Basic Concepts Underpinning Economic Evaluations

The theoretical underpinnings of economic evaluations which compare the costs and outcomes of different courses of action are to be found in the fundamental assumption of the discipline of economics. This assumption is that resources are limited. No society has limitless resources to spend on health care, education, or any other form of public or private spending. As Mooney (1992, p. 7) expresses it:

> *"Economics exists as a science of human behaviour for two simple reasons. First, there is a finite limit to the resources available to mankind as a whole, to any individual society, any organisation or, indeed, any individual. Second, as individuals and societies, it appears that to all intents and purposes our wants are insatiable. These two factors taken together mean that choice has to be exercised not only about what to do but also (and equally important) what to leave undone."*

Economics then provides advice on how choices can be made among competing claims on resources. One of the most prominent aims of decision-making is to allocate scarce resources in such a way as to maximise the welfare of society as a whole. This concept is based on the political philosophy of utilitarianism. This is associated with the philosophers Jeremy Bentham and John Stuart Mill and postulates that ‘the good life’ to lead is the life which seeks to maximise the utility or satisfaction of the greatest number of people (MacIntyre 1991, p. 235). A necessary precondition to this is the pursuit of economic efficiency. One of the conditions attached to this is that no program of health care spending should be adopted unless the benefits derived from it exceed the costs it incurs. To prioritise among those programs whose benefit exceed costs, it is necessary to compare the incremental increase in costs of any proposed expenditure with the incremental increase in utility derived from the proposed expenditure. The program which should be chosen is the program which yields the greatest additional increase in utility at the lowest additional costs. In other words, that program should be chosen which yields the greatest ‘value for money’. The discipline of health economics, with the help of economic evaluations as its essential tool “can provide a systematic framework in which to assess the marginal costs and benefits of alternative policy options”(Shiell 1987, p.322).

3.3. The Health Economic Toolbox

The health economists’ toolbox comprises a number of different types of economic evaluations which allow a more or less comprehensive view of resource allocation. At the most comprehensive end of this spectrum can be found cost-benefit studies which estimate the resource implications for at least two different alternative courses of action as well as the prospective outcome of these in monetary terms. These types of study can as a result be used at least in theory to compare the expected increase in utility for society from two very different types of resource expenditure, such as double-glazing council houses and vaccinating children against meningitis. It is only really this type of enquiry which could even theoretically lead to actually maximising society's welfare since it allows the comparison of the costs and outcomes of programs across all sectors of public and private spending. The next in line at the broader end of the spectrum of economic evaluations is the cost-utility analysis, then the cost-effectiveness analysis and the cost-minimisation analysis. Each of these compares the costs and outcomes of a programme, however this may be defined in practice (see Drummond, 1997), apart from the latter which assumes that outcomes are equal. At the heart of all comparisons of costs and outcomes lies an assessment of the costs associated with a particular condition or health care programme. Without an accurate assessment of costs, there can be no meaningful comparison of outcomes, programmes and value-for-money.

The next sections lay out the current knowledge of what issues need to be addressed specifically, in order to be confident that a cost estimate is as accurate a reflection as possible of the underlying economic costs of a prevention or treatment programme for hip fracture.

3.4. Methodological Choices

An assessment of the costs associated with a particular course of action involves the identification, measurement and valuation of the resource consumption associated with that course of action. Each of these aspects of cost assessment requires methodological choices to be made which may bear an impact on how closely the resulting cost estimate mirrors the true underlying costs associated with a course of action. These methodological choices are contingent on the resource consumption patterns of each particular course of action. The specific methodological choices facing a researcher of hip fracture can be gleaned from the epidemiological information presented in the previous chapter. To model the cost of hip fracture would seem to imply methodological decisions with respect to the following:

- Study Perspective
- Geographical Location
- Type of Study
- Time Horizon
- Type of Costs
- Method of Costing
- Future Costs
- Censoring, and
- End-of-Life Costs

The following sections provide a brief overview of each of these issues in turn as related to the cost assessment of hip fracture specifically.

3.4.1. Study Perspective

The question of which is the most appropriate perspective for a hip fracture cost study is linked to the more general question of the most appropriate form of economic analysis. According to Drummond (1997, p.17), "the answer to this question depends not only on the problem being tackled, but also the institutional framework, the practical measurement challenges and the perspective the analyst takes on the role of economic evaluation." Sugden and Williams (1978) distinguish between two broad approaches, the Paretian and the decision-making approach.

The Paretian Approach

The Paretian approach is based on the idea that "social states, and hence alternative public decisions, may be compared in the light of fundamental ethical principles whose validity is independent of decisions taken within the political system" (Sugden and Williams, 1978, p. 234). This thus renders the economic analyst in a way independent of the decision-makers since he or she is accountable only to the criterion of economic efficiency. The role of economic evaluation is thus to identify and rank courses of action with respect to economic efficiency in order to increase social welfare. The perspective to be taken in economic evaluations is thus prescribed to be broad, that of society as a whole. An evaluation consistent with this approach would thus not be confined to the health care sector alone but include all aspects of a course of action in its evaluation.

The Decision-Making Approach

The decision-making approach, in contrast, places the economic analyst below the decision-maker. The role of the analyst is to assist the decision-maker in making choices that are consistent with his (that is, the decision-maker's) objectives (Sugden and Williams, 1978, p. 235). The role of economic evaluation is thus to be an essentially value-free technique for comparing alternative courses of action in an explicit, transparent and consistent way. Economic evaluation "shows how choices should be made so as to pursue some given objective as efficiently as possible. In principle, at least, any objective could be used." (Sugden and Williams, 1978, p. 236). If thus the decision-maker's objective were to allocate the health service budget, economic evaluations to help him or her do so would thus confine themselves to resource implications of courses of action on the health sector budget only. In contrast, the Paretian approach should for example include also effects on the social services budget in its pursuit of economic efficiency.

The approach to the role of economic evaluation thus determines the viewpoint of the economic evaluation, such as the viewpoint of society as a whole or that of the health care provider only. The viewpoint of a study, in turn, should determine the time period, the type of study, the economic sectors and the population group to be considered. This is important in the case of hip fracture specifically, because, as the previous chapter has illustrated, the condition is treated surgically. Any surgery in a mainly elderly patient group presenting with several other health conditions is likely to lead to effects on people's lives extending beyond the reach of the health sector.

3.4.2. Location

As indicated above, the choice of location for a study is likely to have implications for any resulting cost estimate through the epidemiology of the disease, in other words the characteristics of the patient group the study is based on. This is of particular relevance when comparing the results of studies over time across different countries. It may also have implications on the relative advantages and disadvantages of multi-centre studies (Drummond, 1992). The differences in the epidemiology of hip fracture between countries, and in many cases even regions, have already been highlighted in the previous chapter. The decision of which country, or region, to base a study on has further implications for costing though. A country or region may differ from another or over time not only with respect to the patient population but also with respect to its treatment patterns. This may be a function of, amongst others, doctors' education and a country's health care infrastructure. For example, in a country where there is less of an emphasis on rehabilitation in the community or special hospitals, length of stay in acute hospital wards might be expected to be longer. This one may expect to also have an impact on the resulting cost estimate associated with a disease or programme in different countries. This observation concerning differences in patterns of care may well also be shown to exist between different regions of the same country. An example of this might be the enduring debate on postcode rationing in the UK. Clearly, differences in treatment patterns and unit costs will have an impact on the costs associated with a disease or health care programme.

By reading the previous chapter, it must have been apparent that the epidemiological literature for hip fracture is not equally distributed among countries. A decision-maker wishing to inform him- or herself about the epidemiological pattern or resource impact of the condition may well have to resort to adapting other countries' results to his or her own. In the case of resource use, this means results have to be compared which are presented in different historical currencies for countries with different price levels. There does not appear to be a consensus in the literature on the use of the appropriate conversion factor when comparing price levels across different countries. (Jefferson,1996; Gosden, 2002). Research has reached different conclusions as to the relative stability of health-related PPPs and GDP PPP conversion factors (Parkin, 1987; Gerdtham, 1991). In Britain, though, the use of non-health-related GDP PPPs has been advised (Department of Health, 1994).

3.4.3. Type of Study

A decision on the purpose of economic evaluations also throws up the question over what type of study should be conducted. In its broadest form, a comprehensive answer to this question is beyond the scope and purpose of this thesis.[7]

The question over what type of study to adopt has, however, implications for studies' attempts to capture the costs associated with a particular course of action as truthfully as possible. It also has implications for the comparison between studies' cost estimates. Three aspects of the selection of the type of study are of particular relevance in this respect. The choice of economic evaluation type may have implications with respect to the type of costs and economic sectors covered by a study. This is addressed in more detail later in this chapter. Cost estimates may also be affected by two further aspects of the type of study chosen which fall into the epidemiological domains of study design: whether a study is based on the prevalence or incidence of disease within a population and whether a case-control design was used.

Prevalence/ Incidence

To estimate the true costs of a disease, it is necessary to know how often it occurs in a given population. This can be assessed in two fundamentally different ways. The prevalence of a disease measures the number of cases in a specific population at a specific point in time. The incidence of a disease, in contrast, measures the number of new cases arising in a specific population during a

[7] The issues over the relative appropriateness and feasibility of the different types of full economic evaluation, cost-benefit, cost-utility and cost-effectiveness studies, have been discussed in Drummond, 1997 for example.

specific period of time (Beaglehole, 1993). The relationship between these two varies between different types of diseases. Chronic diseases, such as diabetes, may have a higher prevalence and lower incidence. An acute curable illness, such as the common cold, may have a lower prevalence but higher incidence. Clearly, were the costs of diabetes approximated by a study based on an incidence-based study designed to count only the cost of the number of new cases per year, the costs attributed to diabetes would be lower than if the estimate was based on the total number of cases, which includes old and new cases per year. To approximate the costs of diabetes by an incidence-based study would thus underestimate the true costs of the disease (Koopmanschaap, 1998).

Case/Control

The other factor which was highlighted as influencing a cost estimate was whether it was based on a case-control study design and if so, on what type of case-control study design. To approximate the costs of an illness by counting hospital days, operations, investigations, and other direct and indirect costs in a population with the disease in question would ignore what resources would have been consumed by the same group of patients had they not succumbed to the disease in question. To estimate the costs of a disease in a group of patients without taking into account that they may have consumed resources of the health and social care budget, for example, even without suffering from the disease being investigated would thus overestimate the costs which can be directly attributed to the disease in question. This is of particular relevance in investigating the costs of a disease which occurs in a patient group with existing co-morbidities, for example diseases which afflict primarily the elderly. To estimate the directly attributable costs of such a disease, it would thus be necessary to deduct the costs of the resources which would have been consumed by the patient group anyway from those that were actually incurred. To do this, a control group might be employed. The make-up of the control group is crucial to approximating the default resource consumption of the cases as closely as possible. For this, the epidemiological characteristics of the control group need to be as close as possible to those of the case group. This means that at the very least, they ought to be age- and sex-matched. For some diseases and large studies, it may be necessary to ensure also that the control group's location, ethnic group or other characteristics of relevance to the disease in question are matched to those of the cases (Beaglehole, 1993, p. 37). Another way of assessing these 'default' costs is to obtain a record of the resources consumed by the cases prior to the onset of the disease in question and deduct them from the resources consumed afterwards. This can be done either by assessing patients' prior resource consumption, for example, were they resident in a nursing home already before succumbing to the disease which is being investigated. Better still, if it were possible to include the assessment of actual prior resource consumption in the research design. The use of a 'self-control' group would seem particularly suited to assessing the resource costs in a patient population which is known to suffer from relatively more co-morbidities than their age-, sex- and GP-practice-matched counterparts. In the case of hip fracture, one might thus suspect that, ceteris paribus, resource consumption of a patient group without controls would be highest and the least accurate approximation of the true, directly-attributable costs of hip fracture. The next best estimate might be obtained by a case-control study design. Ceteris paribus, the most truthful approximation of hip fracture costs might be given by deducting patients' pre-fracture resource consumption from their post-fracture resource consumption.

This raises the question over what time period resource consumption might be considered to be directly attributable to the disease in question.

3.4.4. Time Horizon

Different diseases will present different patterns of how they affect sufferers. To continue the example used above, since the common cold is an acute illness which the patient recovers from within a week usually with few long-term effects, its main effects on resource consumption are expected to be seen within that time period. The epidemiological literature on chronic diseases such as diabetes, in contrast, suggests that the effects of the disease on patients' lives and resource consumption may be felt over a much more extended period. Estimating the effects of diseases such as diabetes on resource consumption within a short time period only would thus appear to lead to an underestimation of the true costs of diabetes. Existing guidelines on the conduct of economic evaluations do not prescribe a specific time period for capturing the true costs of a disease. The researcher hence has to resort to the existing disease-specific epidemiological literature to judge which timeframe may capture the impact of a disease in the most appropriate manner given the purpose of the research.

The question over which is the appropriate timeframe for a study is also linked to another aspect of costing which is introduced in the next subsection. Depending on the timeframe adopted by a study, as well as its purpose, the true costs of hip fracture include different types of costs which may extend across different economic sectors of society.

3.4.5. Type of Costs

In economic parlance, the term 'costs' has a very broad meaning. Ideally, costs should represent economic opportunity costs, the value of the best alternative use of that resource (Sugden and Williams, 1978, p.30). It encompasses all aspects of the physical resource consumption associated with a condition or programme. Furthermore, it may encompass aspects which cannot be readily measured in physical units. Which costs are included depends mainly on the viewpoint and specific purpose of a particular study.

The following sections set out briefly the different types of costs which need to be assessed for a study to be able to represent the costs of a condition or programme as faithfully as possible. These include direct and indirect costs as well as intangibles.[8]

Direct Costs

The term 'direct costs' refers to changes in resource use directly attributable to the intervention or treatment regimen (Luce, 1996, p. 179). This includes both health care and non-health care costs. Examples of the former include items such as the cost of diagnostic tests, drugs, health care personnel and medical facilities. Examples of the latter include items such as the cost of child care during his or her parents' treatment or home care provided by the patient's family or unpaid

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[8] These costs elements can also be classified in different ways, such as costs arising from the use of resources within the health care sector, costs arising from resource use by patients and their families and costs arising from resource use in other sectors (Drummond, 1997). Gold and colleagues (1996, p. 178/9) chose to call what has traditionally been called economic indirect costs 'productivity costs'. However, whatever terms are used, the overall elements to be included in costing a condition or programme are the same.

volunteers.[9] Ideally direct costs should also include an element of the costs associated with the patient's time spent in treatment, travelling and waiting (ditto).

Indirect Costs

In addition to these directly attributable costs, a condition or health care programme may also entail indirect costs. This term is usually taken to refer to the productivity gains and losses related to mortality and morbidity. Some also consider the intrinsic value of health to fall into this cost category (Luce, p. 179). Indirect costs are often omitted from economic evaluations. This may be due to practical difficulties in obtaining the necessary data as well as methodological disputes over how to measure indirect costs.[10]

Intangibles

Even more difficult than the assessment of indirect costs is the assessment of the so-called 'intangibles' associated with a condition or course of action. This term includes all those effects which by their very nature are difficult or near-impossible to measure because they cannot be counted directly in physical units. However, in order to give a reasonably fair approximation of the costs of a

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[9] If these costs occur over a period of time, the concept of time-preference (payment now preferred to payment later) is incorporated into the estimation of costs by discounting future streams of payment. (for further discussion see Drummond, 1997, p. 68-74)

[10] There are four approaches to this in the mainstream literature. The oldest and most widely used of these is the human-capital approach (Koopmanschap 1998, p. 146). This way of thinking about indirect costs was challenged by the willingness-to-pay approach (Hodgson, 1993). There are two other approaches to measuring indirect costs. These are the implied values approach and the newer friction-cost method (Koopmanschap 1995). It is also worth noting that Hodgson (1983, p. 139) argues that it is not theoretically sound to view the human-capital as well as the willingness-to-pay approach as relevant alternative methods only for the estimating of indirect costs. He views them instead as alternative overall frameworks for assessing the costs of a disease.

disease or programme, the possibility of these types of effects also need to be taken into account. Although it is impossible to assess directly the effect of, for example, a fractured hip on each individual patient's quality of life, it is possible to attempt to approximate this by assessing patients' comparative pre-and post-fracture well-being along a number of dimensions of mental and physical well-being (Bowling, 1997; Bowling, 1995).

Table 3.1. shows how the inclusion of certain cost elements can vary depending on the perspective of a study. It is clear that the decision over which costs to include in a cost assessment will have an impact on the resulting cost estimate. This is explored further in the case of assessments of the costs of hip fracture in the following chapter. The remaining sections of this chapter will provide an overview of some of the other important methodological issues in the cost assessment of hip fracture, the choice of costing method, the treatment of future costs, the issue of censoring and the treatment of end-of-life costs.

Table 3.1. Relationship between Study Perspective and Cost Elements (source: adapted from Gold, 1996, p. 187)

Cost Elements	**Societal Perspective**	**Patient & Patient Family Perspective**	**Public or Private Insurer**
Medical care (aggregate)	All medical care costs	Out-of-pocket expenses	Covered payments
Medical care "Units"	All units	Those paid out of pocket	Those covered
Medical care "Price"	Opportunity cost (incl. Admin. Cost)	Amount paid out-of-pocket	Amount paid + admin. cost
Patient time cost for treatment or intervention	Cost of all time used	Opportunity cost to patient	none
Marketed Caregiving	All costs	Out-of-pocket expenses	Covered payments
Unmarketed, informal caregiving	All costs	Opportunity cost to caregiver	None
Transportation and other nonmedical services	All costs	All costs	None
Sick leave, disability, other transfers, (taxes?)	Admin. Costs only	Amount received	Amount paid by insurer + own admin.

3.4.6. Method of Costing

Average vs. Marginal Costing

There are two major methodological decisions to be made concerning the assessment of costs. The first of these is to address the question whether a cost assessment's aim is to assess average or marginal costs. An assessment of average costs in this context would involve the identification, measurement and valuation of resources consumed after, for example, the patient sustained a hip fracture. This type of costing, as highlighted in the previous section addressing the issue of the study design with respect to the use of a control group, ignores any possible default resource consumption. It would thus in all likelihood lead to an overestimation of the costs which may be directly associated with the course of action being costed. In contrast, a study interested in the marginal costs of this would seek to estimate only those costs which can be more directly associated with the course of action by deducting an estimate of default resource consumption from actual resource consumption (Luce, 1996, p. 188). This would seem to be of importance particularly in the assessment of the impact of conditions affecting primarily the elderly so as to avoid falsely assigning the costs associated with other existing conditions to the one being assessed.

Micro- vs. Case-Mix vs. Per Diem Costing

The second decision to be made concerning the method of costing is to do with the method used to attach a monetary value to the consumed resources once they have been identified and measured. Numerous approaches exist, allowing for practical time and resource constraints as well as different study aims. At its most precise, micro-costing involves the identification and measurement of each component of resource use (such as diagnostic tests, individual drugs consumed, number of days spent in each type of ward, number of time spent in operating theatre). A unit cost is then derived for each of these cost components, including the patient-specific allocation of overhead costs, if indeed these are to be included in the study (Gold, 1996, p. 193). Slightly less precise is it to base costs on a case-mix group. This would represent the value of the consumed resources as an average across a range of patients with a similar disease profile. The level of precision with which such a cost estimate would approximate the real resource consumption of a study's patient group depends on the level of detail to which the case-mix is specified. A still less precise measure of cost would be an average daily (per diem) cost specific to a particular disease or type of treatment. The least precise cost measure would be a per diem figure across patients in one hospital, averaged across all diseases and treatments (Drummond, 1997, p. 67).

The term 'cost' is used very loosely in this context. Real costs often have to be approximated by charges used by an institution which are publicly available in some form or another to researchers. However, as prices are not equivalent to costs in any health care system, the use of charges is not a very accurate way of estimating economic opportunity cost (Finkler, 1982). For example in the UK, until the introduction of the internal market in 1991, costing data were almost entirely absent from the NHS. Due to public funding as well as public provision of health care within the NHS, 'market' prices may bear little relation to costs, because of differing pricing structures, price discrimination, cross subsidisation and the reimbursement policies of third-party payers. Charges are thus relatively crude and often arbitrary estimates of cost (Ellwood, 1992; Ellwood, 1996). Until NHS information systems are improved, however, the estimates of costs will remain 'crude' because they were constructed for the needs of the organisation rather than for economic analyses (Mellett, 1993).

3.4.7. Future Costs

The issue of which future costs incurred by patients to include in an assessment of the resource implications of a condition is an issue which is not specific to hip fractures. There has been much methodological debate not only about the definition and assessment of these costs but also regarding the theoretical justification of their inclusion in the first place.[11] The basic question to ask is the following: If a health care programme prevents death or prolongs life, should any subsequent costs which are incurred by the survivors be counted as a cost of the programme? Given the high mortality observed in the wake of a hip fracture, this is a relevant question to ask. One would thus need to consider to what extent the overall assessment of the costs and outcomes of a programme might change through the inclusion of a model of future costs within the costs of the programme. Hence, the question of which future costs to include in an assessment would be of relevance primarily in full economic evaluations. However, the question being asked here is 'What are the costs of hip fracture?', not 'What are the costs of preventing hip fracture?'. This thorny methodological debate may thus be deferred primarily to those colleagues working on full economic assessments of hip fracture prevention programmes.

3.4.8. Censoring

It has been seen in the previous chapter that hip fracture appears to lead to substantial mortality. Expressed in a different way, this means that a substantial number of patients 'drop out' of a study, for example of a hip fracture prevention

[11] This debate centres around the treatment of costs which fall into three categories: 1) Costs which are related to the programme being assessed, which are being incurred during those years of life that would have been lived without the programme. 2) Costs which are unrelated to the programme being assessed, which are being incurred during those years of life that would have been lived without the programme. 3) Costs which occur in years of life which were added or subtracted by the assessed programme. These can include health care costs for the diseases affected by the assessed programme, for other diseases, and non-health costs such as food and shelter. The main methodological issues occur with respect to this third category of costs. For a non-disease specific overview of the arguments, please refer to Gold, et al., 1996 and Drummond, et al., 1997.

regimen, before the study is complete. These 'censored' observations are of particular relevance to the estimation of treatment costs from data collected in conjunction with clinical trials. Fenn, and colleagues (1995) have argued that the presence of such censored observations can present methodological issues for the analysis of that study's results. They have argued that using traditional statistical techniques, for example for inference testing, on censored data may result in systematic bias. The nature of this bias depends on the nature and pattern of censoring in a particular dataset and the relative order of magnitude of costs. For example, they show mathematically how the average costs of a programme can be represented adequately by dividing total programme costs by the full, uncensored number of patients, if total costs are large and patients drop out towards the end of the programme: "When C (= programme costs) is large,…, and censoring is end weighted, the calculation of mean within-trial program cost using the full sample and ignoring censoring may be a reasonable approximation to the 'true' product limit estimator" (Fenn, et al., 1995, p. 856). Alternatively, if patients drop out of a programme at a steady rate, the degree of bias is the same whether average programme costs are calculated by dividing the total programme costs by the total number of patients or only by the survivors (Fenn, et al., 1995, p. 855). If either of these cases does not apply, mean programme costs would best be approximated by using the Kaplan-Meier product-limit method. The authors argue that biases in mean programme costs might also lead to biases in the calculation of incremental costs. Biases in incremental costs might in turn lead to misleading evaluations of the relative costs and outcomes of alternative programmes. In a later publication, Fenn, et al. identify a context in which a simple Kaplan-Meier estimator of mean costs would be insufficient (Fenn, et al., 1996). This is if the costs (and efficacy) of a programme vary systematically in relation to different circumstances. Some of these conditions may well be present in the case of hip fracture. This issue will thus be revisited in several of the following chapters.

3.4.9. End-of-Life Costs

The last methodological issue to be discussed here which is of importance to the assessment of the impact of hip fracture is based on an empirically observed phenomenon. Numerous international studies have shown that on average a person consumes more health care resources in their last year of life than before (Lubitz, Prihoda, 1984; Gaumer, Stavins, 1992; Hogan, et al., 2000; Long, et al. 1984; Lubitz and Riley, 1993; McCall, 1984; Scitovsky, 1988; Spector, Mor, 1984). In the US, the proportion of annual Medicare spending attributable to the 5 - 6% of people who die that year has remained stable at around 25% since the late 1970s (Hogan et al., 2000; Lubitz and Riley, 1993). This increased resource consumption overall appears to be independent of the actual age at which a person dies (Busse, et al., 2002; Yang, et al., 2003). However, these cost increases in a person's last year of life may not be evenly distributed across patients of different ages. US Medicare payments for decedents in their last year of life have been shown to decrease as age at death increased (Lubitz, et al., 1995). These payments averaged $15,436 for those aged between 65 and 69 who died in 1988. The equivalent figure for those aged 90 and more averaged $8,888 (Lubitz and Riley, 1993). German data also suggests that the amount of days in hospital during the last year of life was lower for patients 85 years and over compared to those aged 55 to 64 (Busse, et al., 2002). It has been suggested at least in a US context that the main cause of this is due to patients receiving decreasing amounts of aggressive medical care as their age increases (Levinsky, et al., 2001). However, as Scitovsky (1994) pointed out, this relationship may be false, since a research design based on Medicare data may miss out other substantial costs incurred by the very elderly, such as nursing home costs. This argument has been supported also by other studies (Roos, et al., 1987; Temkin-Greener, et al., 1992).

Regardless of how much the increase in end-of-life costs differs between different age groups, though, the phenomenon itself has potential implications for any estimate of the resource consumption attributed to hip fracture. The aim of such an assessment is to distinguish between costs which are incurred as a direct result of the fracture and costs which are incurred during the study period but for reasons unconnected to the fracture. This distinction is usually made by deducting the amount of resources the hip fracture patient is assumed to have consumed in the study period regardless of the fracture. This assumption can be either based on the resource consumption of a matched control group or by extrapolating from the individual hip fracture patients' resource consumption prior to the fracture. In either case, the described phenomenon of rising resource consumption in the year prior to death has direct implications for the calculation of these baseline costs. In principle, it would seem easy to include this phenomenon in a model by raising the baseline costs of those patients who will die during the study period. This, however, involves a judgment with respect to which deaths are attributable to the hip fracture and which are not, not an easy question in a study population of mostly frail, elderly persons. It remains to be shown in the next chapter how the existing hip fracture literature has actually dealt with this and the other described methodological issues. The following section concludes this brief overview of methodological issues relevant to the cost assessment of hip fracture by exploring very briefly the two major medical journals' recommendations with respect to these methodological issues.

3.5. Journal Guidelines

The two most detailed economic evaluation guidelines adopted by medical journals are those of the British Medical Journal (BMJ) and the Journal of the American Medical Association (JAMA). Their recommendations with respect to cost assessment are detailed in Table 3.2. Comparison between these two dominant sets of peer-reviewed journal guidelines shows that although many issues which were addressed in this chapter so far have been mentioned, the recommendations by no means address all the fundamental issues raised so far. It is clear that even if researchers fully adhered to these peer-reviewed journal guidelines, they only go some way towards making studies more transparent and comparable.

Table 3.2. Medical Journal Guidelines to Cost Assessment (source: adapted from Walker, 2001)

Methodological Aspects	BMJ	JAMA
Identification of costs and outcomes	Resource use associated with an intervention	Resource use associated with an intervention, i.e. costs of health care services; patient time expended for the intervention; caregiving (paid or unpaid); other costs associated with illness, i.e. child care and travel expenses; economic costs associated with employment; and costs associated with non-health impacts of the intervention Fixed costs should not be included The inclusion of health costs resulting from the fact that a patient lives longer due to an intervention is left to the discretion of the analyst
Measurement of costs and outcomes		Costs should be measured in constant monetary units and adjusted for distortions
Valuation of costs and outcomes	Costs should be adjusted for inflation and currency conversions	

3.6. Summary

This chapter has provided an overview of the main methodological issues which need to be addressed by any researcher seeking to assess the costs of hip fracture. These included the study perspective, the geographical location of the study, the type of study and its time horizon. It further included the types of costs included as well as the costing methods employed, the issue of which future costs to include in an assessment, the issue of censoring and end-of-life costs. Choices thus need to be made for model 'inputs' as well as processes and model outputs. The next chapter examines the hip fracture cost- specific literature to find out what choices existing studies have made with regard to these issues to assess the costs associated with the condition.

4. Characteristics of Existing Studies of Hip Fracture Costs

4.1. Introduction

Chapter 3 has outlined the main methodological choices facing an investigator of hip fracture costs. The research presented in this chapter will show how the existing literature has assessed the economic costs of hip fracture. Zethraeus and Gerdtham (1998) criticised the state of the literature which existed at that point in time on several counts. They argued that many of the existing studies of hip fracture costs and potential cost savings had a limited perspective which rarely included rehabilitation and long-term care. Studies rarely considered the possibility that hip fracture patients might consume more health care resources than their age- and sex-matched counterparts in the general population even before the fracture. Finally, the authors pointed out the failure of existing studies to draw a proper distinction between patients who survive and those who die. In presenting an overview of the characteristics of the current literature on the subject, it will be examined whether Zethraeus and Gerdtham's criticism is still valid today.

The chapter starts by describing how relevant studies were retrieved. It then presents how the retrieved studies dealt with the methodological issues surfaced in the last chapter.

4.2. Methodology of Literature Retrieval

Studies were retrieved by a combination of methods. Primary searches of different databases (cut-off date of (and including) December 2001) were supplemented by checking the references of the retrieved papers and hand-searching locally available paper- or online versions of journals such as Osteoporosis International, the British Medical Journal, The Lancet, Health Economics, the Journal of Health Economics and Medical Decision Making. The databases searched included the US National Library of Medicine's Medline and Healthstar databases, utilizing both, the now defunct Internet Grateful Med interface, as well as the PubMed interface for searching. In addition, the Web of Science's Arts and Humanities, Science and Social Science citation databases were searched. The aim was to cast a wide net for all potentially relevant studies. The keywords used for all these database searches included variations, truncations and different combinations of 'cost', 'hip fracture', 'osteoporosis', as well as 'cost-of –illness', 'cost-minimization', 'cost-effectiveness', 'cost-utility', 'cost-benefit', 'marginal cost' and 'incremental cost'.

In addition, a more specific search of the NHS Economic Evaluations Database was conducted (http://nhscrd.york.ac.uk). It was queried for 'hip fracture' or 'osteoporosis' in the title and abstract and limited to 'economic evaluations'. The following paragraph details how the retrieved publications were further filtered to yield an answer to the question 'How much does a hip fracture cost?'.

Studies which did not provide an estimate of hip fracture costs in monetary units were not incorporated in the analysis. Publications which provided only a review or secondary, non-original cost estimates[12] were equally excluded from the

[12] For example, a study of the cost-effectiveness of an osteoporosis prevention programme might collect original data with respect to the costs of this prevention programme. More often than not, the costs of the avoided hip fracture, however, would then be based on a previously published study of the costs of hip fracture. Often the measure of 'avoided costs' would not only be based on a different study but on a study assessing costs in a different country. Alternatively, the same study of the osteoporosis prevention programme might collect data with respect to 'avoided' resource consumption and attach monetary units to it based on the unaltered costs of another study. In each case, only the study containing the original cost estimate can give an answer to the research question. Studies basing their cost estimates on other studies were included in this

analysis, since the original cost studies which they used as their cost estimate were already included in the analysis. The same applied to multiple publications based on the same underlying dataset with respect to costs. In this case, the publication with the most detailed information with respect to the inputs and processes of costing was chosen as a basis of further analysis. All these studies which, based on the title and/ or abstract, appeared to offer answers to the research question 'How much does a hip fracture cost?' but on closer examination did not provide an answer based on original research are included in Appendix 2, together with the reason for their exclusion from the analysis. This appendix contains 69 studies. This left 34 original research studies in a language[13] and a publication format detailed enough to enable the author a closer examination of their results. (see Appendix 1). The remainder of this chapter is devoted to describing and examining the choices these studies have made with regard to the methodological variables derived from the generic costing literature in the previous chapter.

4.3. Study Perspective

32 of these studies adopted the format of a cost-of-illness study (including cost-consequence studies) (Appendix 1). The remainder adopted any of the formats a full economic evaluation can take, cost-effectiveness, cost-utility or cost-benefit studies. Only 5 out of all studies presenting cost assessments based on primary data included effects of hip fracture beyond the wider health care impact. Only 5 studies could thus claim to aspire to the consideration of the wider societal

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chapter's analysis though if they made attempts to customise the other cost estimates to characteristics of their own study population.

[13] English, French, German, Italian, Spanish. Three original studies could not be incorporated into the analysis because they were only published in Danish or Norwegian. (See Appendix 2)

impact of hip fracture. The majority of economic evaluations of hip fracture can thus aspire only to help improve the decision-making process by providing a technique for comparing alternative courses of action in an explicit, transparent and consistent way.

The decision on which perspective to adopt is followed closely in importance by issues of which population should be studied. This is the topic of the next section.

4.4. Location

The term 'location' is used here to denote a whole number of issues related to the characteristics in time and space of the patient population who are to be used as the basis of hip fracture cost assessment. This includes primarily points that have been raised already in chapter 2 in the context of the epidemiological literature on hip fracture. This includes the following:

- Year of Study
- Country or Region
- Sample Size
- Male/Female Mix
- Age
- Inclusion or Exclusion Criteria
- Definition of Hip Fracture
- Patient Origin
- Treatment Algorithm

The next sections examine how those 34 studies (see Appendix 1) which presented original cost assessments dealt with each of these points.

4.4.1. Year of study

All the studies that were based on original cost data were published after 1985. More studies were published in the last time period from 1995 onwards than in the two time periods before combined. The period between 1985 and 1989 saw the publication of 4 studies. Between 1990 and 1994, publications doubled with 8 studies. 1995 to 2000 almost tripled the stock of studies which were published using original cost data (22 studies). Knowledge of hip fracture costs is thus based on a relatively substantial body of literature stretching back for more than a decade.

4.4.2. Country

With 24 studies, the majority of hip fracture cost assessments were conducted in Europe. Of these, the majority were conducted in Northern Europe, which was also the basis of much of the epidemiological literature. One-third to half of these Northern European studies were based on Swedish data. [14] *(Table 4.1.)*

[14] One third to half, depending on whether France and Switzerland are considered Northern Europe.

Table 4.1. Studies per Country

Country	No. of Studies
Australia	2
Austria	1
Belgium	2
Canada	1
Denmark	1
France	3
Germany	1
Greece	1
Netherlands	1
New Zealand	2
Portugal	1
Spain	2
Sweden	6
Switzerland	3
UK	3
US	5

4.4.3. Sample size

With 65%, the majority of studies were based on sample sizes greater than 100. Only a small number of studies considered the reporting of their sample size unnecessary *(Table 4.2.).* In comparison to the literature of other diseases, the knowledge base of the cost implications of hip fracture do appear to rest on firm foundations as far as sample size is concerned.

Table 4.2. Sample Size

Number of Patients	Number of Studies
<100	9
100-1,000	11
>1,000	11
Not specified	4

Having established these more general features of the hip fracture studies' patient samples, the following parts of this section on study location continue to establish the epidemiological characteristics of these samples in some more detail. One of the first things to consider, as the epidemiological literature reviewed in chapter 2 has established is the age and sex distributions of patient groups.

4.4.4. Male/ Female Patient Mix

79% of studies included both male and female hip fractures in their sample. No study was found that assessed the costs of such fractures in men only. 15% of studies though concentrated exclusively on hip fractures in women. 6% of studies did not provide any information on this basic aspect of their patient population at all.

4.4.5. Age

As chapter 2 has shown, men and women tend to suffer from hip fractures at different stages in their life. In addition, the age of a patient group may affect cost estimates indirectly by its link with general health status.
The mean ages at which fracture occurred differed between studies, if it was reported. However, most studies found the average age to be somewhere in the range between 75 and 85. If no average age was reported, average ages of different patient groups were sometimes substituted instead, for example for men and women, first and repeat fractures, etc. Most studies also provided information on in- and exclusion criteria which were used to recruit the patients of their sample, one of which may be age. This is the topic examined next.

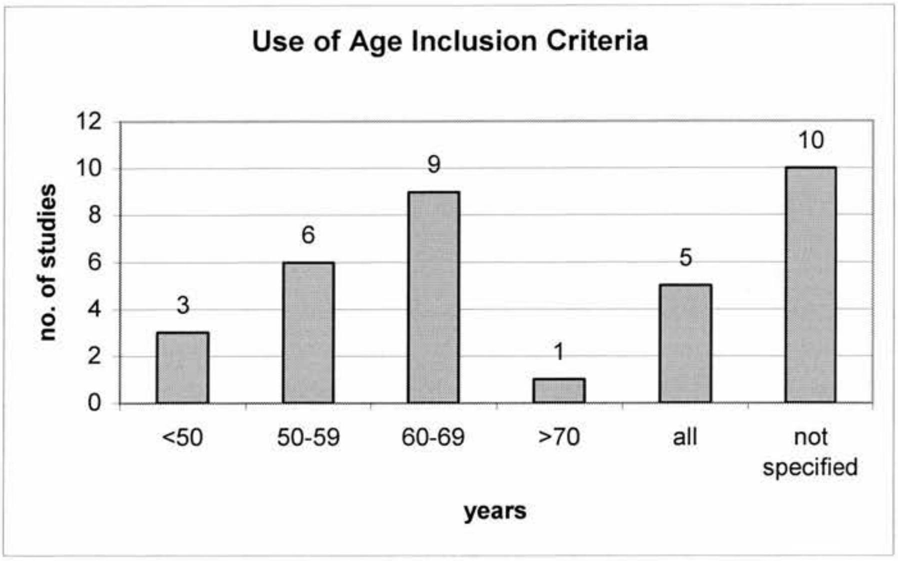
4.4.6. Inclusion/ Exclusion Criteria

Most studies (94%) explicitly stated how patients were recruited to take part in the study. People were included for example on the basis of criteria such as age, the diagnosed presence of osteoporosis or an atraumatic fracture. Other people were excluded from studies due to the presence of other diseases such as Paget's disease or the presence of metastatic disease. The exact location of the fracture was also used, both, as an inclusion and an exclusion criterion. 2 studies based their assessment of the costs of hip fracture only on patients suffering their first fracture.

38% of all original studies (13) did not specify an exact definition of what they considered a 'hip fracture'. The rest used either ICD codes to specify which fractures should be included, or direct definitions, such as only cervical or cervical as well as trochanteric fractures or fractures of the proximal femur.

By far the most common criterion by which eligibility was judged was patients' age. 94% of studies reported the use of age (>45) to exclude hip fractures in patients who were deemed atypical for this reason. Studies thus tended to concentrate on older patients, as Figure 4.1. shows. 6 studies gave neither an indication of the age inclusion criteria, nor any indication of the mean ages of the patients whose resource consumption they were reporting.

Figure 4.1. Use of Age Inclusion Criteria



In addition to criteria such as the exact definition of hip fracture or the age at the time of fracture, patient origin was also used as a criterion on the basis of which to include people in a study.

4.4.7. Patient Origin

A significant characteristic of a study's patient population with respect to incurred costs and outcome would appear to be their general health and independence prior to the fracture (Elffors, 1998). One way this can be approximated is by looking at where the patient was resident before their fracture, be that their own home or one of a number of institutional settings.[15] The majority of studies did specify where their patients originated from and covered all types of patients. Over half of all original studies (56%) included hip

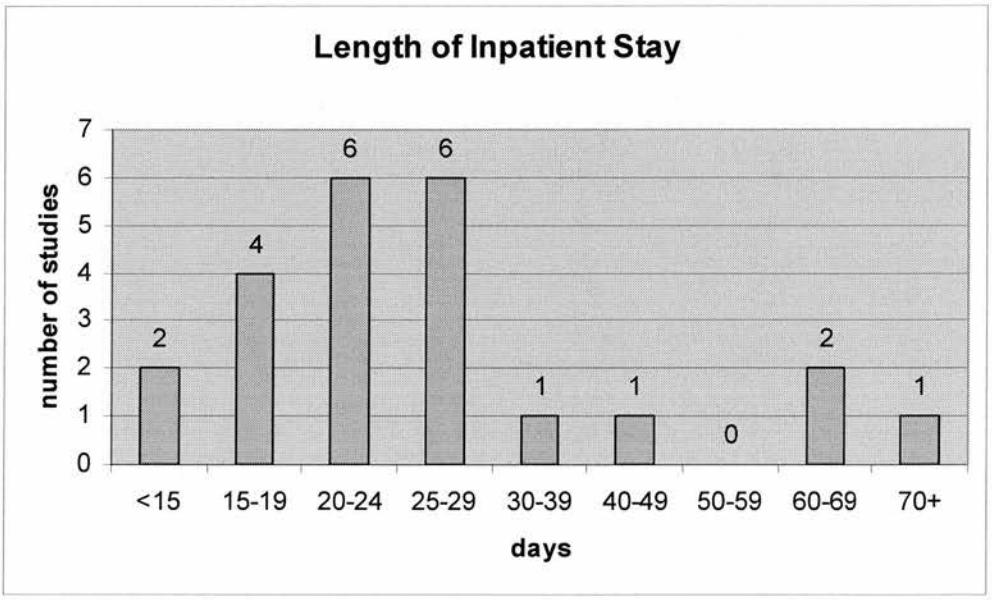
[15] This is linked not only to age but also to the country's culture within which the study takes place. For example, more people of the same age tend to live in homes for the elderly in northern Europe rather than in Mediterranean Europe, where they tend to live more often with members of their family (Lyritis, 1992). The origin of the patient can thus be an indicator of how fragile patients were at the time of their fracture only within certain limits.

fracture patients from all settings. 15% of studies only included patients who were independently living at home prior to fracture. 26% of all studies though did not specify at all where their patients sustained their hip fracture. It is thus doubtful whether more than a quarter of all studies which were based on original cost data are thus able to distinguish between resource consumption which can be directly attributed to hip fracture and resource consumption that would have occurred regardless of the fracture.
The next and last part of this section detailing the existing hip fracture literature's treatment of aspects of their patient sample takes a closer look at patients' inpatient stay.

4.4.9. Treatment Algorithm/ Length of Stay

Hip fracture leads to hospitalisation. It is also well-established that the length of hospitalisation varies from country to country (OECD Health Data, 2002). Since hospitalisation is also resource intensive, the length of stay as a proxy for the more general treatment algorithm becomes important to any cost assessment. Obtaining a single representative figure for each study concerning length of stay was difficult due to the profoundly heterogeneous ways of reporting results between studies. Some studies gave a single point estimate of length of stay, others gave a range of figures, others gave none. Of the 23 studies that did provide a single point of reference, the majority reported an average length of stay in any type of acute and rehabilitation hospital ward of between 20 and 29 days. However, as Figure 4.2. clearly shows, there were great differences between studies. More than one-fifth of studies (21%) did not report any measure of average length of stay, whether for their entire sample, or for specific subgroups within the sample. This would seem to make it difficult to compare cost estimates among these studies. This difficulty is compounded by the fact that almost one third of all studies did not specify whether the length of stay figure they report refers to acute or rehabilitation wards.[16]

Figure 4.2. Length of Inpatient Stay



4.5. Type of Study

Once the study group has been chosen, there remains the question over how to distinguish between costs which are directly attributable to the hip fracture and those which might have occurred even in the absence of the fracture.

The literature has shown that hip fracture patients appear to cost the health and social services already more money before their fracture than their healthy age- and sex-matched counterparts, an issue not addressed specifically in the generic

[16] It is possible that in some studies this was not reported because in some countries no clear distinction seems to be made between the acute stay and the rehabilitation stay.

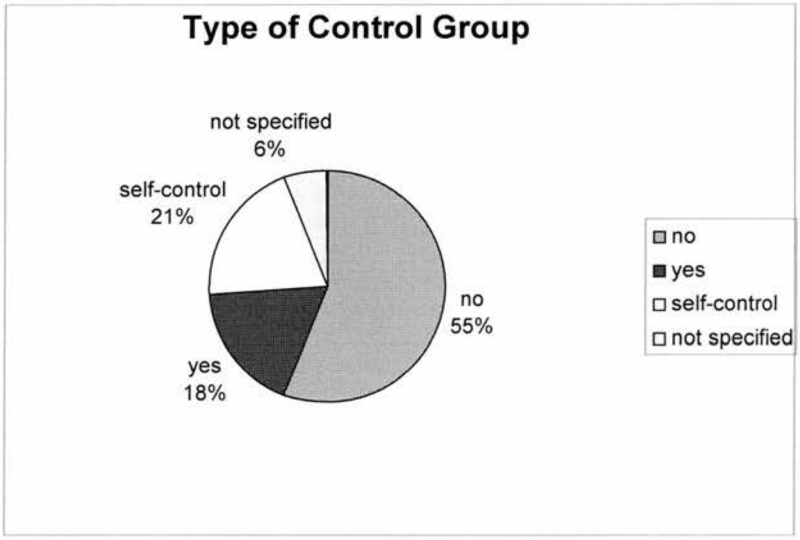
costing literature (Sernbo, 1988; Campion , 1987). In order to correctly estimate the costs attributable to hip fracture only it is important to exclude these prior costs. This can be done with the help of a control group in a number of different ways. One is to search for a control group among people who conform as closely to the certain epidemiological characteristics of the patient group, such as age, sex and ethnicity. Another way of allowing for this previous resource consumption would be to estimate patients' resource consumption before their fracture and deduct these costs or a proportion of them from the costs incurred after the hip fracture.

As Figure 4.3. shows, more than half of all studies used no controls at all. As the object of the cost assessment of many of these studies also included the estimation of costs beyond acute care costs, this would appear to be a methodological weakness. It might lead the studies to overestimate the costs associated with hip fractures and hence to overestimate how much money could be saved by preventing hip fractures and hence to overestimate the cost-effectiveness of drugs to prevent hip fractures.
However, almost 40%[17] of all studies did use some sort of control group. About half of them, almost a quarter of all studies, used the resource consumption of the same group of hip fracture patients before their fracture as a control.[18] The remaining studies, 18%, used a control group of patients which were in some

[17] This is the sum of the 21% of studies who used self-controls and the 18% of studies that used normal control groups.
[18] There are a variety of ways how this can be done. Most studies merely asked the patients or their proxy a number of questionnaire items as a point estimate of their resource consumption just preceding the fracture. Others, a small minority only unfortunately, went to considerable lengths to estimate previous resource consumption over the preceding 6 months for example. The next variable to consider if self-controls are used is the researcher's estimate of how this resource consumption would have continued to behave had the fracture not happened.

way matched to the patient group. Most commonly, the control group was recruited among patients of the same age and sex as well as the same geographical area. Given the evidence about hip fracture patients prior morbidity profile, the use of an external control group, or indeed no control group, in these circumstances may well lead to an overestimate of directly attributable hip fracture costs.

Figure 4.3. Type of Control Group

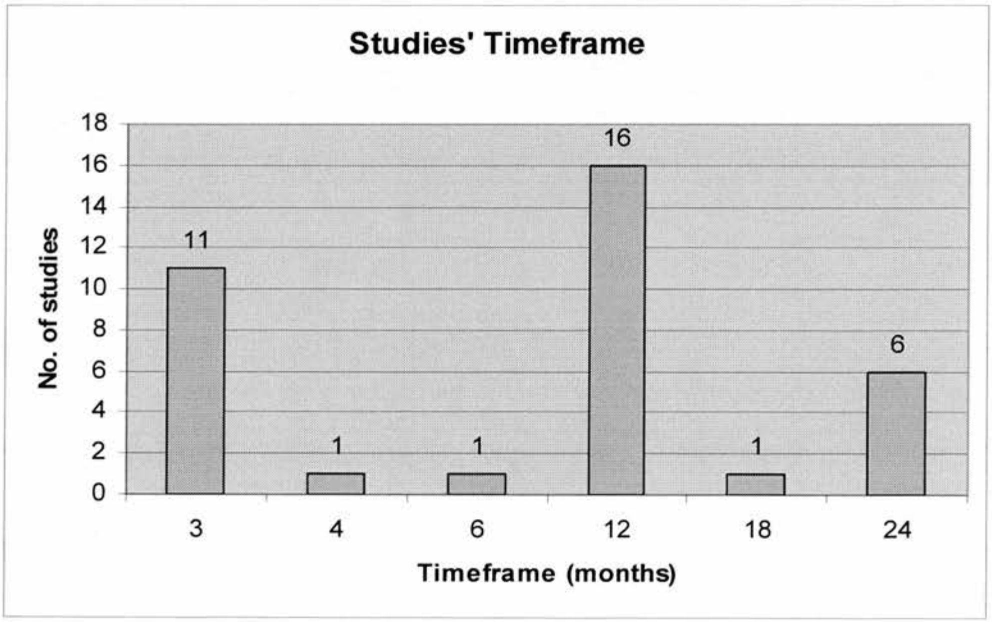


A further aspect of study design has been highlighted as having an impact on resulting cost estimates which has not so far been addressed. None of the studies of hip fracture costs based on original cost data sought to give an estimate for the lifetime impact of hip fractures. This was evident in the time period chosen for analysis, as the next section reveals.

4.6. Time Horizon

Having decided which group of patients and, if applicable, of controls are to be used as the basis of any assessment of hip fracture costs, the scope of the study is of major importance. This involves decisions as to the timeframe of the analysis and related to this the type of costs that are to be incorporated in the analysis. Almost half (47%) of all existing studies sought to assess the costs associated with hip fracture in the twelve months following the fracture. The other half confined themselves either to the assessment of mainly inpatient costs with a shorter timeframe of between three and four months or sought to estimate the impact of hip fracture on resource consumption up to two years post-fracture *(Figure 4.4.)*.

Figure 4.4. Studies' Timeframe



The timeframe of analysis is one of the two major determining factors of the scope of a study of hip fracture costs. This can be but does not necessarily have to be related to the second factor determining the scope of a study, the choice over which costs should be included in the analysis.

4.7. Type of Costs Assessed

Table 4.3. provides a summary not only of the type of costs included in studies' estimates but may also be an indication of the care taken in ensuring or analysing to what extent these costs might be representative of studies' patient samples.

Table 4.3. Type of Costs Included in Analysis[19]

Type of Cost Data Collected	Number of Studies	% of Total
Acute	7	21%
Acute?	5	15%
Detailed Acute	23	68%
Rehabilitation	23	78%
Community Care	14	41%
Long-Term Care	18	53%
Other Societal Costs	5	15%

4.7.1. Direct Costs

36% of studies gave only a very limited picture of what types of cost were included in their cost assessment of hip fracture ('acute' and 'acute?'). The majority of these studies used a simple per diem figure, usually without reference to where this figure had originated, how it might have been arrived at or how accurately it might reflect the resource consumption of the patient sample, or, indeed, any group of hip fracture patients. This includes also studies which did not report their results in such a way as to enable the distinction between acute

[19] It is not always easy to distinguish between the types of costs which were included, nor how they were derived and estimated. The category 'acute' simply refers to a study estimating the acute costs of hospital admission. The majority of studies which estimated this were estimating only the primary admission which occurred directly after the hip fracture. However, some studies, especially when they were of the marginal costing type, also included subsequent related or unrelated acute hospital admissions during the study period. The category 'acute?' refers to those studies which appeared to assess acute costs only but this was unclear from the timeframe, or it was not clearly stated.

and rehabilitation care, even taking their reported average length of stay into account.

The majority of studies overall, 68%, however, sought to provide a more accurate estimate of the monetary value associated with the resource consumption of their patient group while in acute care.

The majority of studies, also 68%, also included rehabilitative care in their estimate of hip fracture costs, usually in the form of a per diem figure. 41% of studies provide a reasonably comprehensive account of the costs associated with community care, such as GP visits, visits by a community nurse and homehelp. An additional 3 studies provided no general community care costs but an estimate of the costs of homehelp, lifting the overall percentage of studies providing any account of community care costs to 60% of all studies.

Just over half of all studies sought to provide an estimate of the more long-term care costs which might be associated with hip fracture. This included items such as residence in a home for the elderly, residence in a nursing home, group living, etc. 4 studies in total sought to cost also informal home care received by hip fracture patients. Only 15 % sought to provide any other estimate of the costs of possible societal effects of hip fracture. This included one study which sought to include in its estimate the costs of social security payments for long-term disability and absence from the work-force.

To reiterate, just over half of all studies attempt to give a more comprehensive cost estimate by including direct medical as well as social care costs. Only 7 of these adopted a marginal costing design. This means that less than half of the studies which seem to give a relatively more comprehensive picture of hip fracture in terms of the resource implications on medical and social care budgets are able to give a more accurate picture of this because they attempted to give an estimate of the costs which are directly attributable to the hip fracture. Of these 7 studies 6 had a timeframe of 12 and 1 of 18 months for their analysis. Of these 7 studies, most were published in the late 1990s. One study each was conducted in Belgium and the UK, two in the US and 3 in Sweden. Only these 7 studies of the total of 34 appear capable by virtue of their methodology to give a more accurate estimate of the costs associated with hip fracture in their respective countries. In other words, only 21% of hip fracture cost estimates can even attempt to shed some light onto the question what the comprehensive direct cost implications of the condition are, never mind estimating the cost-effectiveness of different health care programmes aimed at preventing or treating the condition.

4.7.2. Indirect Costs

Only one single study (Meine, 1993) went beyond this assessment of direct costs and included elements of indirect costs in their study. 80% of their 2-year estimate of hip fracture derived from indirect costs, such as pensions and other compensations (including pensions for dependents ('rentes de survivants') and daily compensations ('indemnites journalieres' and 'indemnites pour l'atteinte a l'integrite')). However, the study was based on an average costing methodology. This makes it difficult to disentangle costs that are a direct result of the fracture from costs which are not.

4.7.3. Intangibles

No study sought to attach a monetary value to the implications of hip fracture commonly considered 'intangibles'. Only 4 studies collected some information to compare patients' functional status before and after the hip fracture. Of these, only three were based on original research (Sernbo and Johnell, 1993; Borgquist , 1992; Chamberlin et al. 1997) and two of these studies were based on Swedish data.

The costs of excess mortality were assumed to be 0 by all studies. In other words, no monetary value was attached to increased mortality resulting from a hip fracture.

4.7.4. Future Costs

Future costs due to averted hip fracture mortality were, not surprisingly, not explicitly estimated in any of the original cost studies. However, two mentioned the issue (Autier, et al. 2000; Hollingworth, 1995) without attempting to place a monetary value on it. Of the full economic evaluations, four made explicit mention of future costs and attempted to estimate them.[20] Two further full economic evaluations made some attempts to explore the issue without explicitly estimating it (Visentin, et al. 1997; Ross and Wasnich, 1988) in their assessment. The issue was furthermore not even mentioned in most publications.

Having looked at what type of costs were included in studies' estimates of hip fracture costs, the next section turns its attention to the way these cost items were estimated.

[20] These four studies were Ankjaer-Jensen, et al. 1996; Roche and Vessey, year unknown; Geelhoed, et al. 1994; Daly, et al. 1992).

4.8. Method of Cost Assessment

The issue of whether a study considered all costs incurred by patients post-fracture as directly related to the fracture has already been addressed in section 4.5. which discussed the use of control groups. It was shown that far less than half (38%) of all studies used a research design consistent with the assessment of directly attributable costs in principle. Just over one fifth (21%) of all studies used a design consistent with the estimation of such costs specific to hip fracture. The remainder of this section thus applies itself to two other aspects of cost assessment, the source and quality of the used cost data.

4.8.1. Source of Cost Data

Economic evaluations of hip fracture prevention and treatment programmes were mainly based on secondary cost data: Only 29% of full economic evaluations which were not obviously reviews[21] did appear to have collected their own cost data (see Appendix 3, which includes 2 studies of Appendix 1 and 11 of Appendix 2). However, only in a minority of cases were unit cost estimates reported in enough detail to make any judgements about the source or quality of the costing. 67% of studies (30 of 45) used other studies' cost assessments as the basis for their comparisons of the costs and outcomes of different programmes[22]. Among the studies which collected original cost data, sources of cost data varied to such as extent as to be unsuitable for formal analysis. In addition, in few studies was it explicitly stated to which year costs applied. Some studies cost data was derived from hospital accounting systems which were sometimes more

[21] As evident from the paper's title.
[22] The remainder of studies consists of the aforementioned studies using original data, those that didn't supply enough information to judge whether their cost data was original and those that didn't report resource consumption in monetary units (see last column in appendix 2).

and sometimes less patient-related. Other studies derived their cost data from national or provincial hospital associations, public insurance companies or government guidelines. Few studies made any mention of how representative that data may be of economic costs or how representative it may be of their particular patient sample.

4.8.2. Quality of Cost Data

The previous parts of this section described aspects of the quality of the cost data deployed by all those studies which used original cost data. This involved mainly cost-of-illness studies. Only two full economic evaluations were based on original cost data[23]. This means that only two full economic evaluations made some effort to relate resource consumption in monetary units to characteristics of their actual patients.

With few exceptions, the full economic evaluations of hip fracture appeared to employ less rigorous costing methodologies than the cost-of-illness studies. As has been indicated in the previous section, 30 full economic evaluations' cost estimates were either based on adaptations of the cost estimates of the retrieved cost-of-illness studies or on crude per diem figures based on average costs across whole hospitals. These studies also did not appear to have given much consideration to the question how well these estimates might estimate resource utilization in the real or hypothetical patient population they were now being applied to.

Of the 13 full economic evaluations with original monetary resource utilization data, 7 do not give enough information on the inputs and processes of their cost

[23] And which were not in Norwegian or Danish and gave some information on the costing inputs and processes which would make it amenable to some form of analysis (see section 4.2.).

estimation to enable any form of analysis. Of the 6 that do, 1 used an incompatible reporting format[24], 2 were in Danish , and one study in Norwegian only. This left two studies (Ruchlin et al (2001) and Farnworth et al (1994)) which provided enough information on their costing inputs and processes to enable some form of analysis to relate their hip fracture cost estimate to either patient characteristics or the modelling processes. Both examined questions of hip fracture rehabilitation. Of a substantial body of literature seeking to give directly relevant policy advice on prevention and treatment options for hip fracture, there are thus only two studies of different rehabilitation programmes whose cost estimates relate to their study population. Among this body of literature there are thus no studies of hip fracture prevention and treatment programmes beyond rehabilitation programmes whose cost estimates relate to their study population and which allow any analysis of their recommendations with respect to this. It could thus be argued that the majority of full economic evaluations which contain directly policy-relevant information, were thus of dubious quality as far as the costing element was concerned.

4.8.3. Censoring

This concept was also introduced in chapter 3. It refers to the consideration of using the statistical techniques of survival analysis to analyse the hip fracture cost data in order to prevent the bias to mean costs from high mortality or missing data. Of the studies with original cost data, only 3 explicitly acknowledged the issue and used the techniques of survival analysis to provide

[24] Chrischillles et al (2001) averaged hip fracture costs across both, the cases and the control groups due to the study's different research question. Since this involved large numbers, the resulting hip fracture costs are incomparable with all the other studies' estimates in this reporting format.

an average cost of hip fracture taking into account substantial mortality rates.[25] Two further studies (both by Zethraeus and colleagues) explicitly sidestepped the issue by providing cost estimates for subgroups of survivors and those that died during the study periods separately. None of the full economic evaluations retrieved made any explicit reference to this issue at all.

4.8.4. End-of-Life Costs

Many studies' reporting of their costing methodology did not appear to be detailed enough to judge whether this phenomenon was given due consideration. Only one study with original cost data (Zethraeus, et al., 1998) provided a monetary measure of how much this might affect a cost estimate. Another 5 studies with original cost data mentioned the issue, however, without attempting to estimate its impact. Of the full economic evaluations, for whom, admittedly this issue should be of far greater immediate importance, only one study attempted to give an estimate of its impact (Geelhoed, et al., 1994). Another full economic evaluation (Visentin, et al., 1997) made a mention of the potential impact of the high end-of-life costs, regardless of age.

4.9. Summary

This chapter has detailed how existing cost assessments of hip fracture have chosen to address the methodological issues outlined in the previous two chapters. The costs of hip fracture appear to be comparatively well researched. They are based on a relatively substantial body of literature going back to the

[25] These three studies were Autier, Brainsky and DeLaet (see Appendix 1).

mid 1980s across many parts of the world. Studies are mostly based on good sample sizes and cover both men and women with and without explicitly diagnosed osteoporosis comprehensively. The majority of studies specify what type of accommodation their sample came from. Information exists on patients from all types of settings. Length of stay figures for hip fracture varied considerably between countries, similarly to what has been reported elsewhere.

Less than half of all studies used control groups in a study design consistent with the estimation of directly attributable costs in general. More specifically, however, less than a quarter of studies used patient pre-fracture resource consumption as a control in a study design consistent with estimating the directly attributable costs of hip fracture.

Based on the literature reviewed here, Zethraeus and Gerdham's criticism of the state of the literature in 1998 does not seem to hold anymore in the majority of points though. The majority of studies adopted a timeframe of one-year or more for their analysis. The evidence from the studies covering 12 months or more suggests that this is sufficient to capture the main impact of hip fracture in the majority of patients. Related to this may be that the accusation that rehabilitation and long-term care was not included in the literature does not hold any more. About half of all studies also sought to give some measure of community care as well as long-term care costs. Only one study though sought to include indirect costs in its assessment. Not a single study quantified intangibles. Only three studies collected original information on the functional status of patient pre- and post-fracture. Two of them were based in Sweden. Studies also shared the assumption of zero costs of excess mortality. Full economic evaluations were in the majority based on secondary cost data. Few made any attempt to relate these secondary cost data to characteristics of the patient samples on whom outcomes data was based. Consequently, the costing methods employed by full economic evaluations appeared to be less rigorous than those of studies whose objective was solely the assessment of hip fracture costs.

One of the main drawbacks of the existing literature overall is the lack of reporting and the lack of consistency in reporting characteristics of the patient sample, methods and processes. This does not allow for easy comparison between studies.

Drawing on these observations of the methodological choices made by existing studies, the next chapter outlines the methodology employed to estimate the costs of hip fracture in Tayside.

5. The Methodology of the Tayside Model

5.1. Introduction

Before presenting an estimate of the costs of hip fracture in Tayside, this chapter describes and discusses the methodology which was used to arrive at this estimate. This is based on the issues that have been surfaced in the reviewed generic and hip fracture specific costing literature. The methodology employed for estimating the costs of hip fracture in Tayside sought to build upon the strong points of the existing hip fracture studies and avoid their weaknesses. The structure of the chapter also broadly follows the outlines of the last two chapters. Section 5.2. outlines the perspective adopted for the study and the methodological choices made with respect to the collection of resource consumption data of hip fracture patients in physical units. In order to attach a monetary value to this data, unit cost data is required. The methods with which this was collected are described in section 5.3., followed by an appraisal of the cost data's resulting strengths and weaknesses. The methods of constructing a model of the hip fracture costs in Tayside are the topic of sections 5.4., 5.5. and 5.6. The remainder of the chapter is devoted to the exploration how changes in the way the model was constructed might influence the estimate of the costs associated with hip fracture in Tayside.

5.2. Methodology of Resource Use Data Collection

Section 5.2. concerns itself with the methodological choices made in collecting data of resource consumption in physical units. Starting with the perspective of the study, the aims, processes and items of resource consumption are laid out.

This is followed by an appraisal of the strengths and weaknesses of the collected resource consumption data, which concludes the section.

5.2.1. Perspective of Study

The perspective of the study was chosen to provide the most meaningful and accurate information obtainable on the impact of hip fracture in Tayside to local decision-makers. As a result, the perspective of the study was chosen to reflect that of the health care as well as social care commissioning bodies in the area.

One way one might view the National Health Service would be as a single universal insurer of the entire population of the UK. The costs that are of particular interest in this situation are those covered in the last column of Table 3.1. which compares the types of costs which would be included in studies conducted with different perspectives. Hence, the focus of this Tayside hip fracture model is on the costs of medical care, marketed care giving and the costs of sick leave, disability and other transfers. The cost of patient time for treatment and the costs of un-marketed and informal care giving are thus not included in this model. In contrast to Gold's (1996) categorisation that was geared towards the US American system of health care delivery though, this model included aspects of transportation and other non-medical services. In the British system of health care delivery and decision-making some of these will be covered by the budget of either the health or social services sector.

In order to provide information only on those costs which can most legitimately be described as hip fracture-related, the study sought to count only the difference between pre- and post-fracture resource consumption during the whole duration of the study ('net costing').

5.2.2. Collection of Resource Use Data in Practice

This perspective of the study, as well as its net costing methodology determine the type of data collected in practice. The following section describes the data which were collected about the patients' pre- and post-fracture levels of resource consumption in physical units.

5.2.2.1. Description of Resource Use Data

In Tayside, two datasets on hip fracture patients' resource consumption have been collected in the last decade. Of these two, one only collected data concerning resource consumption of female osteoporotic hip fracture patients while they were in hospital. The second dataset consists of more recent as well as more comprehensive data. This is the dataset which will be used as the basis of the model of the costs of hip fracture in Tayside.

These data were collected over a period of 28 months, (between October 1996 and including January 1999) by trained dedicated audit staff associated with the orthopaedic department of the Tayside University Hospitals NHS Trust. At the beginning of the study period this was located in the Dundee Royal Infirmary (DRI) and subsequently moved to Ninewells Hospital. As part of the Scottish Hip Fracture Audit, the orthopaedic ward had been collecting information on the care and outcomes of all hip fracture patients admitted there between the dates specified. The 449 cases analysed here are the 449 first consecutive cases collected since the start of the Audit. They comprise both men and women.

The Hip Fracture Audit Initiative

The Scottish Hip Fracture Audit in turn is part of a larger initiative which originated in Sweden, the Rikshoft Swedish Multi-Centre Hip Fracture Study. This means that the same basic data is collected at all participating institutions. The Scottish Hip Fracture Audit is funded by the NHS in Scotland Clinical Resource and Audit Group (CRAG) and local Area Clinical Audit Committees (ACACs).

The Scottish Audit started with the Royal Infirmary of Edinburgh and the Borders General Hospital in June 1993.

5.2.2.2. Aims and Process of Resource Use Data Collection

The aim of this audit initiative is to "document hip fracture care in Scotland by means of a standard core data set including case-mix, surgical procedures and complications, mobility, dependency, residential status and mortality" (Mountain and Currie,1997, p. 2).

Patients' hip fracture was ascertained from their medical records. They were then interviewed by dedicated and trained audit nurses 14 days after their hip fracture operation (or on the day of discharge if this was earlier). Four months and 12 months after the fracture patients were followed-up, mainly by telephone. The whole process was aided by an audit coordinator and a project leader. Part of their responsibility was to make sure that the same core data were collected by each participating hospital according to a set protocol. Table 5.1. summarises this process of data collection.

Table 5.1. Method and Timing of Resource Use Data Collection

	Time of Data Collection		
	Fracture of Hip	**14 Days Post-Fracture**[26]	**4 & 12 Months Post-Fracture**
Method of Data Collection	Medical records	Face-to-Face Interview	Mostly telephone interview, Some face-to-face interviews

The following sections describe in more detail those items of data that were collected which are relevant to the type of cost analysis which was envisaged given the decision on study perspective outlined in the previous section.

5.2.2.3. Items of Resource Use Collected

Acute stay

During patients' primary admission, information was collected as to the length of their stay as well as details concerning their care and fracture. *(Table 5.2.)* The type of data which was collected for the patients' stay in the orthopaedic ward was thus very detailed as to the surgical care received. Information was also collected concerning the direct or indirect complications arising from the treatment. The information collected is lacking in terms of other elements of acute care such as the level and intensity of nursing care required, physiotherapy and diagnostic tests.

[26] Patients were either followed up 14 days post-fracture or on the day of discharge if this was earlier.

Table 5.2. Acute Care Data Collected

Data Item	Measurement
Inpatient days during primary admission	Date of admission, operation & discharge
Delay to admission	Time in A&E in minutes until admission to orthopaedic ward
Delay to Operation	No. of days patient had to wait after admission to orthopaedic ward
Identification of Side of Fracture	Left or right side of body
Type of Fracture	Undisplaced/Displaced cervical Basocervical Trochanteric two-fragment Trochanteric multifragment Subtrochanteric
Type of Operation	Single screw 3 screws Telescoping screw & plate Intramedullary nail Hemiarthroplasty Total hip replacement No operation Other
Anaesthetic	Type of anaesthetic, duration of anaesthesia, grade of anaesthetist
Re-operations during Primary Admission	Yes/No
Dead in Hospital During Primary Admission	Date of Death
Wound infection	Yes/No
Pressure sores	Risk assessment score on admission, grade of sore if sore present on admission, grade of sore if sore present at 14 days/ discharge

Non-Acute Health and Social Care

Information was also collected which allowed the comparison between patients' dependency levels at the time of fracture, the time of discharge from the orthopaedic ward, four and twelve months after the fracture *(Table 5.3.)*.

Table 5.3. Non-Acute Care Data Collected

Data Item	Measurement
Live Alone	Yes/No
Type of Accommodation on Admission	• Own home • Convalescent home • Full-service unit with meals (or home for the elderly) • Geriatric department or rehabilitation clinic • Long-term care institution (or nursing home) • Acute hospital • Other/not admitted/other department/unknown
Type of Accommodation on Discharge	As above
Type of Accommodation during 4-month follow-up	As above, up to 5 different locations recorded between discharge and 4-month follow-up
Type of Accommodation 12 months after fracture	As above
Homehelp prior to fracture	Hours per week
Homehelp at 4-month follow-up	Hours per week
Subsequent Inpatient Days	Days in acute hospital between discharge from primary admission and four-month follow-up
Death	Date of Death

The data collected provides information not just on the type of accommodation after the fracture but also prior to fracture. The accommodation on admission can only provide a point estimate of the patients' resource use and dependency levels prior to fracture though. The information collected on the type of accommodation is much more detailed after the discharge from the orthopaedic ward. Here the data allows not only the analysis of where patients were discharged to after the acute stay in the orthopaedic ward. The data collected allowed for the recording of up to 5 different locations between discharge and 4-month follow-up. The collected data thus allows for the construction of a detailed model of patients' dependency levels and accommodation after the hip fracture, not just an isolated snapshot at one point in time. The information collected on the type of accommodation patients were residing in after twelve months does not allow for the examination of all the different locations up to this point as the four months follow-up data does. However, the twelve months follow-up data allows a snapshot of patients' accommodation at that point in time. This is the longest follow-up examined in published estimates of the costs associated with hip fracture in the UK to date.

Overall, the data allow the analysis of the development of patients' dependency levels as estimated by the type of accommodation they stayed in over a period of four months as well as twelve months after the fracture. In addition, the data allows the comparison of this post-fracture information with a point estimate of their dependency levels as approximated by their location and homehelp on admission.

5.2.2.4. Missing Data

Of the total of 449 patients, there is no missing data at all during their acute hospital admission. After discharge from hospital only 4 patients were lost to the four-months follow-up. This represents less than 1% of the entire dataset. Over twelve months, we know of all but 12 patients (2.7%) whether they were alive at the end of the study period. Equally, if they died we know their exact date of death for all but these patients. Of another 9.6% of the total 449 fractures there was incomplete or entirely missing data with respect to items such as location.

As a result, there was missing data with respect to estimating 12 months resource consumption on 12.3% of the original number of fractures only.

This existing set of data of the resource consumption of hip fracture patients in Tayside is thus an unusually complete set of data. This has important advantages for the analysis which can be conducted of this dataset. These strengths and also the weaknesses associated with this data are further discussed in the following section.

5.2.3. Strengths and Weaknesses of Resource Consumption Data

This section highlights how these characteristics of the data collected on patients' resource consumption translate into some of the strengths and weaknesses of the model of the costs associated with hip fracture in Tayside.

5.2.3.1. Weaknesses of Resource Consumption Data

There are weaknesses associated with these data on resource consumption both during the acute stay as well as during the follow-up.

Acute stay

The acute stay data collected misses out on aspects of inpatient care related to the level and intensity of nursing care. It also misses out on diagnostic tests and procedures as well as physiotherapy.[27]

Follow-up

One weakness of the follow-up data is the paucity of information regarding outpatients costs as well as costs associated with community care other than homehelp. Few of the published studies reviewed in chapter 4 included more

[27] It will become clear, however, from the next section on cost data that this will be compensated for to some extent.

elements of community care than homehelp into their studies. Similarly, few collected data on outpatient appointments. Those that did, indicate that these costs accounted for only between 1% of total costs in a 1-year cost model based on Swedish data (Zethraeus and Gerdtham, 1998) and 1.8% in a Belgian study (Autier, 2000).

Another weakness of these data is that the twelve months follow-up is in the form of a point estimate only. In contrast to the more detailed four-months follow-up, it is thus not possible to follow resource consumption patterns directly for the whole year after the fracture. Assumptions had to be made concerning patients resource consumption between the four-months and twelve-months follow-up period.

5.2.3.2. Strengths of Resource Consumption Data

The strengths of the resource consumption data are the following.

- The entire data was collected by trained and dedicated specialist audit staff from medical records as well as face-to-face and telephone interviews. This goes some way towards ensuring not only reliability but also consistency of the data.
- This trained staff collected detailed data on what appear to be the two main cost drivers of hip fractures from a health and social services perspective. These are the resources consumed during the primary inpatient stay as well as the change in residential status that seems to accompany many a hip fracture.
- These data are available in not only a good-sized sample size but also with near complete four-months follow-up. Missing or incomplete data of

only 12.3% of the original dataset for the period between four and twelve months post-fracture also allow the drawing of conclusions about the longer term effects of a hip fracture on resource consumption with confidence.

- The type and level of detail of data collected for pre-and post-fracture accommodation allows the adoption of a net costing framework. This involves the subtraction of pre-fracture costs from post-fracture costs. This methodology allows the estimation of those costs most likely to be directly attributed to the sustained hip fracture. The use of patients' pre-fracture resource consumption as their own control effectively is another strength of the model. The literature has shown that hip fracture patients belong to a particularly fragile group (Sernbo, 1988). Using a matched patient sample as controls would thus be likely to underestimate patients' resource consumption prior to the fracture. This could then result in an overestimation of the cost saving that could be achieved with any programme of hip fracture prevention.

5.3. Method of Cost Data Collection

The data described so far have all measured resource consumption in physical units. This needs to be combined with local unit cost data in order to construct an overall model of the costs of hip fracture in Tayside. The generic costing literature suggested the use of micro-costing as the most accurate method of attaching a monetary value to items of resource consumption (see section 4.3.6.). Much of the information on resource consumption (in physical units) which is needed for micro-costing is in fact available for the sample of 449 hip fracture patients in Tayside. However, the locally available costing information is too aggregated to allow for the adoption of a micro-costing approach. The only available local cost information appears to be the amount charged per inpatient day in different types of acute wards and the amount the different local councils pay for different types of accommodation and homehelp. In order to better understand how the resource consumption of the patients in this sample might be different to the one underlying these per diem cost estimates, attempts were made to establish the average amount of the component resources consumed (such as the average time of operation, the average length of stay, the average number of blood tests, physiotherapy visits, etc.) which underlies these aggregate cost estimates. It proved impossible to establish this (Tayside University Hospitals NHS Trust, Finance Department, 2000-2001). This also had an impact on the decision whether or not to attempt to collect individual patients' costs via micro-costing. This was discarded for several reasons. There were issues of timing, access, confidentiality and quality. The exercise would have been extremely time-consuming and difficult to conduct for one person, while it was doubtful whether the quality of the cost data would have been significantly more reliable. Despite the existence of detailed information with respect to the physical units of resource consumption, the assignment of costs in micro-costing still relies on information from the same centralised cost accounting system. As indicated earlier, this proved either incapable or reluctant to yield further information which would have been needed for micro- as well as for macro-costing. As a result, per diem cost estimates were used for both the acute care (specialty-specific per diems) as well as the non-acute health and social care of the model.

Given the state of cost analysis in evidence in the literature analysed in the previous chapter, the difficulties of obtaining detailed cost data are shared by many studies (see section 4.6.). This model shares the remedy to these issues which is also shared by most of the literature: The impact of different assumptions as to different unit costs on the overall result are subjected to a sensitivity analysis (see chapter 6, section 9).

However, this forced use of estimates based on a variant of gross-costing also has positive aspects in the case of acute care. The available orthopaedic per diem cost estimates were calculated to include not only those items of resource consumption which were collected by the Audit nurses. They also include average amounts of those items of care which were not collected for acute care, such as physiotherapy, nursing level and intensity and diagnostic tests and procedures. The reasons for this being that those costs are calculated top-down and thus include all costs incurred in a specialised unit during a specific time period (Tayside University Hospitals NHS Trust, 2000-2001). To a certain extent this might cancel out some of the weaknesses of the acute data referred to at the close of the last section.

The figures used to construct the Tayside hip fracture cost model are summarised in *Table 5.4.*

Table 5.4. Best Estimate Unit Costs

	Best Estimate (1999 £)
Acute Hospital Orthopaedic Ward (per day)[a]	305
Acute Hospital (per day)[b]	318
Homehelp (per hour)[c]	7
Convalescent Home (per day)[d]	51
Full-Service Institution (per day)[e]	31
Geriatric Rehabilitation (per day)[f]	153
Long-Term Care (per day)[g]	47

a: average cost per inpatient day. Source: David Hood, Trust Management Offices, Tayside University Hospitals NHS Trust, fax to author dated 4th July, 2000

b: average cost per inpatient day across all specialties in Ninewells Hospital, Dundee. Source: David Hood, Trust Management Offices, Tayside University Hospitals NHS Trust, fax to author dated 4th July, 2000

c: The used figure represents the straight arithmetic average per hour cost to the council of the three local councils involved in supplying homehelp to this particular dataset's patients: Perth and Kinross Council (£7.30, source: Bridget Barker, Social Work Department, telephone conversation with author on 25th July, 2000), Dundee City Council (£6.30, source: Mark O'Donnell, Community Care Services, e-mail dated 10th August, 2001), Angus Council (£6, source: Tim Armstrong, Social Work Department, letter to author dated 9th July, 2001)

d: not used in either Angus Council or Perth and Kinross Council, figure used thus based on Dundee City Council (£354 per week average cost to council. A variable proportion of this is borne by the client. However, this proportion is usually funded by other council funds. Hence, the total figure was used in the best estimate case of this cost study. Source: Mark O'Donnell, Community Care Services, Dundee City Council, telephone conversation with author on 15th August, 2001)

e: The figure used here is based on Perth and Kinross Council. The costs to the council across the three councils were £220, £231 and £271 per week. (Sources for all three councils as above.) Perth and Kinross Council's figure of £220 per week was used because the cost structure of the council incorporates a mixture of urban and rural conditions which the author considered to be the most typical of the study population and the geographical region of Tayside. In addition, this council has the most hip fracture patients in the region. (Tayside Health Board, 2001)

f: The figure used represents the straight arithmetic mean between the two main providers of geriatric rehabilitation services in the area: £134 per inpatient day in geriatric medicine ward in Ninewells Hospital, Dundee and £172 per day for rehabilitation services at Dundee's Royal Victoria Hospital. (source: David Hood, Trust Management Offices, Tayside University Hospitals NHS Trust, fax to author dated 4th July, 2000)

g: The figures given by the three councils involved were £330, £337 and £354 per week (sources: as above). Perth and Kinross' figure of £330 was chosen again for the reasons given already under 'e'.

Issues over the magnitude of these unit costs were addressed by making them a central feature of the sensitivity analysis. Separate unit cost estimates for the resulting upper and lower estimate are not given in table 5.4. due to the way these were constructed. This is described in more detail in the next chapter.

Strengths and Weaknesses of Cost Data

This section finishes with a discussion of the strong and weak points of the employed unit cost data.

Acute Care

The cost data which is routinely generated within the institutions of the health and social care system suffers from a number of serious weaknesses affecting its use in economic evaluations. These are due to the absence of bottom-up costing at an institutional level. The absence of this at an institutional level, however, also has implications on the relative 'cost-effectiveness' of collecting original cost information from the bottom-up. Even original cost data relies on aspects of the routinely generated data, for example with respect to overhead costs. In addition, it has not been possible to ascertain the average amount of resource items consumed which the generated top-down cost estimates are based on. This neuters some of the strengths of the resource consumption data for acute care described in the previous section. It does, however, also neuter some of the weaknesses of that data. The top-down cost estimates used include the costs of some resource items which were not collected, namely physiotherapy during the acute stay, nursing level and intensity, diagnostic tests and procedures.

Non-acute Health and Social Care Costs

The data generated within the health and social care system did, however, allow for the costing of the other major strength of the resource use data collected. Per diem cost estimates were available for all the different types of accommodation before and after the hip fracture. In addition, estimates of the average individual patient and council contribution to these charges were available.

Although the costs of acute care are thus not as accurate as the resource use data would have allowed, the unit cost data available allowed the other major strength of the data, comparison of pre- and post-fracture accommodation, to be expressed fully.

5.4. The 4-Month Model

The next sections describe how the resource consumption data were combined with these unit cost data to construct a model of the costs of hip fracture in Tayside from the perspective of the health and social services. This Tayside model was built up in various stages. In order to make the assumptions underlying the whole model transparent, the different stages of the model are described in separate sections. The first section describes how the pre- and 4-months post-fracture costs of the 449 cases were combined for what is for this purpose termed the '4-month model'.

5.4.1. Total Costs

The total costs associated with hip fracture in the four months following the fracture in the 449 cases were constructed as follows.

Total Costs = Inpatient Costs + Residence Costs

Total costs are the sum of the resources consumed by the 449 cases during their acute stay on the orthopaedic ward, any subsequent acute stays and the costs associated with their place of residence for the four months following the fracture.

Each of these cost components was adjusted for an estimate of baseline costs. This is an estimate of what resources would have been consumed by each individual patient in the same period of time had they not sustained a hip fracture.

The following paragraphs describe in more detail how each of these cost elements was constructed.

5.4.2. Inpatient Costs

Inpatient costs were estimated to be the difference between the actual resource use of the patient after sustaining the hip fracture and the resources they would have consumed during the time they stayed in hospital if in fact they had not been hospitalised. In other words, inpatient costs were estimated as the total costs of all inpatient episodes within four months of the fracture, minus four months' baseline costs. This is expressed simply in the following equation. This is followed by a more detailed description of how each cost component in this equation was estimated.

$$\text{Inpatient Costs} = \text{Total Cost of Primary and Subsequent Inpatient Stays} - \text{Baseline Costs}$$

Where: baseline costs = daily cost associated with place of residence prior to fracture multiplied by inpatient days on primary and subsequent admission.

Inpatient costs were calculated as the number of days spent as an inpatient during the primary admission as well as subsequent admissions to an acute hospital, multiplied by the closest available per diem cost estimate for the respective type of inpatient stay. From this figure was deducted the cost associated with any hypothetical resources the person would have consumed had he or she not in fact become a hip fracture patient. The estimate used for this model is the cost associated with the patient's place of residence prior to sustaining the hip fracture, multiplied by the number of inpatient days on primary and subsequent admissions.

To this estimate of the costs associated with a hip fracture during inpatient stays was added an estimate of the costs of residence during the four-month follow-up period.

5.4.3. Residence Costs

Residence costs were constructed along similar lines as just described for inpatient costs. Residence costs were estimated to be the difference between the costs associated with the patients' place of residence for four months following the fracture and the hypothetical costs associated with their residence had they not sustained the fracture.

Residence Costs	=	Total 4-Months Residence Costs	-	Baseline Costs

The first of these two component costs, the costs of residence for four months following the fracture, was estimated by the costs associated with each of the up to five different places of residence the patients stayed at in the four months following the fracture which were described earlier in this chapter. The daily costs associated with each of these locations were multiplied by the number of days the patients spent there to give an estimate of the actual resources consumed by the patients in the four months following their fracture.

From this were deducted the resources which it was hypothesized the patients would have consumed had they not sustained the fracture. This cost was assumed to be the same as the costs associated with the place of residence where the patients sustained the fracture.[28] This was multiplied by the number of days of total follow-up which was recorded for the individual patient outside their primary and subsequent inpatient stays. This yields an estimate of the difference in resources consumed by the individual patient pre-and post-fracture.

Drawbacks

This method of estimating the extra costs associated with the patients' place of residence has two drawbacks. It is assumed a) that the patient would have died on the same day that he or she died within the study period regardless of the fracture and b) it does not take into account that the patients may become older and frailer in the four months of follow-up.

Drawback a) means that the model effectively assumes that the costs of excess mortality as a result of hip fracture is zero. This, however, is shared by this study with all other studies reviewed in the last chapter. The reason for this has to do

[28] Patients who sustained the hip fracture in an acute hospital setting were assumed to have been resident at the places they were resident in four months after the fracture. This effectively assumes that the patients experienced no greater dependency levels post-fracture than they did pre-fracture. This assumption is probably not entirely realistic. It does, however, yield the best available estimate of the residence costs associated with hip fracture for this group of 33 patients. (7% of all 449 patients)

with the methodological difficulties of costing positive as well as negative health effects associated with increased longevity (Meltzer, 1997; Weinstein, 1990). Drawback b), that patients may have become older and frailer during the four months follow-up even without the hip fracture was addressed in the sensitivity analysis by raising baseline costs.

Combining these residence costs with inpatient costs yielded a model of the costs associated with hip fracture in 449 cases in the four months following the fracture. The following section discusses the assumptions made to extrapolate from this to the costs of hip fracture in 449 cases during the 12 months following the fracture.

5.5. The 1-Year Model

It has been suggested that no improvement was felt in activities of daily living or instrumental activities of daily living between six-month and 12-month post-fracture (Magaziner, 1990; Magaziner, 1989). It could thus be argued that it is possible that much of the directly attributable effects of hip fracture on patients' living arrangements and other areas of major resource consumption would have already taken placed by the end of the fourth month after the fracture. As existing UK cost assessments have tended to concentrate on the acute and rehabilitation phase, little UK information exists on the longer-term effects of hip fractures on resource consumption. The construction of a model of the costs incurred by hip fracture patients in Tayside up to one year post-fracture thus presents the opportunity to close a major gap in knowledge.

The sections below describe the methodological choices made in constructing this model.

Methodology

Based on the two point-estimates of patients' resource consumption four and twelve months post-fracture it is necessary to make assumptions about what happened to the patients in between. The assumptions underlying the twelve months model are the following:

1. Inpatient costs during primary admission are unaffected by the change of timeframe
2. Inpatient costs during subsequent admissions are also unaffected
3. If the location of the 291 cases that survived for twelve months after the fracture changed between four and twelve months, this is assumed to have taken place immediately after four-month follow-up information was collected. Patients were thus assumed to have consumed resources for eight months in accordance with their twelve months point estimate.[29]
4. Baseline costs stay the same.

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[29] Concerning the number of days follow-up between four months and twelve months post-fracture, the following individual decisions were made about modelling resource consumption. There were only four patients for whom it was not known one year after the fracture if they were dead or alive at all. All four of them were resident in their own homes, consuming no health and social services resources apart from small amounts of home help. Since no information as to the duration of their follow-up existed at all, the best assumption was therefore to assume they consumed zero resources during the 4-12 month follow-up period. For patients who died between four and twelve months post-fracture, the exact number of days of follow-up was calculated between each individual's admission and death dates. For patients whose whereabouts at 12-months were not known but it was certain they were alive, the modelling assumption was that they consumed resources for the following eight months on the same level as they did at four months follow-up.

It is obvious that these assumptions are simplifying the course of events which would be likely to happen to each individual patient. However, it is possible to make an informed guess whether the assumption is likely to over- or underestimate the real resource consumption in general terms.

Assumption 1

The first assumption about primary inpatient costs staying the same is entirely reasonable since the timeframe of the analysis does not change what happened during the primary inpatient admission.

Assumption 2

The second assumption that no further admissions will occur during the additional eight months follow-up period is more complex. On the one hand it is probably optimistic to assume that the mainly elderly to very elderly patients would not have any hospitalisations during these additional months. On the other hand, the assumption is not indefensible given the fact that the costs being estimated are those costs which can be directly attributed to hip fracture. The complexity of the biological interactions between co-morbidities makes it methodologically as well as practically difficult to decide which hospitalisations more than 4 months after the fracture should be attributed to the hip fracture. The best estimate of those costs which can be directly attributed to the hip fracture is therefore to assume that no further hospitalisations would occur in the remaining eight months follow-up which can be directly attributed to the sustained hip fracture.

Assumption 3

The third assumption about the projected resource consumption patterns of the surviving patients for an additional eight months is the best that can be made given the information that was collected. In 249 cases patient location did not change between the four-month and twelve-months follow-up. This represents 86% of the twelve months survivors. This assumption does therefore not touch at all on the way the twelve-months resource consumption of the vast majority of cases was estimated. In addition, although it is possible that some patients' may have changed accommodation and then changed back again to the same location as before due to the hip fracture during the last eight months of follow-up, given the age of the patient group this appears somewhat unlikely and likely to only affect a very small number of people. The information on which the model is based is thus the best available in the UK at present.

Assumption 4

The fourth assumption concerning the baseline costs is likely to be simplifying the real course of events. It is unlikely that baseline costs would have stayed the same for all patients over the period of twelve months. Given the average age of the patients, it is likely that they would have died or increased their resource consumption of health and social services even without the hip fracture. However, since there is no firm data to go on for the 'what if' scenario, baseline costs were kept level over the relatively short one-year study period for the best estimate scenario. The sensitivity analysis was conducted in such a way to yield an upper and a lower limit to the estimated hip fracture costs which should amply include any effect of rising baseline costs.

In summary, the assumptions used for extrapolating from the four-month study period to a 1-year period may not be an entirely dynamic and accurate description of patients' real resource consumption. However, they constitute the best publicly available data in the UK to date. In addition, assumptions were chosen to yield the best estimate of the costs which are directly attributable to hip fracture based on the gold standard of hip fracture cost assessment described in chapter 3.

5.6. The Tayside Model

The previous sections of this chapter illustrated the methodology of estimating the 4-months and 1-year costs directly attributed by this model to the 449 hip fractures which were treated in the orthopaedic department of the Tayside University Hospitals NHS Trust. This patient group represents approximately half of the total number of hip fracture patients occurring in the region covered by the health and social services planning bodies at whom the model is aimed. This section describes the assumptions made in this last stage of constructing the final model of the costs associated with hip fracture in Tayside in the year following the fracture.

Methodology

The data of the 449 cases covered by the model so far represents all those hip fractures which passed through the major orthopaedic department of the area over a period of 16 months[30]. This is the equivalent of 27.88 cases per month.

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[30] 446 cases which were covered in the 16 months. 3 cases occurred in the first few days of the 17^{th} month of data collection.

Hence the equivalent 12-month caseload would be 335 cases.[31] It was not possible to obtain the exact number of hip fracture cases which occurred in Tayside in the years 1996-98 when the data for the model was mainly collected. However, it was possible to obtain discharge rate information by principal diagnosis of neck of femur from Tayside Health Board for the years 1999-2001[32]. According to this, the average number of hip fracture cases in Tayside was 649 during a period of 12 months[33]. The 335 cases per 12 months which were analysed here, would thus represent 52% of all hip fractures which occur in Tayside. The model will thus be extended to cover the remaining 48% of hip fracture cases which has not been covered yet. To do this, it is assumed that the costs of the additional hip fractures which were not covered by the model would be similar to those analysed. Acute care costs in the area's two other orthopaedic wards appear to be higher than those of the hospital whose costs were used to construct the model. Both Perth Royal Infirmary and Stracathro Hospital are significantly smaller hospitals than Ninewells. Compared to the latter's 832 beds overall, Perth Royal Infirmary musters only 324 and Stracathro 127 beds across all specialties. What unites these three very different hospitals is the fact that all

[31] Data from the ongoing Dundee Hip Fracture Audit gives average yearly admission figures for hip fractures as 324. (Mountain, 2001) This figure was calculated from monthly averages between July 1997 to June 1999. The most recent figure for the average yearly admissions is 321. This was calculated in the same way between January 1999 and December 2000. Using these figures would result in the orthopaedic ward in question treating between 49% to 50% of hip fractures in Tayside. However, this bears no impact on the estimate of the Tayside model because the estimate was arrived at by multiplying Tayside Health Board's figure of 649 average yearly admissions with the average per person cost of the previous 4-month and 12-month models.

[32] Hip fractures tend to cause such severe discomfort that it can be safely assumed that all of them will be treated in an acute hospital. Hence it is reasonable to assume that the discharge information will cover virtually 100% of all occurring hip fractures.

[33] Hip fracture rates appear to have stabilised in the last few years. (Tayside Health Board, 2001) Hence it is reasonable to assume that this estimate of the average number of hip fractures per year over the last three years is roughly accurate of the number of hip fractures which would have occurred in Tayside in the period of data collection.

of them incurred orthopaedic specialty costs significantly above the Scottish average of 1999/2000. This held true also over the years (see isd Scottish Health Service Costs, various years). Compared to Ninewells' 29%, Perth Royal Infirmary and Stracathro incurred 33% and 40% higher average total costs per orthopaedic specialty case compared to the Scottish specialty average (isd Scottish Health Service Costs, 1999/2000). To the author's regret, it proved impossible to ascertain with either the isd or the finance departments of the hospitals in question why this should be the case. Although the author speculated at length about this, be it different fixed or variable costs, such as different case severities, different lengths of stay or treatment patterns, it proved impossible to obtain sufficient information as to the actual or average resource consumption underlying the other two hospitals' cost per case estimates. It was thus even less possible to differentiate the number of hip fractures compared to other orthopaedic conditions incorporated in these figures. At least in this case, some of the numbers underlying the model could be made more transparent. Although probably not accurate, not enough information was available even after considerable efforts were expended to either make the assumptions underlying the Tayside model more accurate or to quantify in some way the resulting inaccuracy. The decision was thus made to extrapolate to all of Tayside on the basis of the resource consumption and treatment patterns encountered in the cases treated in Dundee's orthopaedic wards. At least that way, some of the numeric assumptions underlying the model and cost estimate could be made more transparent. As most of the costs used for the residence cost component of the model come from the council of the region with the highest number of hip fracture patients in this region or were calculated as the average costs across all three councils of the Tayside region, the best estimate appeared to be to assume that the residence cost component of the rest of Tayside's hip fractures would be similar to those already costed. Regarding the question of how satisfactory the assumption is of all costs being identical across Tayside, using Ninewells' costs which are the lowest of all possible hospitals yields in a fashion a minimum threshold for the costs of hip fracture. Given the difficulties encountered in attempting to disentangle the different cost elements included in the official cost information for all these hospitals, and given the uncertainty involved in calculating as well as the way they seem to be calculated, the unit cost estimates are probably not the most accurate approximation of economic opportunity costs. However, since policy makers require advice at specific points in time, this is the best estimate available at this point in time. Given the information provided in this chapter, chapter 6 and 8, however, it should be possible to replicate the cost model and analysis for different costs, too.

5.7. Discounting

The rationale for adjusting streams of payment occurring in different years by a discount rate is to allow for the incorporation of people's preference of payment today over payment tomorrow. The costs which occurred in this study were effectively spread out over a period of little more than one year in each individual patient's case. As a result, the discounting of costs appears to add little to this cost model. This was also the way all published original cost studies with a similar timeframe dealt with this issue.

5.8. Sensitivity Analysis

It has been seen in the preceding parts of this chapter that although the dataset on which the Tayside hip fracture cost estimates are based has definite strengths, there are also weaknesses inherent in its construction. It is therefore of importance to investigate to what extent the overall result is sensitive to changes in the modelling inputs and processes. Ideally, one would wish to attempt to place some form of a boundary on the uncertainty inherent in it. To this end, this last section of the chapter introduces some of the issues relating to the sensitivity analysis of the 1-year model of hip fracture costs in Tayside. The section describes the principles of the methodology followed in order to construct an upper and a lower limit for the 1-year costs of hip fracture in Tayside. The methodology is addressed in more detail at the end of the next chapter, together with the results of the sensitivity analysis (see chapter 6, section 9).
The main points of uncertainty in the models which have been constructed here are the following:

- the assumptions underlying the baseline costs.
- the assumptions underlying the extrapolation from 4- to 12-months.
- the unit cost estimates used.

However, there are no particular conclusions that can be reached by this sensitivity analysis since there is no specific outcome to this cost analysis, such as an estimate of cost-effectiveness which might vary depending on the particular values of the parameters of the analysis. As a result, the sensitivity analysis' main objective is to supply a reasoned upper and lower estimate of the costs of hip fracture in Tayside within which the true underlying costs are likely to fall by combining different estimates of uncertain variables. These variables are discussed in more detail when the results of the analysis are presented in the next chapter.

The uncertainty concerning the unit cost estimates is addressed by constructing upper and lower estimates for the model with a combination of different unit costs and different assumptions about baseline costs. These upper and lower estimates are estimated for the 4-month model, the 12-month model and the Tayside model using the reasoned existing assumptions. These assumptions are based on the best information available to the author at this point in time. No information is available to the author at this point in time which would allow the attachment of better reasoned probabilities of the various estimates representing the true value of the variables in question.

5.9. Summary

This chapter has outlined the methodology with which the data concerning resource consumption was collected. It has also outlined the characteristics of the cost data which were used. The chapter then summarised the main methodological choices which were made in constructing the model of hip fracture costs in Tayside from the perspective of the health and social care commissioning bodies. The result is a model which has many strengths but also some weak points.

There are weaknesses inherent in the resource consumption and cost data as well as weaknesses in the assumptions which had to be made to construct the 1-year Tayside model from these data. The main drawback of the model components is the paucity of cost information available to cost the acute stay. Much of the detail in patients' resource consumption data was thus lost to the complete analysis. Another weak point of the model components is the lack of data concerning outpatients and community care costs other than homehelp. The main drawback of the 1-year Tayside model is that eight months follow-up is based on a point estimate of resource consumption at twelve months post-fracture. In addition, resource consumption data covering about 50% of cases was used as a basis for estimating the other 50%'s resource consumption.

The model attempted, however, to minimise the weaknesses of other studies identified in the previous chapter. In this partial success was achieved. The area of most concern is not to be found in the resource consumption data which were utilised but in the data used to attach a monetary value to these. The model also attempted to capitalize on the positive and negative points of other studies. It is built on a very solid foundation. Data on resource consumption in not only acute health care but also in non-acute health and social care was collected by trained staff. This resulted in a good-sized and exceptionally solid dataset with few missing data. This covers what have been shown by the literature to be the two main cost drivers of hip fracture costs, acute care and the costs associated with accommodation during follow-up. The data allowed the adoption of the most accurate costing methodology by comparing patients' own pre- and post-fracture resource consumption. In addition, it is the only UK-based estimate of the resource consumption associated with hip fracture in the full year following the fracture. The results from the 4-month, 1-year and the Tayside model of the costs of hip fracture as well as the results of the sensitivity analysis are reported in the next chapter.

6. The Costs Associated with Hip Fracture in Tayside

6.1. Introduction

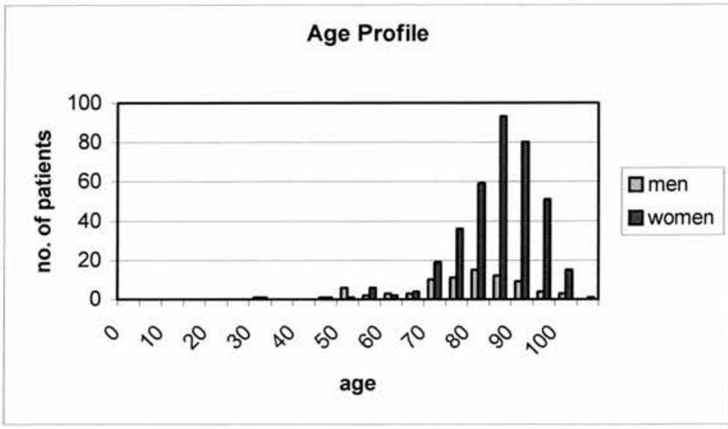
This chapter reports the results of the model of the costs associated with hip fracture in the Tayside region which was constructed as outlined in the last chapter. These results are designed to inform decision-making by providing the most comprehensive local estimate of the resource use associated with the condition in the region.

The chapter is set out as follows. Detailed information is given in the following section concerning the epidemiological characteristics of the patient sample the model is based on. Special attention is paid to the length of inpatient stay which is reported in section 6.4.. The results of the model and its component parts are given for the total dataset as well as for different sub-groups of the sample in section 6.5. and 6.6.. Sections 6.7. and 6.8. present the results of the model of the costs associated with hip fracture in the twelve months following the fracture and the Tayside region overall. The 9th and last section of this chapter finally reports the results of the sensitivity analysis. The next chapter is then devoted to the comparison of the model inputs, processes and results with the published literature.

6.2. Age, Sex and Mortality of the Study Sample

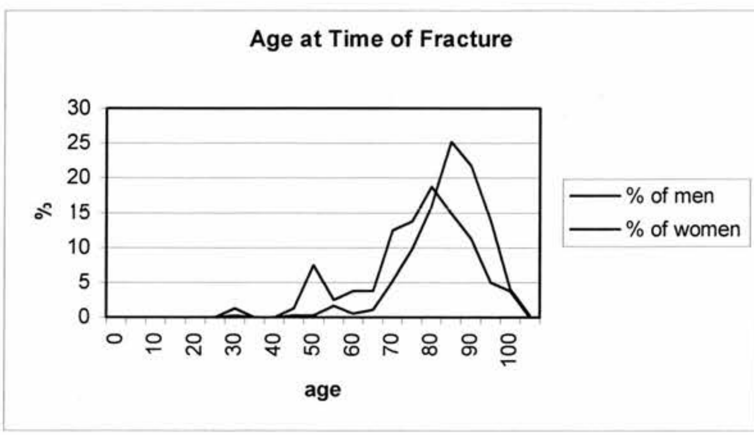
Women constituted the vast majority of hip fracture patients in this sample. 82% of the sample hip fracture patients were female. 18% were male. This represents a male to female fracture ratio of 1: 4.6. The mean age at which patients (whole sample) fractured their hip was 81 years, the median age 83 years. Half of the patient group are between the ages of 76 and 88 at the time of fracture *(Fig. 6.1.)*

Figure 6.1. Age Profile



The average age of fracture differed between men and women. *(Fig. 6.2.)* Women's hip fractures peaked at a considerably older age. On average men were 74 years of age when they fractured their hip. Women were on average 82 years old. The majority of female hip fractures also occurred within a narrower age range than their male equivalents.

Figure 6.2. Age at Time of Fracture



Mortality

7% of patients died during their primary inpatient stay, immediately following their hip fracture. These included comparatively more men than women, despite women's more advanced age.[34] None of the patients below the age of 70 died during their acute hospital stay. In fact, with an average age of 85, patients who died during their primary inpatient stay were considerably older than those who survived for four months (average age 80).

85% of 4-month survivors were female, 15% were male. Compared to the age distribution of the entire dataset as well as those that died during the primary hospital admission, more women than men survived, even though they were older on average.

In addition to the 7% who died during their acute primary admission, 15% of all patients died between their discharge from hospital and the four-month follow-up. Four-months mortality is thus 22%. Another 11% died between the four and the twelve months follow-up period. Overall one-year mortality was thus 33%.[35] *(Table 6.1.)*

Table 6.1. Overall Mortality

	Mortality
Acute	7%
4-months	22%
12-months	33%

[34] 27% of these were male, 73% female. As the distribution of men and women across the entire dataset was 82% women and 18% men, this means that comparatively more men than women died during their primary admission. Given the older age of women at the time of fracture, one would expect relatively more of them to die during their inpatient stay.

[35] Since the amount of missing data with respect to mortality was an almost negligible 1.7% of fractures, this one-year mortality can be relied upon with some confidence to represent the true extent of mortality.

The age and sex distribution of the dataset is presented here in order to facilitate comparison of the model results with the literature. As shown in chapter 4, many studies explore only the resource consumption pattern of particular groups of patients, such as patients who fractured their hip at home and returned there after their acute and rehabilitation stay. As indicated in the introduction to this section, the distribution of age and sex across any dataset is important because it has been linked to resource consumption. Any comparison of the Tayside model results would thus be meaningless if it was not detailed which types of patients the model is based on.

The next section explores the characteristics of the sample with respect to the location at which patients fractured their hip, where they went on discharge from their primary admission to the orthopaedic ward as well as what type of accommodation they were living in four and twelve months after the fracture.

6.3. Patient Location from Admission to Discharge to Follow-up

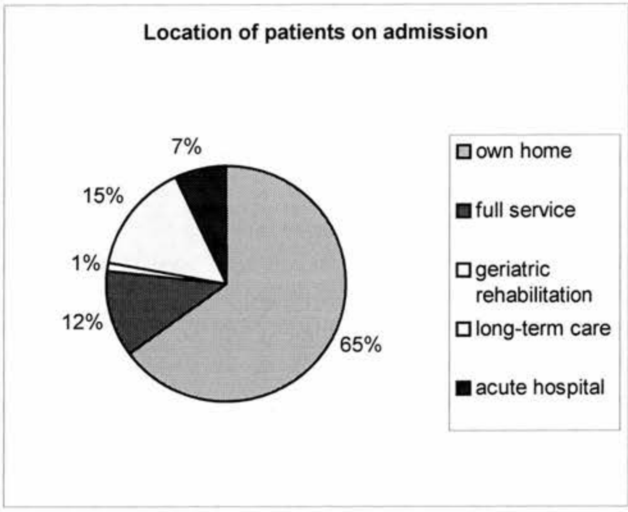
6.3.1. Location on Admission

The place where patients sustained their fracture is important for a number of reasons. In most cases, one would expect this to reflect the patient's normal residence. With the exception of those patients who fractured their hips while in an acute hospital or a geriatric rehabilitation ward, the location where the hip fracture was sustained allows us to draw certain conclusions with respect to the levels of independence a person enjoyed before their hip fracture. It is clear that this cannot replace a detailed assessment of the person's health-related quality of life or any objective assessment of their functional health. For example, the fact that a person lived at home and required no homehelp from the local council does not itself warrant the conclusion that they were functionally perfectly independent. They may well have had substantial help from family members or friends. In contrast though, if a person sustained a hip fracture in a home for the elderly or a nursing home, it may well indicate that the person was not capable of independent living even before the hip fracture. In the absence of other, more formal measures of a future hip fracture patient's functional status, the location where the patient sustained the hip fracture may allow the drawing of certain conclusions as to the effects on resource consumption of a hip fracture. This comparison of possible scenarios before and after the hip fracture allows a more accurate assessment of the true impact of a hip fracture on resource consumption. In addition, it allows a more accurate comparison of the results from this model with other studies' results.

Almost 2/3 of the patients in the sample lived at home at the time of their hip fracture. The remainder are almost evenly split between residents in full-service institutions, such as homes for the elderly (12%) and institutions of long-term care.[36] *(Fig. 6.3.)*

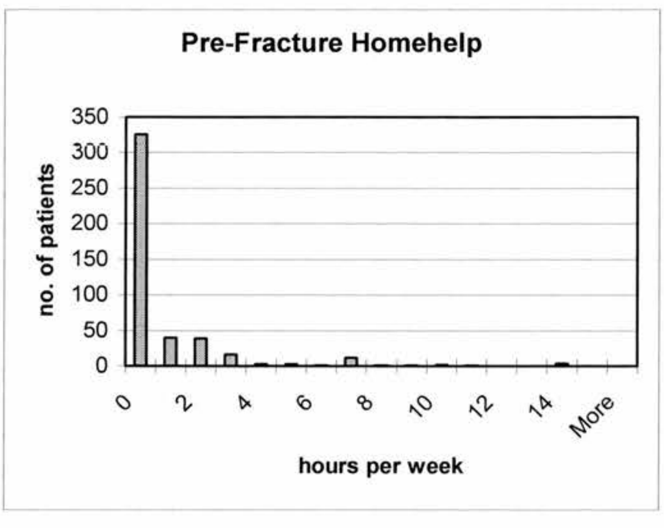
[36] The difference between so-called 'full-service' and long-term care institutions is that only the latter offer full nursing care to patients who have difficulty with all or most aspects of basic hygiene, feeding, etc.

Figure 6.3. Location on Admission



An additional patient characteristic which allows us to draw some limited conclusions as to patients' state of health prior to fracture is the amount of homehelp received by patients living at home. Almost three quarters (73%) of those patients who fractured their hip at home had not used any homehelp service. Of those that did use this service, relatively few hours of support were provided, averaging 3 hours per week. *(Fig. 6.4.)*

Figure 6.4. Pre-Fracture Homehelp



In summary, the dataset on which the model of hip fracture costs is based in Tayside is mixed as to patients' accommodation at the time of fracture. Almost 2/3rd of all patients were living at home. Of these, the majority appear to have been relatively independent as far as the local authorities are concerned, receiving no formal homehelp.

6.3.2. Location on Discharge

The aim of this section is to compare the type of accommodation from which patients were admitted with the type of accommodation patients were discharged to after their acute hospital stay in the orthopaedic ward.

Table 6.2. Admission vs. Discharge Location [37]

Admitted from	Discharged to				
	Home	**Full Service Institution**	**Long-Term Care + Geriatric Rehabilitation**[38]	**Acute Hospital**	**Died**
Own Home 64%	55%	none	40%	2%	6%
Full Service Institution 12%	none	50%	30%	7%	13%
Long-Term Care + Geriatric Rehabilitation 16%	1%	none	88%	none	10%
Acute Hospital 7%	12%	none	33%	50%	6%
Total % of whole dataset	36%	6%	44%	7%	7%

37 The percentage figure given in each box signifies what percentage of patients who came from the type of accommodation specified in the relevant row were discharged to the type of accommodation specified in the relevant column. The last row of the table summarises the discharge destination as a percentage of the entire dataset.

38 This category includes also those 2% of all patients who were discharged to a convalescent home.

Only 36% of patients were discharged immediately to their homes. The majority of patients, 44%, were discharged to institutions of long-term care or geriatric rehabilitation. Virtually all patients who had come from long-term care or similar institutions and did not die during their acute stay returned to long-term care. However, only approximately half of all patients who came from their own homes or homes for the elderly were able to return there immediately on discharge from the orthopaedic ward. Over half of all patients (57%) required institutionalised care in some form on discharge from the orthopaedic ward. Since 35% of patients were already in an institutional environment when they sustained a hip fracture and 7% died, this means that in the aftermath of a hip fracture an additional 15% of patients required institutionalised care beyond the time they spent in the orthopaedic ward.

The next section examines in which way patients' accommodation needs developed between admission, discharge and the four-months follow-up.

6.3.3. Location 4-Months Post-Fracture

Four months after their fracture, 50% of all patients were back in their own homes. 22% of patients had died. 21% were to be found in long-term care institutions or geriatric rehabilitation units. *(Table 6.3.)*

Table 6.3. Admission vs. 4-Month Location

Admitted from	4-Month Location				
	Home	Full Service Institution	Long-Term Care + Geriatric Rehabilitation	Acute hospital	Died
Own Home 64%	71%	2%	9%	2%	15%
Full Service Institution 12%	6%	30%	26%	4%	35%
Long-Term Care + Geriatric Rehabilitation 16%	5%	3%	61%	none	31%
Acute Hospital 7%	21%	6%	27%	3%	42%
Total % of whole dataset	50%	5%	21%	1%	22%

27% of patients who were discharged to geriatric rehabilitation or institutions of long-term care were no longer to be found there after four months. Although for some patients this meant a move to their own homes or less care-intensive full service institutions, most of the difference is due to increased mortality. The most pronounced increase in mortality occurred among those patients who had been admitted from and discharged to another acute hospital ward. As a result, the percentage of patients who were still receiving acute hospital care had shrunk to a negligible figure four months after the fracture.

In terms of resource consumption, the most significant development between the follow-up on discharge and after four months is increased mortality. In addition, another 16% of formerly relatively independent patients managed to return to their own homes between discharge and four months follow-up. This brings the total proportion of patients who came from their own home and had returned there four months post-fracture to over 70%, a substantial increase compared to the discharge location.

A comparison of the levels of homehelp as an indicator of the degree of independence of patients living at home showed that only 5% of those who had previously not received any had started receiving an average of 3 hours per week (median 2 hours) within four months of their fracture. Homehelp levels among those who had already received it before their fracture did not increase substantially in the aftermath of a hip fracture (2.7 hours per week pre-fracture vs. 2.9 hours four months post-fracture).

6.3.4. Location 12-Months Post-Fracture

Overall, the single biggest change in patients' living circumstances between four and twelve months post-fracture was increased mortality. *(Table 6.4.)* The number of patients who were living in their own homes decreased from 50% to 43% between four and twelve months after the fracture. Both the percentage of patients staying in full service and long-term care institutions increased only slightly during that time period.

Table 6.4. Admission vs. 12-Month Location

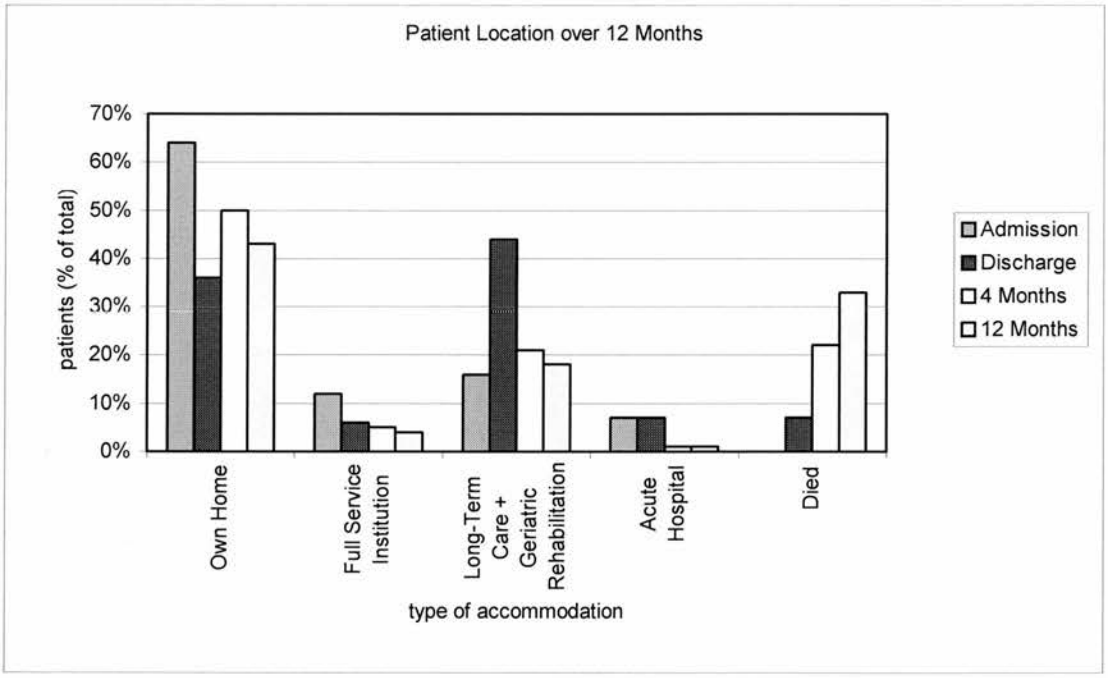
Admitted From	**12-Month Location**				
	Own Home	**Full Service Institution**	**Long-Term Care + Geriatric Rehabilitation**	**Acute Hospital**	**Died**
Own Home 64%	56%	3%	13%	1%	25%
Full Service Institution 12%	13%	7%	24%	2%	54%
Long-Term Care + Geriatric Rehabilitation 16%	24%	1%	36%		39%
Acute Hospital 7%	27%		9%		61%
Total % of whole Dataset	43%	4%	18%	1%	33%

Apart from mortality, only a minority of patients thus experienced a change in the type of accommodation between the four and the twelve months follow-up. This would seem to suggest that the main impact of a hip fracture on residential status is felt within four months of the fracture already.

6.3.5. Section Summary

Patient location has been examined over the twelve months following on from the hip fracture due to its influence on resource utilisation. It has been seen that significant changes take place in patients' living arrangements over this period. These changes are summarised in Figure 6.5.

Figure 6.5. Patient Location over 12 Months



Overall, the most drastic and widespread change in living arrangements was observed when comparing patients' discharge location with their pre-fracture circumstances. If patients are examined by group, the following emerges. Of those patients who had fractured their hip at home which encompassed the majority of patients in this sample, just over half returned there immediately on discharge from the orthopaedic ward. The numbers bounced back though. Three quarters of patients were back in their own homes again four months after the fracture. The proportion of patients residing in their own homes then fell again between four and twelve months post-fracture, mostly due to increased mortality. The number of patients living in an old people's home or similar type of full service institution fell steadily over the entire study period. A particularly pronounced fall in patient numbers in this type of accommodation was observed between admission and discharge. Contrary to the observations in the previous group though, they never bounced back. The second biggest group of patients in this sample sustained their fracture when resident in institutions of long-term care and geriatric rehabilitation. Their numbers increased substantially on discharge but fell back to a slightly higher level than pre-fracture after four months. After twelve months, these numbers had fallen again to a level only marginally higher than before the fracture. A small but resource-intensive group of patients were admitted to the orthopaedic ward from another acute hospital ward. The size of this group stayed level on discharge but was approaching zero after four months and stayed there also after twelve months. The single biggest change which was observed in the entire sample over the twelve months following the fracture was increased mortality. Although a sizeable number of patients died already during their acute stay in the orthopaedic ward, the steepest increase in mortality was observed between discharge and four month follow-up. There was another steep increase between four and twelve months. To what extent this second increase may be directly attributed to the hip fracture, however, is open to debate.

Before the chapter progresses to the monetary results of the cost model, it is necessary to describe the dataset with respect to one variable which appears to be crucial when comparing different studies cost estimates, inpatient length of stay.

6.4. Length of Inpatient Stay

The length of inpatient stay was calculated in the following way: It comprises the sum of

- the number of days spent as an inpatient on primary admission to the orthopaedic ward,
- the number of days spent in a rehabilitation or geriatric ward and
- the number of days spent as an inpatient on any subsequent admission to an acute hospital within the four months follow-up period.

6.4.1. Primary Admission

Most typically, patients stayed in the orthopaedic ward for 13 days (median). However, the distribution's pronounced positive skew (3.47) led to the average length of stay being longer at just over 16 days. Half of the patient group stayed in hospital for between 7 and 19 days immediately after their fracture.

6.4.2. Rehabilitation

The great majority of patients, 73%, did not stay in rehabilitation or in a geriatric ward at all. Those that did, stayed for 48 days on average.

6.4.3 Subsequent Admissions

Only 11% of all patients had any additional stay in an acute hospital ward of any type during the four-month follow-up period. Their average length of stay was 31 days. This hides considerable variation: 50% of patients had stays of between 7 and 41 days. Even though only a quarter of patients were admitted to an acute hospital again within four months of their hip fracture, they had stays of over 41 days. The resource implications of this are likely to be substantial. The design of the study did, however, not allow the direct distinction between hip-fracture related complications of any kind and hospitalisation for any unrelated reasons after the primary admission period. It can thus not be said with certainty that these hospitalisations only occurred because of the patients' hip fracture. Including these costs in the estimate of hip fracture costs may thus overestimate the costs directly attributable to the fracture. This is addressed in the sensitivity analysis.

6.4.4. Total Inpatient Days

Over the four-months follow-up period, the 449 patients of the sample accounted for an overall total of 14,736 inpatient days. The primary admission to the orthopaedic ward accounts for just under half of all inpatient days (49%). Another major proportion (40%) of inpatient stay was accounted for by rehabilitation and geriatric ward stays.

If these figures are distributed across the entire dataset, this translates to a typical inpatient stay of 18 days across all three categories (median). This, however, ignores the proportion of patients with a substantially longer length of stay. Half of all patients experienced inpatient stays in orthopaedic, acute, rehabilitation or geriatric wards of between 9 and 45 days. The mean inpatient stay across all three categories was thus 31 days.

6.4.5. Section Summary

Hip fractures in Tayside lead to a significant consumption of inpatient resources. It is not possible to ascertain which inpatient days would have occurred even without the hip fracture. However, the number of inpatient days on primary admission can be almost directly associated with the hip fracture. They would have been extremely unlikely to occur without the person fracturing his or her hip. The same is probably true also for the geriatric and rehabilitation ward stay. The case is less certain as regards the subsequent admissions. Although these only accounted for a small number of patients and 11% of total inpatient days, they involve a substantial amount of resources. The uncertainty regarding the direct attribution of the resource consumption associated with any subsequent hospital stay will be accounted for in the sensitivity analysis of the results later in this chapter.

The following sections combine the resource consumption patterns which have been described in this and the previous section with local unit costs to yield estimates of the costs associated with hip fracture in Tayside to the health and social services.

6.5. Results of the 4-Months Cost Model

This section describes the results of the model of the four-months costs which were directly attributable to hip fracture in Tayside on the basis of the resource consumption patterns of those 449 patients described above. The model results from combining the data of all the individuals' resource consumption post-fracture with local unit costs. From this are deducted the baseline costs that were constructed on the basis of the patients' pre-fracture resource consumption. This yields an estimate of those costs that should be directly attributable to the individuals' hip fractures.

6.5.1. Total Costs

In total, the costs directly associated with hip fracture in this patient group of 449 in Tayside in the four months following the fracture is estimated to be just over £3,400,000. Almost half of all patients incurred extra costs in the four months following their hip fracture of between zero and £5,000[39]. About one third of all patients incurred costs in excess of this, between £ 5,000 and £15,000.
The mean extra cost directly attributable to a hip fracture in the four months following the fracture is thus £7,614 (median £5,123). The mean costs of the population are to be found between £6,849 and £8,380 with 95% certainty.
A very small number of patients incurred negative costs. This is a function of the way the baseline costs were calculated. Their costs are negative because the cost associated with their accommodation prior to the fracture was greater than the equivalent cost post-fracture. This small left tail of the distribution includes people who were for example resident in a home for the elderly before the fracture but managed to return to the community with the help of their family or social services by the end of the study period four months after their fracture.

[39] In this and the following sections detailing the results of the various cost models, the expression 'between amount x and amount y' refers to 'greater than the amount x and smaller than or equal to amount y'. In other words, the frequency referred to excludes the lower limit but includes the upper limit.

Total costs are composed of the following components: 62% of the costs directly attributable to hip fracture are accounted for by the primary inpatient stay. The remainder are made up of costs associated with a change in residential status (24%) and any subsequent inpatient stay (14%) that may have occurred. These cost components are described in more detail in the remainder of this section.

6.5.2. Inpatient Costs

Inpatient costs were divided into those incurred during primary and subsequent admission.

Primary Admission

Costs associated with the primary admission in this group of hip fracture patients total just over £2,100,000. This results in a mean cost of £4,746 per patient (median £3,938). At the 95% confidence level, it can thus be said that the mean costs in the underlying population will lie between £4,324 and £5,168. Half of all patients incurred costs between £1,966 and £5,760. Some 5% of patients incurred costs higher than £10,000. Due to the way these costs were calculated, they mirror the patients' length of stay. Hence the reason for the very high inpatient costs of these 5% are to be found in the amount of time they stayed at the orthopaedic ward.

Across the 449 cases, there were only 7 cases which had to be re-operated on during their primary inpatient stay. The net inpatient costs of those cases were on average £10,031 and thus around double that of the total average inpatient costs during that period.

Gross Costing

In many studies of the costs associated with hip fracture or the inpatient costs associated with hip fracture specifically it is not taken into account that the majority of hip fracture patients are elderly and hence not cost-neutral before their fracture. This means that in most studies the costs which are incurred in hospital post-fracture are taken as an adequate measure of the costs associated with hip fracture. This ignores that many of these patients would have consumed health care or social services resources even if they had not sustained a hip fracture. The above estimate attempts to take this into account. However, since many estimates from the literature are not constructed along the same lines by deducting pre-fracture costs, it is useful to highlight the estimate which would have resulted from only summing up post-fracture resource consumption without deducting pre-fracture resource consumption. With this gross costing methodology, the total inpatient costs associated with the primary admission would have amounted to just over £2,200,000. The average cost per patient would thus have been £4,951 (median £3,965). Compared to the cost estimates of primary inpatient costs which resulted from net costing, gross costing overestimated those costs which can be directly attributed to the hip fracture by 4%. *(Table 6.5.)* The amount of overestimation may be lower for studies which included patients who were more independent than those included in this sample. The overestimation may be higher if more dependent patients are used as the basis of a cost model.

Table 6.5. Gross vs. Net Inpatient Costs on Primary Admission

	Total Primary Inpatient Costs	Primary Inpatient Costs (per person)[40]
Gross Costing[41]	£2,222,840	£4,951
Net Costing[42]	£2,130,847	£4,746
Difference[43]	4%	

Subsequent Hospital Admissions

In total, the cost associated with hospital admissions for any reason after the primary admission came to just over £470,000 in the four months study period. 89% of all patients did not have any subsequent inpatient costs at all during the four months following the hip fracture. Accordingly the median of the distribution was zero. However, the length of hospitalisations among the small minority that had them accounted for some considerable costs. Averaged out across the entire patient sample, the mean extra costs due to subsequent hospitalisations accounted for £1,057 per person.

It is difficult to directly assign a proportion of these costs of patients' subsequent hospitalisations to the sustained hip fracture. The sensitivity analysis will be used to attempt to shed some light onto the question how the inclusion or exclusion of these costs might influence the overall costs of hip fracture.

[40] This is calculated as total primary inpatient costs divided by the total number of patients in the entire dataset.
[41] This was calculated as the sum of each of the 449 patients' number of inpatient days on primary admission, multiplied by the cost per primary inpatient day.
[42] This was calculated as the sum of each of the 449 patients' number of inpatient days on primary admission, multiplied by the cost per primary inpatient day. From this were deducted each patient's specific baseline costs which consisted of the number of primary inpatient days multiplied by the per diem cost of that specific patient's location on admission. This was described in more detail in chapter 5, section 4.
[43] The difference between net and gross costs, expressed as a percentage of net costs.

6.5.3. Residence Costs

To arrive at the total hip fracture costs, residence costs were added to the primary and subsequent inpatient costs which were incurred by the patients in the four months following the fracture. 'Residence costs' again refer to the difference between pre- and post-fracture levels of resource consumption. Calculating this difference, residence costs amounted to a total of just over £800,000 for all 449 patients. This translates into a mean cost of 1,812 per person for the four months following the hip fracture in this sample. With 95% certainty, the mean costs per patient of the underlying population would thus be found between £1,446 and £2,178. The median cost of 0 indicates that the mean cost hides considerable differences in residential costs across the sample.

54% of all patients experienced zero extra residence costs in the study period. In other words, the resource consumption of more than half of all patients was the same after the hip fracture as before. However, one fifth of patients experienced higher residence costs in the study period post-fracture than before. These costs ranged between just over zero and up to £20,000. Hence, the median of zero extra residence costs post-fracture hides this smaller group of patients some of which incurred substantial residence costs.

Gross Costing

As in the previous section of primary inpatient costs, the residence costs were also calculated using a gross costing methodology. If pre-fracture residence costs are not deducted from post-fracture costs, total residence costs for the entire patient sample amount to approximately £1,300,000 for the four months following the fracture. Per patient, the mean residence costs would have been £3,028 (median £555). If pre-fracture residence costs were not deducted from post-fracture residence costs, the resulting cost estimate would thus overestimate the directly attributable costs by 67%. *(Table 6.6.)*

Table 6.6. Gross vs. Net Residence Costs

	Total 4-Month Residence Costs	4-Month Residence Costs (per person)[44]
Net Costing[45]	£813,568	£1,812
Gross Costing[46]	£1,359,414	£3,028
Difference[47]	67%	

6.5.4. Section Summary

Table 6.7. below summarises again the net costs associated with hip fracture in the four months following the fracture for ease of comparison with later sections and chapters. The quoted figures refer to the mean costs, as only these, not the median, are able to give a picture including the whole distribution of the entire patient sample.

Table 6.7. Summary of 4-Month Costs

	Primary Inpatient Cost	Subsequent Inpatient Cost[48]	Residence Cost	Total Cost[49]

[44] This is calculated as total 4-Month Residence Costs divided by the total number of patients in the dataset.
[45] This is calculated as the sum of the number of days follow-up for each person for each type of accommodation they stayed in within this time period, multiplied by the per diem unit cost for each type of accommodation. From this are deducted the estimate of baseline costs which consists of the sum of the number of days follow-up available for each person, multiplied by the per diem of their admission location. (see also chapter 5, section 5.4.)
[46] This is the sum of the number of days follow-up available for each person in each type of accommodation they stayed in during the four months following their fracture, multiplied by the per diem unit cost for each type of accommodation.
[47] Net costs, expressed as a percentage of gross costs.

4-Month Costs, per person[50]	£4,746	£1,057	£1,812	£7,614

6.6. Results of the 4-Months Cost Model for Subgroups

This section relates the results of the four-months cost model for two subgroups of patients. The results of these subgroups are considered separately because they are expected to differ from those of the whole patient sample. They are presented here in order to facilitate comparison with the literature in the next chapter. It was shown in chapter 4 that much of the published literature of the costs associated with hip fracture is based on models with different patient groups. Some models are based only on patients who sustained their hip fracture while living relatively independently at home and who returned there after discharge from the primary inpatient stay and survived for the whole study period. Others are –similarly to this model- based on a mixed patient group who were admitted to hospital from various locations and were discharged to various different locations. It is not enlightening to compare the results of these models based on different groups of patients without taking this into account in the best possible way. As a result the costs incurred by men and women were compared, as were the costs of patients who were more or less independent prior to hip fracture.

6.6.1. Men vs. Women

The epidemiological literature reviewed in chapter 2 indicated that different factors may lead to female and male fractures. This seems to be reflected in

[48] This was calculated as the sum of the number of inpatient days during hospital admissions after discharge from the primary admission, multiplied by the per diem unit cost for these admissions, divided by the total number of patients in the dataset.
[49] Total costs are calculated as the sum of primary and subsequent inpatient costs plus residence costs in the four months following the fracture. (see also chapter 5, section 4.)
[50] As above, all cost components and total costs divided by the total number of patients in the dataset.

different disease patterns. Male mortality following a hip fracture, for example, is higher than that of women. Men also appear to sustain hip fractures earlier in their lives than women (Sernbo and Johnell, 1993). Differences were observed also within this patient sample of 80 men and 369 women. *(Table 6.8.)* The average four-month net cost of a male hip fracture was approximately £6,800 (95% confidence interval £5,249 -£8,478) in this patient sample, compared to the female average of around £7,700 (95% confidence interval £6,914 - £8,640). Overall, the costs incurred by the men of the sample were thus on average 12% less than those of the women[51].

Table 6.8. Comparative Costs Male and Female Hip Fractures[52]

Costs (£ per person)	Men	Women
Baseline Costs (per day)	15	16
Primary Inpatient Costs	3,915	4,926
Subsequent Inpatient Costs	1,590	941
Residence Costs	1,359	1,910
Total 4-Month Costs	6,864	7,777

6.6.2. Independent vs. Long-Term Care Patients

Although a 12% cost difference is substantial, this pales in comparison to the differences observed between the costs incurred by the 288 patients who were admitted from their own home and the 74 patients who were resident in geriatric rehabilitation or long-term care already before their fracture. On average, the more dependent patients of the latter group incurred less than one-third of the costs of the independent patients in the four months following the fracture.

[51] Expressed as % of women's costs.

[52] This was calculated in the following way. The whole database of 449 patients was filtered by sex. The component costs for men and women were then summed up separately as described for the previous table.

(Table 6.9) This has implications for the costs which may be avoided by different programs aimed at preventing hip fracture. One of the reasons for the lower costs of the more dependent patients is probably found in their disproportionately higher death rate during the first four months following the fracture (31% vs. 16%).

Table 6.9. Comparative 4-Month Costs Independent and Long-Term Care Patients[53]

Costs (£ per person)	Independent Patients	Long-Term Care Patients
Baseline Costs (per day)	1	54
Primary Inpatient Costs	5,259	2,111
Subsequent Inpatient Costs	801	11
Residence Costs	2,367	288
Total 4-Month Costs	8,426	2,411

6.6.3. Section Summary

This section has illustrated that any measure of the average cost of hip fracture in this patient sample hides considerable differences in resource consumption. Male hip fractures cost the health and social services on average 12% less than female hip fractures during the four-month period following the fracture. The difference between more or less dependent patients was even more striking. Patients who sustained their hip fracture in long-term care or geriatric rehabilitation cost on average less than one-third of those patients who fractured their hip while living at home. This is of relevance on two counts. It is important to know the

[53] Similar to the procedure described for the different costs of men and women, this was calculated by filtering the total database by the admission location. In this case those admitted from their own homes constituted one group. The other group consisted of patients admitted from geriatric rehabilitation wards or long-term care institutions. The component costs for each of the two groups were then added up in the same way as described for the previous two tables. The total costs of the second, more dependent group of patients constitutes only 29% of the total costs of the group of patients who were admitted from their own homes.

composition of the study sample with respect to their accommodation when examining cost estimates. It is further important when considering the potential for cost savings by preventing hip fractures in different target groups.

6.7. Results of the 1-Year Cost Model

This section relates the results of the model of the costs associated with hip fracture in the first twelve months following the fracture.

As one might expect, changing the timeframe changes the relative magnitude of the cost model components. *(Table 6.10.)*

Table 6.10. Relative Magnitude of Cost Components of 4-Month and 12-Month Model[54]

Cost Components	4-months	12-months
Primary Admission	62%	53%
Subsequent Admissions	14%	12%
Residence Costs	24%	36%

As the timeframe is extended from four to twelve months, the relative proportion of costs associated with the primary admission decreases as the relative proportion of costs associated with the residence cost component increases. After twelve months, residence costs accounted for 36% of the total, compared to less than one-quarter of the total after four months.

Table 6.11. summarises the actual figures underlying these proportions.

[54] This table shows the relative magnitude of the different cost components expressed as a percentage of the respective total cost estimate (i.e. each column adds up to 100%). For actual figures, see the following table.

Table 6.11. Total 12-Month Costs and Component Costs

Cost Components	Total Costs[55]	Costs per Case[56]
Inpatient Costs Primary Admission	£2,130,847	£4,746
Inpatient Costs Subsequent Admissions	£474,376	£1,057
4-Month Residence Costs of whole dataset	£813,568	£1,812
8-Month Residence Costs of whole dataset[57]	£638,319	£1,422
Total 1-Year Costs	£4,057,110	£9,036

Inpatient costs as well as the residence costs of the first four months following the fracture are the same as in the four-month model of the costs of hip fracture. An additional £1,422 of residence costs was incurred on average across the 449 cases between the four and twelve months follow-up. Overall then, the costs associated directly with hip fracture in the year following the fracture were just over £4,000,000 for the whole patient group of 449. This is the equivalent of just over £9,000 per hip fracture case in this patient sample.

The following section extends these results from the existing patient group to the whole Tayside region to yield an estimate of the costs directly attributable to hip fracture not only in this patient group but for the population of Tayside overall.

[55] Inpatient and 4-month residence costs are the same as in the previous section.
[56] Total cost per case expresses the average costs per patient of the original dataset. In other words, it was calculated by dividing total costs by the 449 patients of the entire dataset.
[57] The total of the 8-month residence costs of the whole dataset represents net costs. It is thus calculated as total gross 8-month residence costs of the 286 12-month survivors (who had no missing data as to their accommodation at this point) + the resource consumption of those who died during this period for the period they were alive minus the appropriate baseline costs over that period. Total gross 8-month residence costs are the product of 8 months multiplied by 30.33 days per month, except for patients who died (their follow-up was their individual number of days follow-up between their individualized admission and death date) and the place of residence at 12-month follow-up (not counting those 4 patients who were found to be in an acute hospital during that time, because counting this for 8 months would have distorted hip fracture costs considerably in all likelihood) and the unit costs associated with that place of residence. Baseline costs were calculated as the product of the same number of days follow-up and the per diem costs associated with each patient's pre-fracture location. For further detail on some of the model's underlying assumptions, see also chapter 5, section 5.

6.8. Results of the Tayside Cost Model

The previous sections of this chapter illustrated the results of the model based on a sample of hip fracture patients in Tayside. These patients only represent a part of average annual 649 hip fractures occurring in Tayside overall. *Table 6.12.* summarises the results of extrapolating the cost estimate of this patient sample to all the hip fractures occurring in Tayside during an average 12 month period.

Table 6.12. Tayside Cost Estimate

	Total Hip Fracture Costs in Tayside
4-Months Costs[58]	£4,941,638
12-Months Costs[59]	£5,864,286

According to this model, the total costs to the health and social services directly associated with the average 649 hip fracture cases which occur in Tayside per year amount to almost £5,000,000 in the four months following the hip fracture. These costs rise to just under £6,000,000 in the 12 months following the hip fracture.

6.9. Sensitivity Analysis

The following section shows the result of the sensitivity analysis. This was undertaken in order to gain a further understanding of the effect of various modelling assumptions on the overall result. The rationale for the assumptions underlying the different analyses is given in each of the following sections. The

[58] This was calculated as the mean 4-month net total costs per case of £7,614 multiplied by the average number of hip fractures in Tayside per year (649). For further detail on the latter, see chapter 5, section 6.

[59] This was calculated as the mean 12-months net total costs per case of £9,036 multiplied again by the average number of hip fractures in Tayside per year (649).

decision was taken to depart slightly from the usual format of comparing percentage changes in in- and outputs of models. This format appears better suited and more meaningful in the context of full economic evaluations which reach definite decisions rather than providing information without aiming to provide decision rules or advice.

6.9.1. Institutional Maintenance Costs

The main analysis of the previous sections has left out that councils may have to pay to maintain a person's place in a home for the elderly or a nursing home while they are hospitalised. Adding these costs[60] onto net inpatient costs adds a total of £109,310 to the analysis. This brings the inpatient costs to £2,714,533 in total for the four-month patient sample. Expressed as a percentage, this adds another 4% to the total inpatient costs of all models, 4-months, 1-year and Tayside models.

6.9.2. Subsequent Acute Hospital Admissions

The way the epidemiological data for this study was collected makes it impossible to assess to what extent hospitalisations after discharge from the primary admission can be directly linked to the fractured hip. *Table 6.13.* shows the results of the best estimate of hip fracture costs if those costs were ignored completely.

Table 6.13.12-Month Cost Estimate Without Subsequent Hospital Admissions[61]

Cost components	Total Costs	Costs per Case
Inpatient Costs Primary Admission	£2,130,847	£4,746

[60] Institutional maintenance costs were calculated in the following way: Baseline costs during primary and subsequent admissions were added up. From this sum were deducted the average costs of homehelp across the 449 patients multiplied by the total number of inpatient days.
[61] Apart from the subsequent hospital admissions which were simply left out here, the contents and calculations of this table are identical to that of Table 6.11.

4-Month Residence Costs of whole dataset	£813,568	£1,812
8-Month Residence Costs of whole dataset	£638,319	£1,422
Adjusted Total 1-Year Costs	£3,582,734	£7,979

The total costs which can be directly associated with hip fracture would thus be reduced to just under £8,000 per case. This would be the equivalent of just over £5,000,000 for the whole of Tayside. *(Table 6.14.)*

Table 6.14. Tayside 12-Month Cost Estimate Without Subsequent Hospital Admissions[62]

	Total Hip Fracture Costs in Tayside
4-Months follow-up costs	£4,255,958
12-Months follow-up costs	£5,178,607

The total 1-year costs were thus reduced by 12% when hospital admissions other than the primary admission were removed from the calculation.

6.9.3. Lower Estimate

To obtain the lower cost estimate overall for all models, lower cost estimates were used for inpatient and residence as well as baseline costs. The estimate used for lower estimate inpatient costs was the estimate of the average orthopaedic bed day cost at Aberdeen Royal Infirmary in 1993 used by French, Torgerson and Porter (1995). This per diem estimate was 38% lower than that used for Tayside in the 'best estimate' scenario described in the previous parts of the chapter. The percentage changes of unit cost estimates employed differed between different types of residences but were between 0 and 21% higher than those used for the 'best estimate' *(Table 6.15.)*. It might at first glance appear

[62] Again, the contents and calculations underlying this table are identical to that of a previous table, Table 6.12., apart from leaving out any subsequent hospital admissions.

counterproductive to choose to employ higher unit costs in an analysis whose explicit aim is to provide a lower cost estimate. Although using higher unit cost estimates will lead to a slightly increased residence cost component of overall costs, the effect of raising baseline costs by choosing the employ lower inpatient unit cost estimates together with higher unit residence cost estimates has a more pronounced effect on lowering the major cost component of inpatient costs. Using higher unit cost estimates for residence costs thus leads to an overall lower cost estimate of total hip fracture costs.

Table 6.15. Lower Estimate Unit Costs[63]

	Lower Estimate (1999 £)
Acute Hospital Orthopaedic Ward (per day)	189
Acute Hospital (per day)	189
Homehelp (per hour)[64]	7
Convalescent Home (per day)[65]	51
Full-Service Institution (per day)[66]	39
Geriatric Rehabilitation (per day)[67]	153
Long-Term Care (per day)[68]	51

The results of substituting these different unit cost estimates for the original ones are summarised in *Table 6.16.*

[63] The source for these lower estimate unit costs are the same as those for the best estimate given in Table 5.4.
[64] This figure was left the same as in the best estimate. The councils in question all pay for homehelp up to a certain amount per week. This figure though was not reached by any patient of the dataset.
[65] The unit cost used for the lower estimate of the sensitivity analysis was the same as that used for the best estimate since only a negligible number of patients fell into this category (see section 6.3.)
[66] The figure used here is that of Angus Council, the council with the highest figure given for this residence category. The reason why the highest figure was chosen here is that choosing a higher unit cost estimate will lead to a lower cost estimate of hip fracture costs overall.
[67] This figure was again left the same as the best estimate since it involved only 4 patients.
[68] Again, a higher unit cost estimate was chosen in line with the explanation given for the unit cost estimate of for full-service institutions above.

Table 6.16. Lower Estimate 12-Month Costs[69]

Costs (Lower Estimate)	In Total (449 patients)	Per Case[70]
Net Inpatient Costs (primary & subsequent admissions)[71]	£1,556,615	£3,467
4M Net Residence Costs[72]	£633,834	£1,412
8M Net Residence Costs[73]	£557,323	£1,241
TOTAL Net 4-Month Costs[74]	£2,190,448	£4,879
TOTAL Net 12-Month Costs[75]	£2,747,771	£6,120

The lower estimate of the total costs directly attributable to hip fracture in the model of the original patient group of 449 patients in the 4 months following the fracture are just over £2,000,000. This is equivalent to a total 4-month cost of

[69] The way the cost components were constructed and combined is the same as that outlined above for the best estimate case (see Table 6.11.).
[70] To arrive at the per-case cost, the total was divided by the total number of cases, 449.
[71] This was calculated as gross inpatient costs minus baseline costs for the same number of days. Gross inpatient costs consisted of the sum of primary and subsequent hospital admission days multiplied by the lower estimate per diem indicated in Table 6.15. To this were added the institutional maintenance costs appropriate to each individual, as described in section 6.9.1. From these gross inpatient costs baseline costs were deducted. These baseline costs were also based on the same lower per diems and multiplied by the number of days each patient spent in hospital during primary and subsequent admissions.
[72] This figure was calculated by deducting baseline costs from the 4-Month gross costs. The gross costs was the sum of the number of days each individual spent in each category of accommodation during the first four months of follow-up multiplied by the appropriate lower per diem unit cost from Table 6.15. The baseline costs during this period were calculated to be the appropriate lower per diem cost from the same table multiplied by the total number of days follow-up each individual had minus the number of days he or she was hospitalized during this time.
[73] 8-Month Net Follow-up costs were arrived at in the following way. Each individual's number of days follow-up between 4 and 12-months post-fracture was worked out. If the person died during this period, the difference between the individual admission and death dates was taken. If the person was still alive one year post-fracture, their follow-up period was taken as 8 months (364 days divided by 12 months = 30.33 days per month, multiplied by 8 months). This number of days follow-up for each individual was multiplied by the appropriate lower per diem figure for their accommodation category at 12-months (see Table 6.15.). From these 8-M gross follow-up costs were deducted the baseline costs for that same period. These were calculated for each individual's number of days follow-up during this period in the same way as described for the baseline costs for the four month follow-up period.
[74] This was the sum of the lower estimates of net inpatient costs and net follow-up costs during the first four months following the fracture. Each of these was calculated as described above.
[75] This was the sum of the lower estimates of net inpatient costs, net four-months follow-up costs and net 8-months follow-up costs, as described above.

approximately £4,900 per hip fracture case. For the time period of the year following the fracture, the lower estimate rises to approximately £2,700,000 for the whole patient group and £6,000 per case.

Table 6.17. extrapolates these costs to the expected average number of annual hip fracture cases of 649 in Tayside as a whole.

Table 6.17. Lower Estimate Tayside 12-Month Costs[76]

Costs (Lower Estimate)	In Total (Tayside)
TOTAL 4-Month Costs	£3,166,149
TOTAL 12-Month Costs	£3,971,722

The lower estimate of the total costs of hip fracture in Tayside in the four months following the fracture is thus estimated to be just over £3,000,000. The equivalent cost estimate for the whole year following the fracture is therefore just under £4,000,000 for the whole of Tayside.

6.9.4. Upper Estimate

This section provides an upper estimate of the costs which can be attributed to hip fracture for the different models. The upper estimate is obtained by omitting the deduction of baseline costs from the different cost estimates. This would be the equivalent to attributing the consumption of all resources post-fracture to the hip fracture, regardless of the amount of resources the patient consumed already before the fracture.

The estimate of direct hip fracture costs resulting from this methodology is in all likelihood much higher than the true costs of hip fracture to the health and social

[76] Again, this was calculated the same was as for the best estimate case detailed above: per case costs for 4- and 1-year costs were simply multiplied by the average number of hip fractures in Tayside per year (see Table 6.12. and chapter 5, section 6).

services. However, it provides a cut-off point below which the real costs of hip fracture are likely to be found. In addition, this estimate is thus based on a gross costing methodology, a methodology which was employed by many studies in the literature.

Table 6.18. Upper Estimate 12-Month Costs[77]

Costs (Upper Estimate)	In Total (449 cases)	Per Case[78]
Inpatient Costs Primary Admission	£2,222,840	£4,951
Inpatient Costs Subsequent Admissions	£499,578	£1,113
4M Residence Costs	£1,359,414	£3,028
8M Residence Costs	£1,295,996	£2,886
TOTAL 4-Month Costs	£4,081,832	£9,091
TOTAL 12-Month Costs	£5,377,928	£11,977

The upper estimate of the costs associated with the four months following a hip fracture in the original patient group of 449 patients is approximately £4,100,000. This translates into an upper estimate of approximately £9,100 per case for four months. Extrapolated to one year, the upper estimate of the costs associated with hip fracture in this group of patients is approximately £5,400,000. The upper estimate of the costs associated with hip fracture in the year following the fracture are thus just under £12,000 per case. *(Table 6.18.)*

[77] The upper estimate was calculated by summing up all the resources consumed by the study's 449 hip fracture patients without deducting any baseline costs. The approach therefore mirrors the results had gross instead of net costing been employed. The individual cost components were thus calculated by following the methodology outlined for the gross costing estimate of 4M costs in section 6.5.2. and 6.5.3. Total 4-month costs are the sum of primary inpatient costs, subsequent inpatient costs and 4-month residence costs. Inpatient costs in turn are calculated as the sum of individuals' inpatient days on primary admission, multiplied by the best estimate orthopaedic unit costs of £305 per diem. Subsequent inpatient costs are the sum of individuals' inpatient days between discharge and 4-months post-fracture, multiplied by the best estimate acute unit cost of £318 per diem. 4-month residence costs are the sum of the individuals' number of days spent in each residence category between discharge and 4-month follow-up, multiplied by the best estimate per diem figure for each of these types of residences. The 12-month estimate adds to this an additional 8-months residence costs. This is arrived at by multiplying the sum of the individual patients number of days follow-up with the appropriate best estimate per diem figure of the residence category the individual found themselves in one year after the fracture.

[78] Total Costs divided by 449 patients.

Table 6.19. extrapolates this to produce an upper estimate of hip fracture costs for the whole of Tayside.

Table 6.19. Upper Estimate Tayside 12-Month Costs[79]

Costs (Upper Estimate)	In Total (Tayside)
TOTAL 4-Months Costs	£5,900,019
TOTAL 1-Year Costs	£7,773,297

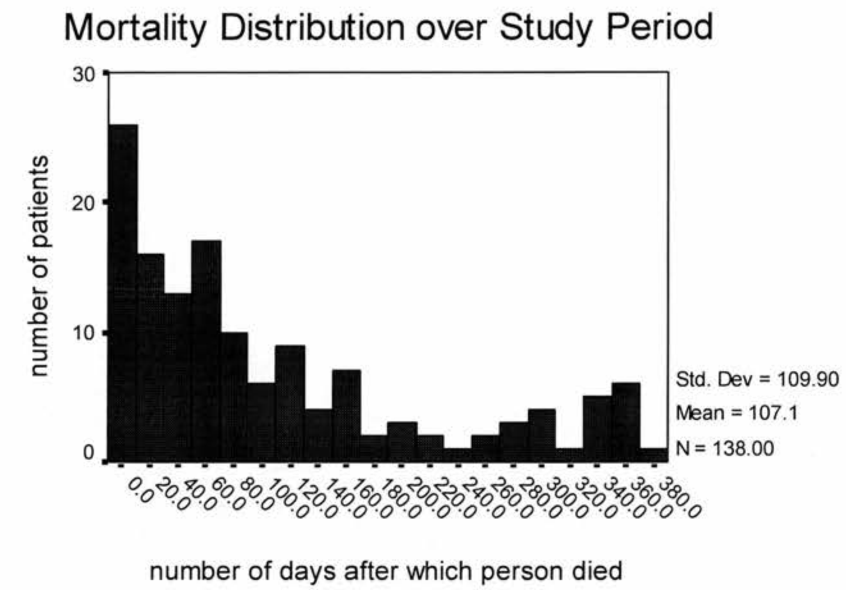
For the whole of Tayside, the upper estimate of the costs associated with hip fracture in the four months following the fracture are around £5,900,000. The equivalent upper estimate of the costs associated with hip fracture in the whole of Tayside in the year following the fracture amounts to just under £7,800,000. The results of the sensitivity analysis are shown in the following chapter summary in comparison with the results of the model based on the best available estimate of the costs.

6.9.5. Adjustment for Censored Data

As indicated in chapter 3 (section 3.4.8.), it has been argued recently that in the face of substantial, non-constant mortality during a study's follow-up, bias in cost estimation might occur. Results should thus be adjusted to reflect this, although this has not been widely used in hip fracture studies. As *Figure 6.6.* shows, mortality was not evenly distributed across the study period.

[79] Again this was calculated by multiplying the per case cost estimates for 4-months and 1-year by the average annual number of hip fractures in Tayside (see chapter 5, section 6).

Figure 6.6. Distribution of Mortality over Study Period



This excludes those patients who were still alive after 12 months.

Also excluded are 13 patients for whom there was no exact date of death.

The methods suggested by which mortality can be taken into account are those of a Kaplan-Meier survival analysis. The appropriate mean costs of hip fracture thus require the multiplication of the probability of survival with the costs among those available for follow-up, in other words, those entering the cohort (Brainsky, et al., 1997; Autier, et al, 2000; DeLaet, et al., 1999).

As Table 6.20 shows, adjusting for mortality did not substantially affect the four-month cost estimate, the difference being merely 3%. As one might expect, the difference between the two cost estimates is slightly more pronounced when the whole year after the fracture is considered. Adjusting for mortality here leads to a 6% lower cost estimate. The fact that the overall difference between the two hip fracture cost estimates is not that substantial though probably reflects the fact that most costs are incurred towards the beginning of the study period. The analysis shows, however, that not adjusting for censoring leads to a small, but systematic overestimation of hip fracture costs of between 3 and 6% in the year following the fracture.

Table 6.20. Kaplan-Meier Best Estimates of Hip Fracture Costs

Cost Components	Best Estimate	Best Estimate (Kaplan-Meier)
Primary Inpatient Costs[80]	£ 4,746	£ 4,746
Subsequent Inpatient Costs[81]	£ 1,057	£ 983
4M Residence Costs[82]	£ 1,812	£ 1,685
8M Residence Costs[83]	£ 1,422	£ 1,109
4M TC	**£ 7,614**	**£ 7,414**
12M TC	**£ 9,036**	**£ 8,523**
Tayside TC	**£ 5,864,286**	**£ 5,531,427**

6.10. Summary

The 1-year costs associated with hip fracture in Tayside according to this model range between £4 million and almost £8 million, with the best estimate being just under £6 million. Per case, the 1-year costs ranged between just over £6,000 to double that, with the best estimate being £9,000. *(Table 6.21.)*

Table 6.21. Summary of Cost Estimates[84]

	Lower Estimate Per Case	Best Estimate Per Case	Upper Estimate Per Case
Inpatient Costs (Primary & Subsequent Admissions)	£3,500	£5,800	£6,100
4-Month Residence Costs	£1,400	£1,800	£3,000
8-Month Residence Costs	£1,200	£1,400	£2,900
TOTAL 4-Month Costs	£4,900	£7,600	£9,100
TOTAL 1-Year Costs	£6,100	£9,000	£12,000

[80] Primary Inpatient Costs are the same for both estimates, since total costs are multiplied by the number of patients entering the particular cohort.

[81] The Kaplan-Meier Best Estimate of Subsequent Inpatient Costs was calculated as the Best Estimate of Subsequent Inpatient Costs multiplied by 0.93, since 7% of patients died during the primary inpatient stay.

[82] The Kaplan-Meier Best Estimate of 4M Residence Costs was calculated the same way as the equivalent of Subsequent Inpatient Costs in the previous footnote.

[83] The Kaplan-Meier Best Estimate of 8M Residence Costs was calculated as the Best Estimate of 8M Residence Costs, multiplied by 0.78, since 22% of patients had died up within the first four months of the hip fracture.

[84] This table does not present new calculations, it merely sums up the estimates presented above, rounded to the appropriate next £100,000.

The modelling method followed for the lower estimate results in a 32% lower estimate, that followed for the upper estimate results in a 33% higher estimate of hip fracture costs compared to the best estimate.

The proportions of total costs accounted for by the individual cost components of the model also change depending which assumptions are used. *(Table 6.22.)*

Table 6.22. Summary of Costs Estimates by Proportion of Component Costs[85]

	Lower Estimate Per Case	Best Estimate Per Case	Upper Estimate Per Case
Inpatient Costs (Primary & Subsequent Admissions)	57%	64%	51%
12-Month Residence Costs	43%	36%	49%

The lower estimate led to a higher percentage of total costs being due to increased residence costs compared to the best estimate. Inpatient costs still account for the largest proportion of costs though. The upper estimate led to costs being almost evenly spread between the inpatient and residence cost components.

This analysis makes clear how the costing methodology impacted the end result in this particular case. The different assumptions employed in the sensitivity analysis led to cost estimates which varied by about one third on either side of the best cost estimate. Gross costing led to a cost estimate double that of the lower estimate. This confirms on the one hand the findings that on average hip fracture patients tend to suffer from ill health already before their fracture. On the other hand this illustrates how the adoption of a gross costing methodology may lead to the severe overestimation of the real costs which can be directly attributed

[85] Again, the table presents individual cost components expressed as a percentage of the appropriate total estimate. Each column adds up to 100%.

to hip fracture. This is particularly important for studies looking beyond the hospital-based care phase.

It may be remembered that the 32% lower estimate was arrived at by employing markedly lower acute care costs as well as estimating only that proportion of non-hospital-based care costs which is borne by the health and social services. *Table 6.22.* shows that the lower estimate is lower mainly because of lower acute costs.

In both, the upper and the lower estimate, acute costs appear to be the single most decisive cost factor. The model is thus most sensitive to inpatient costs as well as the costing methodology and baseline costs.

The next chapter will explore how the costs associated with hip fracture in Tayside compare with other studies' estimates.

7. The Tayside Cost Estimate in Context

7.1. Introduction

This chapter explores how this model's estimate of the costs associated with hip fracture in Tayside compare with the costs associated with the condition in the global literature which was profiled in chapter 4.

First of all, section 7.2. describes the methods with which existing studies' cost estimates were standardised in order to enable comparison between them. Section 7.3. then presents these standardised cost estimates which the global literature has associated with hip fracture. As chapter 2 has shown, there are many uncertainties in the current medical knowledge of the phenomenon 'hip fracture'. Differences in the disease processes have been shown for example in men and women, as well as in the fracture location. One might therefore legitimately expect the costs of hip fracture to reflect two things. First, one might legitimately expect variation in the costs associated with hip fracture due to a different underlying disease process. One might also expect to see legitimate variation in the costs associated with hip fracture due to different ways of treating it. These differences in turn might arise due to differences in patient characteristics or differences in the combination of different elements of health, social and informal care which characterise different countries. How large one might expect these differences to be has not been an issue which has been discussed in the literature at all so far. It is thus difficult to make a judgement of how large a variation in hip fracture cost estimates might reflect real underlying differences in costs, as opposed to differences due to the way studies have been set up to arrive at the different cost estimates. Whether hip fracture cost estimates vary because they express real differences in what they were measuring or whether they vary because different study methodologies are more or less accurate at capturing the condition's true underlying costs is important. If the main aim of economic evaluations of hip fracture is to ultimately lead to a better use of resources in a society, this can only work if one may place one's trust in these evaluations actually measuring what they are meant to be measuring.

To explore whether cost estimates of hip fracture actually do reflect the true underlying costs of hip fracture, whatever they may be in a given context, one might expect to be able to explain variations in cost estimates with reference to certain factors to do with patient characteristics or study methodology. This chapter therefore takes the factors identified as relevant in the case of hip fracture in chapters 2 and 3 to investigate whether cost variations between studies can be explained with reference to these factors. These factors were the following:

- Year of Study
- Country
- Treatment Algorithm/ Length of Acute Stay
- Control Group
- Age
- Sex
- Patient Origin
- Timeframe of Study
- Type of Cost Data Collected, and
- Costing Methodology.

Section 7.4. of this chapter investigates whether any of these factors can explain variations in hip fracture costs estimates. But first, what are the costs associated with hip fracture across the world? And where does Tayside stand in comparison?

7.2. Currency Conversion and Relative Purchasing Power

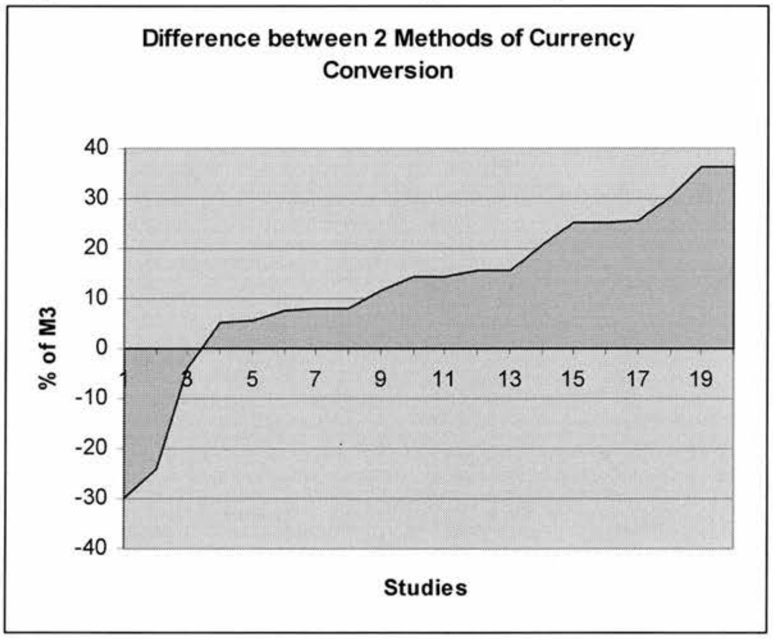
To compare the estimate of hip fracture costs in Tayside[86] with those associated with the condition elsewhere, one must first convert all estimates into the same currency in the same year. The following paragraphs describe the way studies' cost estimates were converted to 1999 US$. The year was chosen due to it being the latest available IMF base year for currency conversions. US dollars were chosen over pounds sterling due to the smaller relative fluctuations of the exchange rate regimen during the relevant time period in which studies were conducted (Bonetti, 2001; Cobham, 2001).

There are two different ways of converting studies' results to 1999 US$ (Bonetti, 2001). One method, abbreviated to 'M1' here for convenience, would mean that, for example 1987 £s were first converted to 1987 US$ and then to 1999 US$ by adjusting for inflation. The second method, abbreviated to 'M2', first inflation-adjusts 1987£ into 1999£s and then converts to 1999 US$. A number of studies did not allow for the calculation of the results of the two methods separately because they had converted their results into US$ already. Often they failed to state which method, or indeed which year's figures were used to convert the results into US$. For the purpose of further analysis, the straight arithmetic average ('M3') between the two methods' results was used as the reference result for those 16 studies where the two methods led to different results. As Figure 7.1.

[86] For the purposes of comparison with the rest of the literature, it was decided to employ mean cost figures for hip fracture in Tayside before they were adjusted for censoring. As indicated in chapter 4 (section 4.8.3.), only three of the 34 studies examined adjusted for censoring. Although the adjustment for censoring as a study methodology variable represents a potential source of systematic bias, the statistical power of any test comprising three studies is not sufficient to draw robust conclusions. To avoid a potential source of bias in the comparison with other studies, it was thus decided to use as the unadjusted estimate as a comparison figure for hip fracture costs in Tayside.

illustrates, the difference between the two methods, expressed as a percentage of M3, was striking at times.

Figure 7.1. Difference between 2 Methods of Currency Conversion



The differences between the two methods of calculating exchange rates ranged from -30% to +36% of M3. In absolute numbers these differences ranged from US$-1,718 (I.e. M2 > M1) to US$ 12,369 (M1 >M2). The majority of studies' results were larger when calculated according to the M1 method. On average, the results obtained by using method 1 were US$ 2,857 higher than if method 2 was employed. A range of differences in results of US$ 14,087 thus arises purely due to two different methods of converting results into a different currency at different points in time. This difference is greater than the lowest estimate of hip fracture costs in the literature.

The following section presents these differences for each country separately. The 16 studies summarised in Table 7.1. are those where results differed between M1 and M2, reported research conducted in Spain, Sweden, France, the UK, New Zealand, Switzerland, Belgium, Germany, Austria, Canada and Australia.

Table 7.1. Summary of Differences of Cost Estimate by Method of Currency Conversion by Country

Authors	Difference expressed as % of M3	Country
Arboleya	21	Spain
Borgquist	36	Sweden
Chamberlin	25	France
Diez Perez	-30	Spain
Dolan	-4	UK
Farnworth	25	Australia
Hollingworth	8	UK
Koeck	8	Austria
Lane	26	New Zealand
Levy	16	France
Lippuner	16	Switzerland
Meine	14	Switzerland
Pientka	6	Germany
Randell	14	Australia
Reginster	5	Belgium
Schurch	30	Switzerland
Thorngren	36	Sweden
Treves	-24	France
Wiktorowicz	8	Canada
Zethraeus & Gerdham	12	Sweden

For some countries, there seems to be no systematic difference in the results obtained by the two different methods. In other countries, one method yielded consistently higher results than the other.

It can be seen from this that the two methods of calculating exchange rates may yield substantially different results in certain countries at certain points in time. Some of the differences in the results between the two methods are greater than other people's entire estimates of the costs of hip fracture. For some countries there appears to be a systematic difference between the results of one method rather than the other at the point in time when the studies were conducted in the 1980s and 1990s. For other countries, no such systematic difference seems to exist. As Table 7.1. indicates, the difference in the two methods fluctuates by

66% around the zero difference mark either way. On average the results utilising method 1 were around 12% greater than using method 2.[87]

There are several implications to this: Great care is needed when comparing results of studies across countries. Even greater care is needed when employing another study's results to approximate the costs per hip fracture avoided in estimating the cost-effectiveness of programmes aimed at preventing or treating hip fractures. Currency conversion appears to be an area which has hitherto not received the attention it is due based on the above evidence. Not a single study of the entire global hip fracture cost literature made any reference to this issue in any shape or form.

Relative Purchasing Power

Having converted all studies' estimates of the costs of hip fracture into a common currency at the same point in time does not, however, automatically enable any meaningful comparison between them without allowing for differential price levels between countries. No study of hip fracture costs retrieved made any explicit reference to the differences in purchasing power which exist even among countries belonging to the developed world. This further amplifies the concern that might be felt at so many studies' indiscriminate use of other studies' cost estimates as a basis for directly policy-relevant recommendations.

As indicated in chapter 3, there does not appear to be a consensus on the use of the appropriate conversion factor when comparing price levels across different countries (Jefferson,1996; Gosden, 2002). Research has reached different

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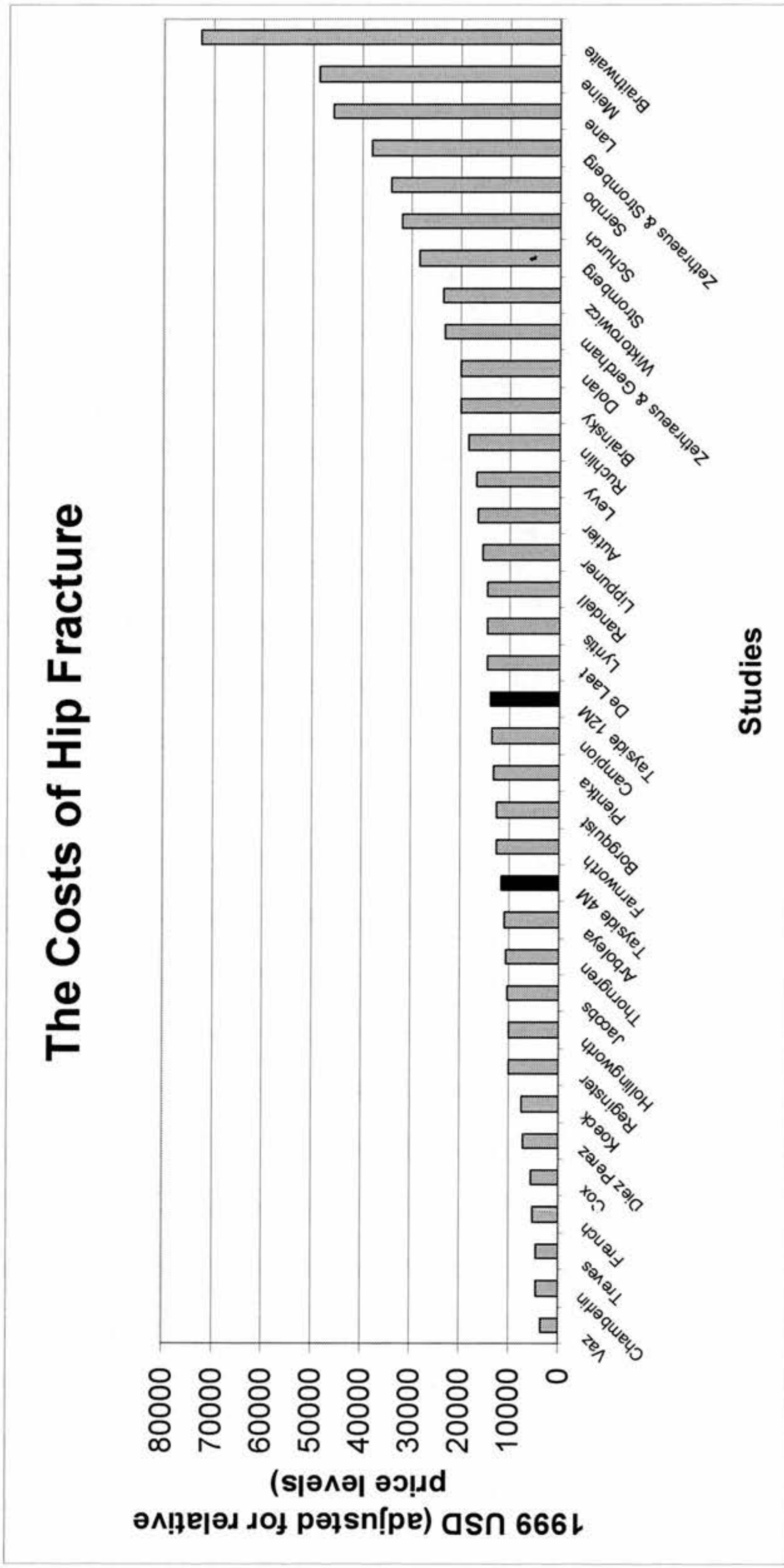
[87] This was calculated as the average of all the 'Difference expressed as % of M3' column in Table 7.1.

conclusions as to the relative stability of health-related PPPs and GDP PPP conversion factors (Parkin, 1987; Gerdtham, 1991). In accordance with the Department of Health's advice, GDP PPPs were used in this analysis and applied to the uniform study results in 1999 US$ (Department of Health, 1994). Section 7.3. presents the literature's estimates of hip fracture costs, once standardised in this way.

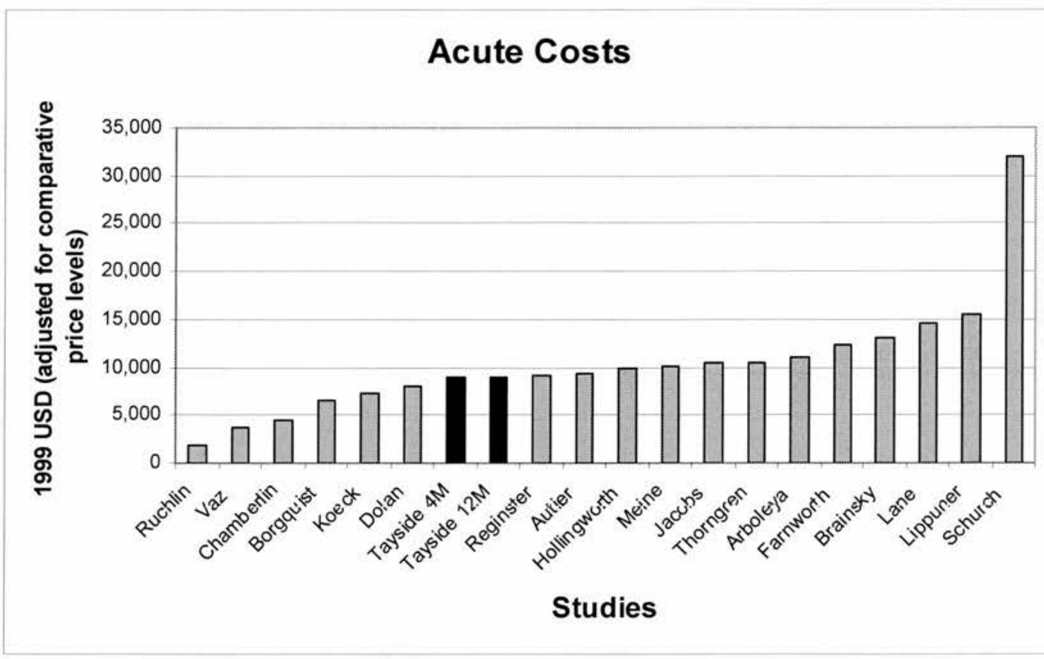
Figure 7.2. Costs of Hip Fracture



7.3. Hip Fracture Cost Estimates

Compared to the estimates of all 34 studies based on original cost data which were presented in chapter 4 the costs associated with hip fracture in Tayside in the four and twelve months following the fracture (the two black columns in Figure 7.2.[88]) are located firmly in the middle of the distribution of all cost estimates. Since the overall cost estimates ranged between approximately US$ 3,600 and over $72,000, the two cost estimates of the 4- and 12-months Tayside models are at the lower end of that scale in terms of the actual costs involved. The picture is similar when the two component costs, acute and follow-up costs are compared. *(Figure 7.3.)*[89]

Figure 7.3. Acute Cost Estimates

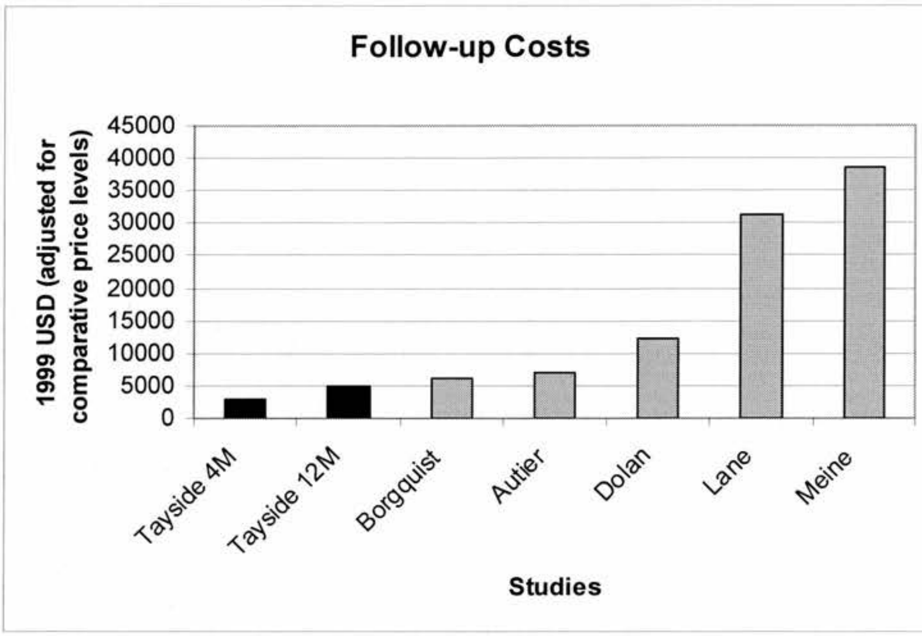


[88] The two black columns represent the results of the per person cost of the 4-month model (the left column) and the 1-year model (the right column) converted to 1999 US$ and adjusted for comparative price levels with the help of OECD data. (OSCE, 2002)

[89] Included in the comparison are studies which presented separate and clearly distinct estimates of the two cost components aggregated across their patient group.

Both, Tayside's four months and twelve months follow-up costs appear to be the lowest estimates of follow-up costs globally. *(Figure 7.4.)*

Figure 7.4. Follow-Up Cost Estimates



What is striking about this comparison of total costs as well as acute and follow-up costs is the variety of cost estimates which have been attached to hip fracture across the world, even when relative price levels are taken into account.

The following section seeks to investigate whether variations in cost estimates can be explained with reference to characteristics of the underlying patient sample or methodological choices made in the construction of the model.

7.4. Comparison of Model Inputs and Processes

The generic and hip fracture specific literature reviewed in chapters 2 and 3 suggested a number of factors which might bear a systematic influence on studies' cost estimates. This section explores whether any of these factors relating to patient characteristics or the methodology of the study could be shown to have a direct influence on the study's cost estimate. The factors examined first are those relating to characteristics of the patient sample. They were:

- the year in which they study was conducted,
- the country or region of a country it was conducted in and
- the length of stay in hospital during the acute and rehabilitation phase.

Other differences in the object of measurement include

- the age and sex inclusion criteria of the sample,
- the type of control group which was used and
- the patient origin.

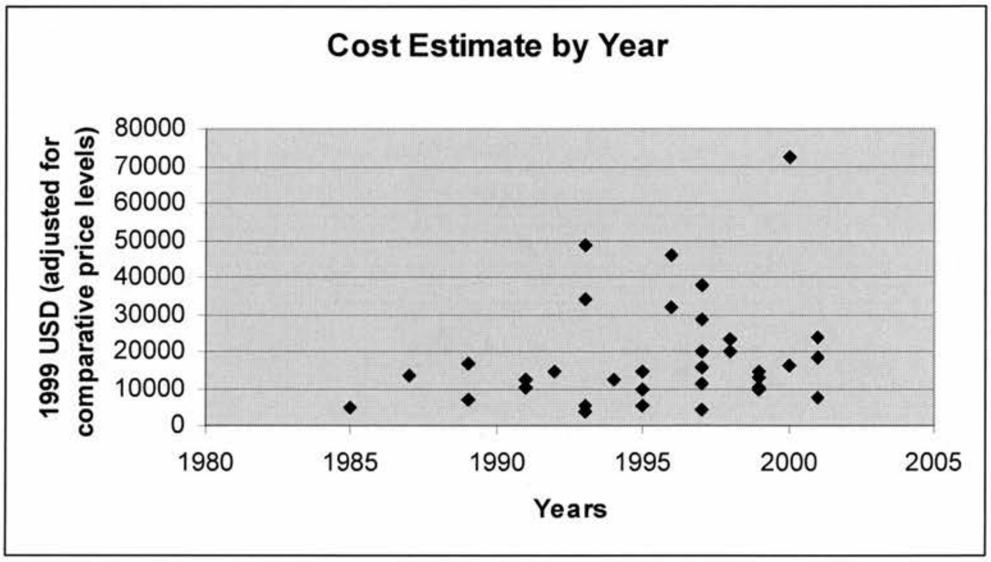
Not all studies provided sufficient detail on every single one of these factors. Therefore each factor is examined separately at first with respect to whether it might lead to systematic variations in hip fracture cost estimates.

7.4.1. Year of Study

The age of study could conceivably influence cost estimates for example through changes in the treatment algorithm of hip fracture over time, as new research findings filter through into clinical practice. However, allowing for the increase in the absolute numbers of studies between the beginning and the end of the period, Figure 7.5. shows at best only a weak positive association between the year the study was conducted and it's cost estimate. This is confirmed by the

Spearman's rho correlation coefficient of 0.255. This weak association is not statistically significant at the 5% level (0.145, 2-tailed). This means that it cannot be said that the age of the study explains the observed variation in results among the studies.

Figure 7.5. Relationship between Cost Estimate and Year of Study



7.4.2. Country

A second factor that might help to explain the observed differences in hip fracture costs across the world is the country in which the study was conducted.

Figure 7.6. Relationship between Cost Estimate and Country

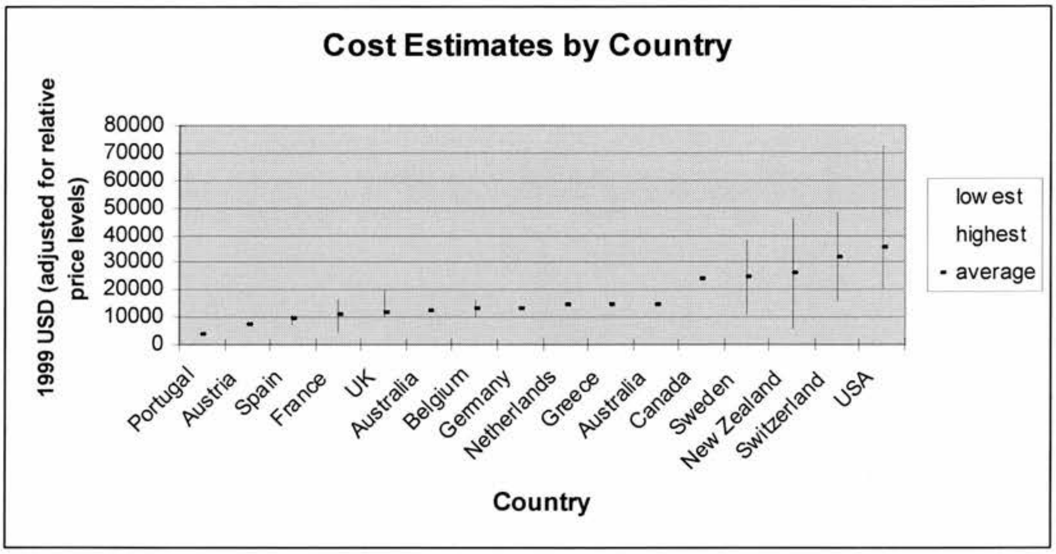


Figure 7.6. shows that there is an overlap between different studies and country's results. It also illustrates the wide variety of costs associated with hip fracture even among studies conducted in the same country.[90] For example, there were 3 Swedish studies which used marginal costing. Their respective cost estimates were \$27,240 , \$40,252 and \$44,933 (1999 USD, unadjusted for comparative price levels). They employed fairly similar inclusion criteria for the type of hip fracture to be included in their study. They all estimated the detailed costs of acute stay as well as rehabilitation, homehelp and long-term care. The study yielding the lowest estimate may have included a slightly younger and healthier age group of hip fracture patients as they included only women coming from their own homes. All three studies used self-control group mechanisms for their marginal cost estimate, they were all conducted in the 1990s and they all had a one-year time horizon. So, the only thing which (from the criteria for which data

[90] It is important to bear in mind that even relatively small differences per case will add up to considerable differences once these small differences are aggregated across a country's or region's population.

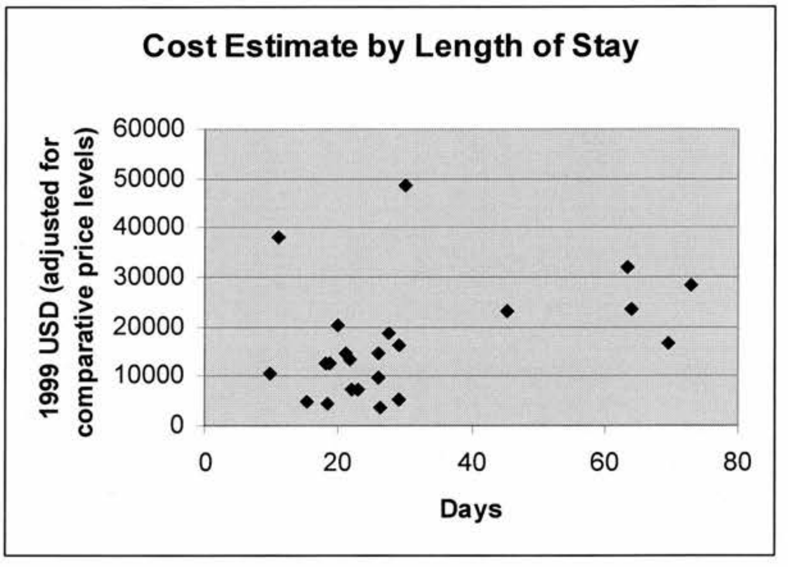
was collected for this database) distinguishes one study's methodology and patient group from the other is the fact that one study may have estimated the costs of hip fracture on a slightly younger and fitter patient group than the other two studies. However, it is doubtful whether this can account for a difference in cost estimate between $13,012 and $17,693.

The variation between countries appears in many cases no bigger than the variation between studies conducted in the same country. The graph thus appears to suggest that the country or even region where a study was conducted can only explain parts of the observed variation in costs associated with hip fracture.

7.4.3. Treatment Algorithm/ Length of Stay

Much of the literature has identified the cost of hospital stay as the major or at least one of the major cost factors in hip fracture. If this is indeed the case, then this cost is likely to vary depending on the amount of time a patient spends in hospital. On attempting to obtain a single representative figure for each study concerning length of stay, it became obvious that the reporting of results of different studies was profoundly heterogeneous. Bearing this in mind, a weak to moderate positive association can be inferred though from Figure 7.7. between length of stay and the resulting cost estimate of the study. The Spearman's Rho Correlation Coefficient of 0.438 confirms this. This is statistically significant at the 5% level (0.036, two-tailed). The null hypothesis that there is no association between patients' length of stay and a study's cost estimate is therefore rejected. Length of stay is thus one variable which can go some way towards explaining the observed variation in hip fracture cost estimates.

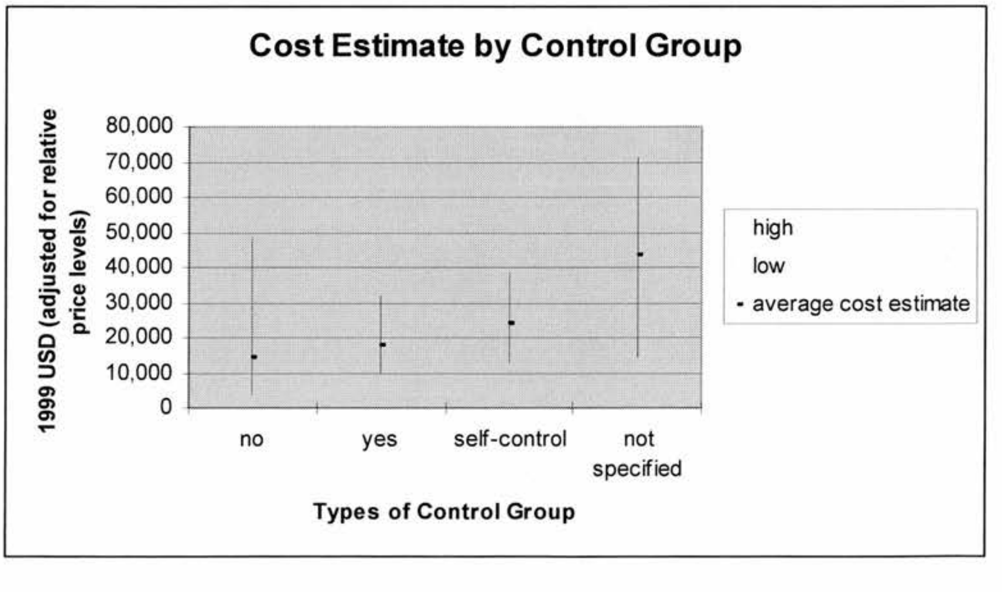
Figure 7.7. Relationship between Cost Estimate and Length of Stay



7.4.4. Control Group

It has been suggested that another possible explanation of the variation in study results might be found in another aspect of research design, the choice of control group.

Figure 7.8. Relationship between Cost Estimate and Choice of Control Group



Although one might expect studies without a control group to result in higher hip fracture costs, ceteris paribus, the average cost associated with that type of study was actually the lowest of all types of studies *(Figure 7.8.)*[91]. The range of cost estimates associated with this type of study, however, also showed the widest variation.[92] Of those studies which did employ control groups, those using self-controls on average resulted in higher cost estimates than those using other control groups. Again, ceteris paribus, this appears to be counter-intuitive. As hip fracture patients have been shown to have higher costs compared to their age-and sex-matched counterparts, one might expect studies employing a self-control design to result in lower estimates rather than what Figure 7.8. appears to suggest. However, the Mann-Whitney U-Test confirms this result (U=62, Asympt. Sig. (2-tailed) 0.018) and even shows it to be statistically significant at the 5% level. The hypothesis that there is no difference in the means of studies employing a control group of any type and studies not employing any control group at all must therefore be rejected. The choice of using a control group does thus appear to affect a study's cost estimate. As the graph shows the direction of this association to be different to what the theoretical writings would lead one to expect, this association may be indirect. Studies employing control groups may for example have chosen to estimate the costs of hip fracture more comprehensively than studies without a control group. This possibility is explored later in the chapter in the context of examining any association of

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[91] The average costs of studies without a control group (all in 1999 USD, adjusted for relative price levels) $ 14,518. For studies with a control group, this rose to $17,725. Studies with self-controls estimated the average costs of hip fracture to be $24,191. Studies which did not specify whether a control group had been used found this to be on average $43,376.

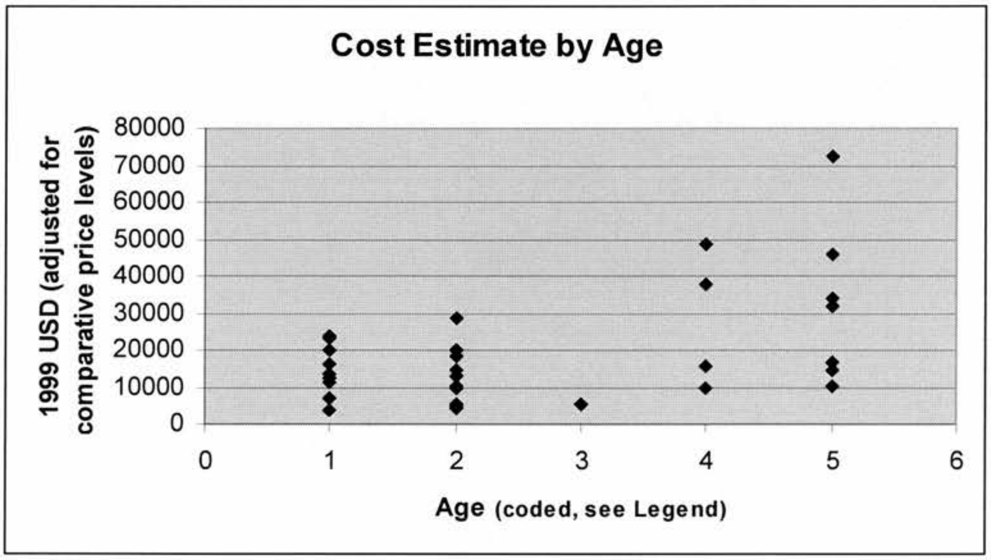
[92] Those studies which did not specify if they had used any control group at all showed the widest variation. However, this can be hardly taken to be representative, since only two studies fell into that category.

studies' methodological choices rather than the characteristics of the patient sample.

7.4.5. Age

The age of the study's patients might help explain the differences between cost estimates directly or indirectly. Since age was reported in a very heterogeneous fashion between studies, age inclusion criteria were used as a proxy for age. *(Figure 7.9.)*

Figure 7.9. Relationship between Cost Estimate and Age



Legend:

Code	Age inclusion
1	<59
2	<69
3	>70
4	All
5	Not specified

It appears that the cost estimates reported by the studies which either didn't specify their age-inclusion criteria or included all hip fractures, regardless of age, covered a wider range than those studies which did specify those criteria. The results of the first two groups cover a similar range. They also appear to result in broadly similar results. Two studies in category 3 had estimates which were higher than those of any study in either group 1 or 2. At first sight this appears to make sense, since one might expect to see higher long-term costs if younger patients are included. However, only one of these two studies included non-health care or accommodation related long-term costs. In addition, if these two studies included younger patients, so did the studies of category 1.

All in all, there does not appear to be any strong relationship between the age inclusion criteria of a study and its resulting cost estimate. As age inclusion criteria were used as a proxy for age due to the difficulty of ascertaining a study's average age at fracture, it cannot be said for certain that there is but a weak relationship between the age of a study's patients and its cost estimate.

7.4.6. Sex

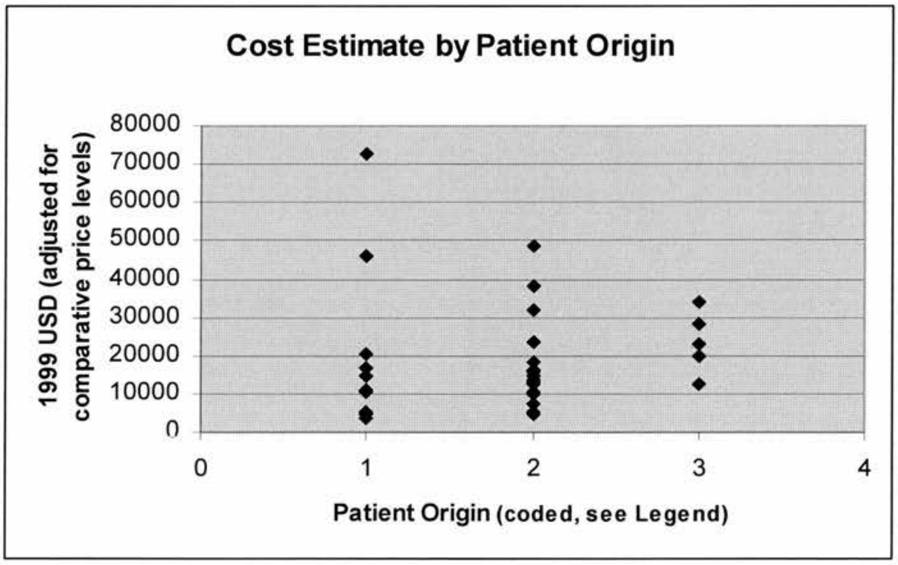
It is difficult to ascertain whether there is a significant difference in cost estimates depending on the sex of their patients. There are only 5 studies which included only women, 27 which included both men and women and none including just men. This comparison is further complicated in that the majority of patients even in mixed studies were women. It is thus not possible to say with any degree of confidence whether studies including only women resulted in significantly different results from studies based on both, men and women.

7.4.7. Patient Origin

The last attribute of a study's patient sample to be examined in its relationship with cost estimates is patients' general health and independence prior to the fracture. One way this can be approximated is by looking at where the patient was resident before their fracture, be that their own home or one of a number of institutional settings.

Both, the studies which did not specify their patients' origin as well as those which included patients from all settings resulted in a wider range of estimates than those studies which included only patients from their own homes. In terms of the magnitude of costs estimates, Figure 7.10. suggests that once the relative number of studies for all groups is taken into account, there appears to be no overwhelmingly strong relationship between the origin of a study's patients and the study's estimate of hip fracture costs. Comparisons are hampered by the small number of studies involved and the fact that the majority of patients which included all also came from their own homes.

Figure 7.10. Relationship between Cost Estimate and Patient Origin



Legend:

Code	Patient origin
1	Not specified
2	All
3	Own home

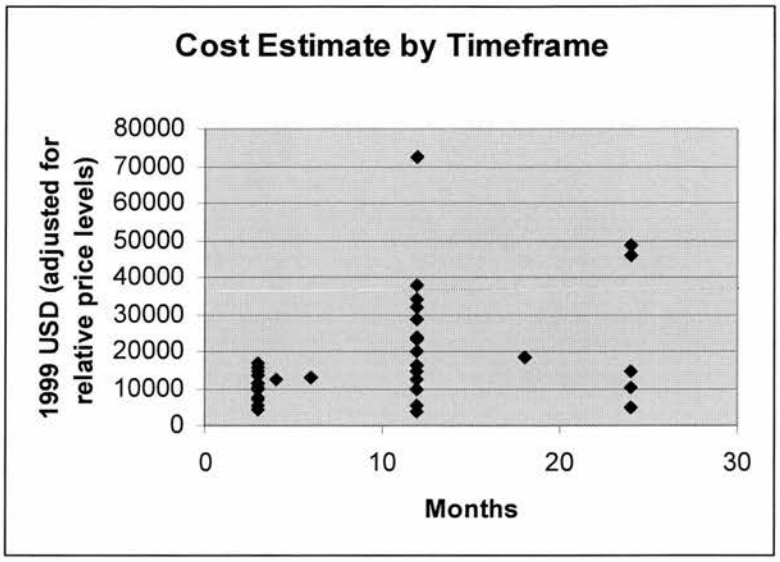
Summary

It appears that the observed differences in costs associated with hip fracture cannot be readily explained by differences in the underlying patient samples alone. Neither the year the study was conducted, nor the country, the age, sex and dependency profile of studies, as approximated by pre-fracture accommodation, could be shown to have a robust link with the study estimate. The only variable which appeared to bear an impact on a study's cost estimate was the length of stay in acute care and the use of any type of control group. The direction of that association though appears to suggest that this relationship may be indirect, though a third factor, possibly related to the methodology of a study's cost model. The next section therefore explores the question whether the variation in study results may be better explained not just by what was measured but how it was measured. Three main differences in methodology were observed with respect to this. These were the timeframe which was used for the study, the type of cost data which was collected and the costing methodology which was employed to attribute this cost data to hip fracture. Their relationship with studies' cost estimates are now examined in turn.

7.4.8. Timeframe of Study

As one might expect, there appears to be an increase in the costs associated in hip fracture between the 3 and the 12-months studies *(Figure 7.11.)*. This is shown to be statistically significant at the 5% level by the Mann-Whitney U Test (U-statistic = 34; Asymp. Sig, (2-tailed) 0.012). There was thus a statistically significant difference between the mean cost estimates of studies assessing the costs of hip fracture during 3 months and one year.

Figure 7.11. Relationship between Cost Estimate and Timeframe



7.4.9. Type of Cost Data Collected

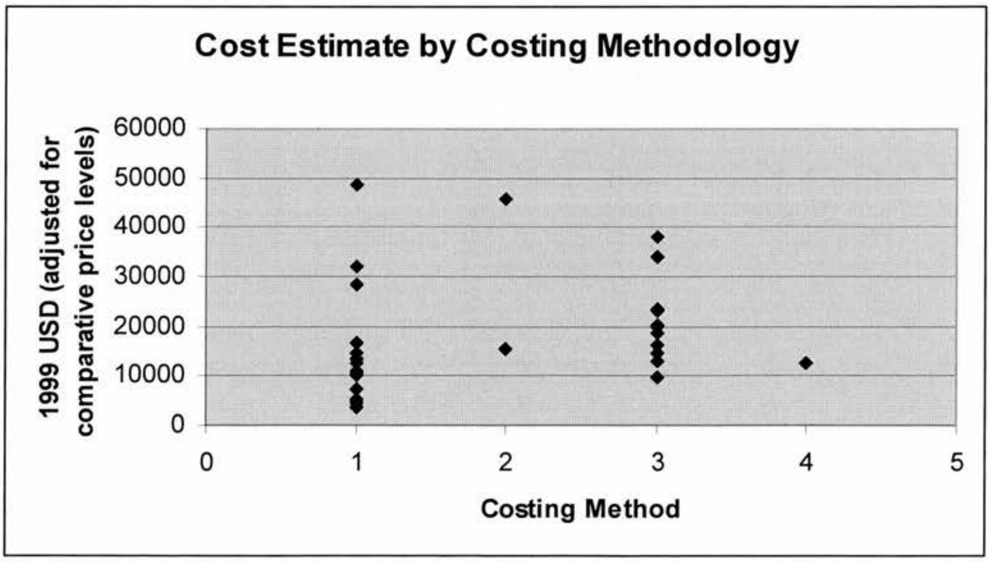
Maybe studies arrived at different cost estimates because they measured different things by including different types of care in their studies. There were 7 studies which by virtue of their methodology (detailed acute care costs, inclusion of social care costs and marginal costing methodology) were able to give a more comprehensive and directly attributable cost estimate of the costs of hip fracture. On the face of it, estimates associated with these studies (average $24,127) do appear to be higher than studies which made different methodological choices (average $17,392). However, given the very few studies involved, these differences could not be shown to be statistically significant.

The inclusion or exclusion of long-term care costs does also not appear to lead to statistically significant differences in hip fracture cost estimates (Mann-Whitney, U = 64, Asympt. Sig. (two-tailed) 0.06). Any direct relationship between the types of costs included in a study and its cost estimate therefore remains inconclusive.

7.4.10. Costing Methodology

The last variable associated with model 'inputs' and 'processes' to be examined is the costing methodology of a study and how it relates to the magnitude of results. Studies with a more detailed average costing methodology showed similar variation in their estimates as average costing studies. *(Figure 7.12.)* However, this effect must be seen in the light of the large discrepancy between the numbers of studies employing the different costing methodologies. Contrary to what one might expect, the results of marginal costing studies appeared to be situated towards the middle to upper end of the range encountered in average costing studies. This tentative difference in the means of the two groups does not, however, hold up to the formal scrutiny of the Mann-Whitney U-Test (U=47, asympt. Sig. (2-tailed) 0.09). There does thus not appear to be a statistically significant difference between the mean cost estimates of studies using an average or a marginal costing methodology at the 5% level.

Figure 7.12. Relationship between Cost Estimate and Costing Methodology



Legend:

Code	Costing Methodology
1	Average
2	Average (more detailed)
3	Marginal
4	Unclear

7.4.11. Summary of Univariate Analysis

Examination of the methods used to estimate the costs associated with hip fracture showed the following. Neither the type of costs it included in its analysis, nor the costing methodology it employed appeared to have any statistically significant relationship with the results of the study. The timeframe of the study did appear to bear a systematic impact on a study's cost estimate though. Despite the described difficulties of comparing studies with respect to these factors, three have been shown in this univariate analysis to bear a systematic impact on a study's estimate of hip fracture costs. Among the factors to do with underlying patient or treatment characteristics, the length of acute stay was shown to be significant. With respect to study methodology, a study's timeframe and use of any type of control group were shown to significantly influence cost estimates. Univariate analysis was thus able to shed some light on the observed variation in cost estimates between studies.

7.4.12. Multivariate Considerations

Multivariate analysis would ideally have been the next step in attempting to shed further light on this issue. Considerable efforts were made to employ this type of analysis. However, the sample size available gave rise to concerns how reliable the results of such an analysis would be, even if they were powerful enough to show any meaningful results. As could be seen already from the univariate analysis, not all 34 studies gave information with respect to all the variables under examination. The actual sample size for the individual subgroups concerning these variables was thus much lower (Table 7.2.).

Table 7.2. Data Characteristics of Hip Fracture Studies

Variable	No. of Studies giving Information on this Variable	No. of Values the Variable Takes (if not metric data)	Type of Data
Year of Study	34		Ratio
Country	34	16	Nominal
Treatment Algorithm/ Length of Stay	23		Ratio
Control Group	32	4	Nominal
Age[93]	29		Ratio or Nominal
Sex[94]	32	3	Nominal
Patient Origin	24	3	Nominal
Timeframe	34		Ratio
Type of Cost Data Collected[95]	34	7	Nominal
Costing Methodology	33	3	Nominal

Of 34 studies only 16 provided some information with respect to aspects of all these 10 variables in a format amenable to multivariate analysis in principle. Only 3 of these variables were metric data. The nominal data categories could be reduced in the majority of cases only accepting a substantial loss of information. In addition, it is doubtful whether these variables are statistically independent of each other. The statistical power inherent in a non-parametric multivariate analysis of 16 studies with respect to 10 different variables which in the majority

[93] 29 studies overall provide information on the age of their patients. They do this in different ways though, either by giving an age inclusion criterion or the mean age of their patients. These two ways of reporting information about the age of the study group though usually cannot be converted into each other with the information given in the published study. The number of studies giving information on this which could be used for multivariate analysis is thus lower.
[94] Rather than a new, third sex, the 3 number of values the variable could take reflect the fact that studies could be conducted on either men, women or include both.
[95] The 7 different values this variable could take were in addition not all mutually exclusive.

also took several different values is thus doubtful. Multivariate analysis does in the case of the existing hip fracture literature not appear to be able to shed much additional light on the question of why cost estimates differed so much between studies.[96] Instead, a closer look at an individual study's patient sample and methodological choices, however, may, yield additional insights into the study results. These might throw additional light onto the issue of whether cost variations reflected true differences in resource consumption and also therefore the transferability of results to different contexts. This is illustrated in the following section by the individual comparison of Tayside's results with those of existing British studies. Studies are compared along the same dimensions as the aggregate comparison in the preceding paragraphs.

7.5. Comparison with Existing British Studies

Starting closest to Tayside, one other Scottish study was identified among published original cost-of-illness studies. French, Torgerson, Porter (1995) estimated the costs of hip fracture to be between 1994 £2,069 and £4,018 in Aberdeen, depending on whether people came from an institutional setting or from their own home. The equivalent range in 1999 US$ (unadjusted for different price levels) would be between $3,583 and $7,646, depending on the method used for conversion. French's estimate of the average costs of hip fracture would thus appear to be around $5,615. The equivalent estimate of the average cost of hip fracture in the 4-month Tayside model is $11,740. Similar to the sample the Tayside model is based on, French's sample included both men

[96] This was also the advice given by Dr. P. Jupp of the Mathematics and Statistics Department of the University of St Andrews in a discussion with the author in July 2002.

and women. Although the sex distribution was similar in the two patient samples, French's women were almost three years and the men almost seven years older than their Tayside counterparts. Although the number of patients who were relatively independent pre-fracture was very similar, it appears that French's sample included a higher proportion of patients from long-term care. This is difficult to verify with certainty though as different information was collected about patients' pre-fracture location in the two datasets. French does not report a single figure for overall mortality, however, their mortality rate appears higher than Tayside's. Overall, based on what was also found in Tayside, the higher proportion of patients from long-term care as well as French's higher mortality might go some way towards explaining French's lower cost estimate. The following section examines whether methodological differences add to this understanding.

French's cost estimate appears to be lower in both cost components, acute care costs and follow-up costs. Hence, the cost difference cannot be explained solely by differences in one of the component costs. The mean and median length of stay in the orthopaedic ward in Tayside were 16 and 13 days respectively. French's equivalent (of the early 1990s) was 17 and 12 days. Patient's length of stay does therefore no appear to hold the key to explaining the difference in costs between the two studies.

French's estimate is based on average costing. They were able though, to incorporate differences in patients' resource consumption with respect to the operation, recovery room, radiotherapy, ECG, laboratory tests and physiotherapy into their cost estimate.

Their estimate of the average acute cost of a hip fracture patient was approximately £154 in 1993/4. This was less than the official average daily charge of £189[97] in Aberdeen Royal Infirmary's orthopaedic ward at the time. Even the latter figure is less than the equivalent charge in Tayside even after inflation is taken into account. These differences appear to be due to both patient-related and non-patient' related costs (isd Handbook of Scottish Health Service Costs, 1993/4). This difference in unit costs would seem to account for much of the difference in acute care cost estimates between the two studies. The difference in follow-up cost estimates between the two studies appears to be two-fold, to do with timeframe and employed unit costs.

French's timeframe was shorter. They measured resource consumption for only three months after the hip fracture compared to four months in the case of Tayside. One would therefore expect their cost estimate of non-acute costs to be lower than that of the 4-month Tayside study. The remaining difference in follow-up costs may be explained by the difference in unit cost estimates associated with patients' location after discharge from the orthopaedic ward. French do not provide unit cost estimates for all cost items. However, the costs associated with a stay in a rehabilitation ward may illustrate this issue sufficiently. They obtained their per diem cost estimates for different kind of institutions and rehabilitation wards from the social services of the area. The Tayside model utilised the Tayside social services equivalents. So the source of the cost data for non-acute care should not in itself hold the key to explaining the observed cost differences. In principle, all social services agencies should adhere

[97] The isd handbook of Scottish Health Service Costs lists £205 in the same year as French and colleagues quote £189.

to similar accounting standards, allowing comparison between an Aberdeen and a Tayside cost estimate. However, they report significant differences in per diem costs of rehabilitation, seemingly depending on whether the unit was located in an urban or rural context. In 1993/4 £s, these costs varied between £40 in some rural hospitals and £110 in the main rehabilitation unit in Aberdeen. A difference was observed between different social services agencies per diem quotes, however, these differences did not appear to be as large as in Aberdeen.

Summary

French's estimate of the costs associated with hip fracture in the three months following the fracture is around half that associated with the condition in the four months following the fracture in Dundee.

French's estimate appears to be lower due to a number of different factors. Differences were observed in acute costs. These appear mainly to be due to a lower daily cost estimate in Aberdeen than in Tayside. The differences in non-acute follow-up costs appear to be due to the timeframe employed as again lower daily cost estimates for institutional care and rehabilitation in Aberdeen than in Tayside.

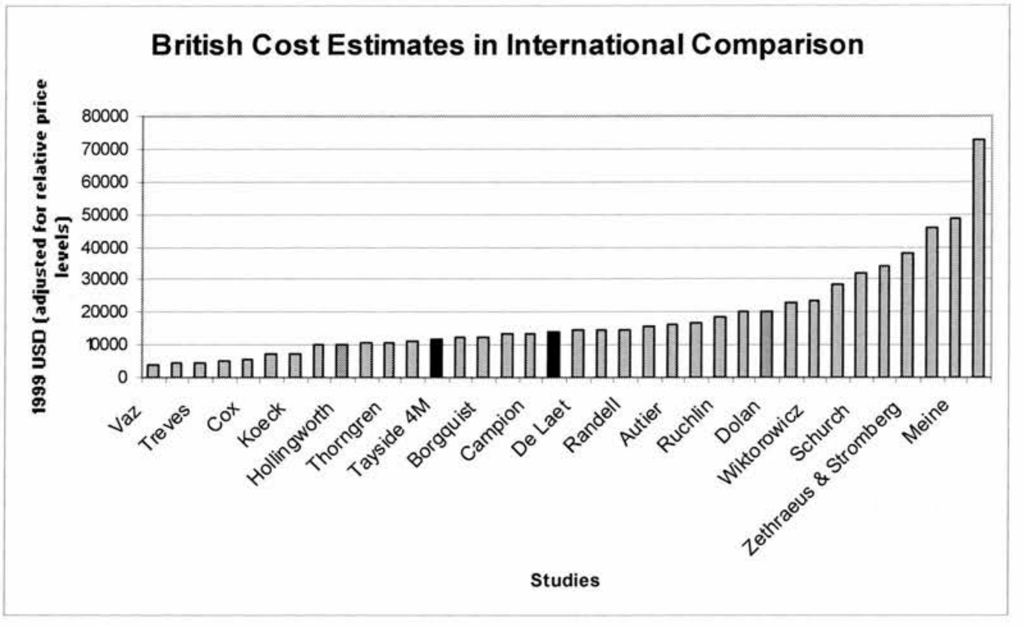
Although French's estimate was markedly lower than the Tayside model's estimate, both studies' estimates of the costs associated with hip fracture were at the lower end of the spectrum across all published original cost studies.

The following section compares the Tayside model's estimates with those of the two other identified British studies.

Two other published studies were identified which used original British cost data. They are shown in international comparison in Figure 7.13., 7.14. and 7.15. in order to illustrate graphically the order of magnitude of similarities and differences between studies which were all conducted in one country compared to studies from other countries. The lower estimate was Hollingsworth's at approximately \$9,919, represented in the darker grey column on the left hand side in the diagram below. The 4-month Tayside model's estimate was \$11,740 which is represented by the left one of the two black columns in *Figure 7.13.* The black column to the right represents the 12-month Tayside estimate of \$13,932. The dark grey column on the right hand side represents Dolan's estimate of \$20,140.

On the surface, the timeframes of Hollingsworth and the four-month Tayside estimate might provide some explanation for the similarity of the two studies' results. However, this does not hold for Dolan and the twelve-month Tayside estimate.

Figure 7.13. British Cost Estimates in International Comparison



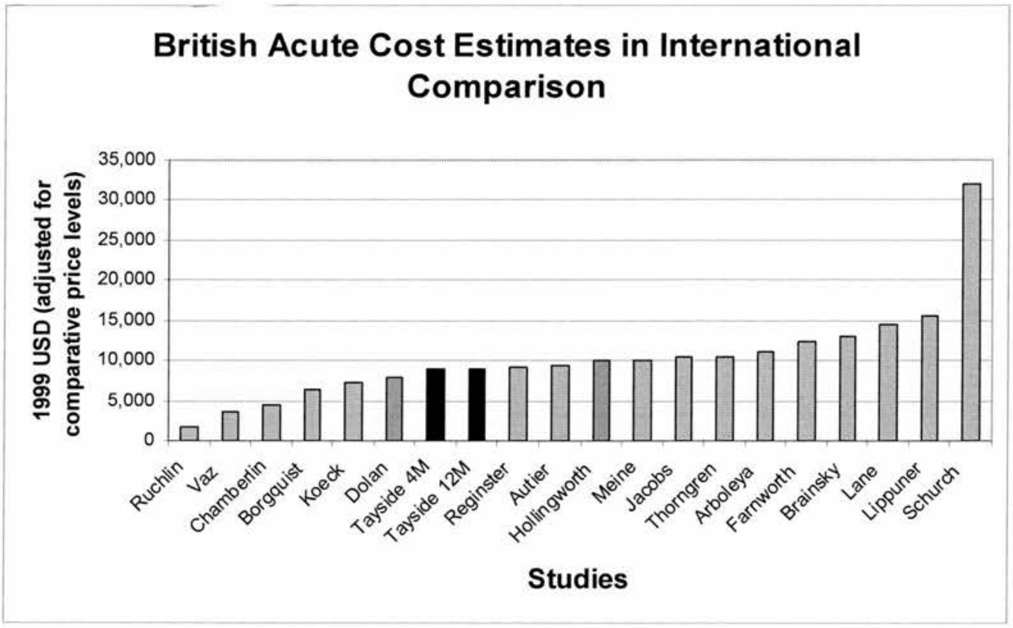
When the cost components of acute care and follow-up are separated, the following picture emerges *(Figure 7.14)*. Dolan's are the lowest acute care costs at \$7,986. Tayside's follow at \$8,948. Hollingsworth's acute costs are the highest of the three at \$9,979. The most likely explanations for this difference might be found in studies' different definitions of acute care and the costing methodology employed.[98] Hollingsworth's length of stay figures were considerably longer.[99] None of Hollingsworth's papers on this dataset gives any of the unit cost estimates used, leaving this unexplored as an explanation for overall lower costs. As a results, Hollingsworth's higher acute care cost estimate could thus possibly

[98] The definition for this acute care component of the Tayside model included only the primary stay in the orthopaedic ward. No rehabilitation was included. In contrast, Hollingsworth's estimate includes also rehabilitation. The authors did not provide a separate cost estimate for acute and rehabilitation care.

[99] Hollingsworth's calculations include an average 14.58 and 16.69 day stay in the orthopaedic ward for women and men respectively. On top of this women stayed on average 19.81 days in a rehabilitation ward, men an average of 24.17 days. These figures are significantly higher than the length of stay recorded for Tayside's patients. The mean length of stay of the 449 Tayside patients was 16.23 days on primary admission in the orthopaedic ward and an average of 13.09 days in rehabilitation wards. Overall, Hollingsworth's patients thus spent 34.39 days (females) or 38.75 days (males) as an inpatient, compared to Tayside's 29.32 days.

be explained, by the information given in the published literature, by their acute costs also including rehabilitation costs as well as a significantly higher average length of stay.

Figure 7.14. British Acute Cost Estimates in International Comparison



One reason for this higher average length of stay might be the fact that the epidemiological data was collected in the late 1980s and early 1990s. One of the advancements in the treatment of hip fracture made since then appears to be the shortening of the time the affected individual has to spend in hospital. Dolan's study can only be used to verify this to a certain extent because they based their estimate of length of stay on Hollingsworth's figures, adjusted for shorter length of stay and inflation. Dolan and colleagues found from Department of Health statistics that the average length of stay in the UK in the middle to late 1990s was around 20 days. They thus use this shorter length of stay. The length of stay of 20 days used in Dolan's model is thus considerably less than that of Tayside (29 days) or French (29 days). One explanation of this difference might again be that Dolan's 20 day estimate only included acute care and not rehabilitation. However, the published paper does not allow a more detailed examination of this issue. Neither Dolan, nor Hollingsworth allowed the comparison of the unit costs used for the costing. It thus remains unclear why exactly Dolan's estimate of acute care costs should be higher than the Tayside model's despite a considerably shorter length of stay.

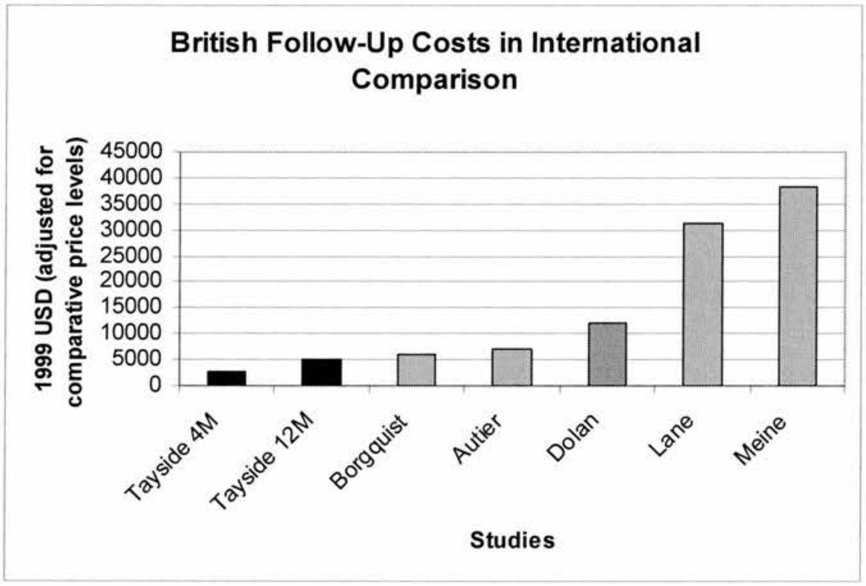
Summary

Although Hollingsworth's estimate at first glance appears to be significantly lower than the Tayside model's and Dolan's estimate, the examination of the acute care cost component of these total costs reveals that in fact Hollingsworth's is not the lowest estimate at all. On the contrary, Hollingsworth's is the highest estimate of the acute care costs associated with hip fracture of the identified published original studies based on British data. The reasons for this appear to be the definition of acute care, timeframe of the analysis, the choice of costing methodology, as well as length of stay. Some of these were modified and updated by Dolan in their study to yield an acute care estimate slightly higher than the Tayside models, in the context of all cost estimates, however, it appears remarkably similar.

Figure 7.15. shows how the different British studies estimates compare in terms of follow-up costs. The figure shows a drastically reduced number of international studies these British estimates can be compared to. This does not reflect on existing studies' methodologies so much as their reporting style which

does not always give separate cost estimates for the acute and follow-up cost components of the study. Among British studies, Hollingsworth only estimated hospital-based costs which leaves only Dolan's study for comparison with the Tayside estimates. Dolan estimated the non-acute costs of hip fracture to be $12,153 in the 12 months following the fracture, compared to the 12-month Tayside model's $4,987. It appears that Dolan's higher estimate might be due to the extrapolation from 6 to 12 months, their inclusion of non-acute health care resource consumption or higher unit cost estimates employed. However, not enough detailed information is provided to judge this for certain.

Figure 7.15. British Follow-up Cost Estimates in International Comparison



Summary

Overall, the two English estimates of the costs associated with hip fracture are higher than French's Scottish estimate. Dolan's is also higher than the Tayside model's cost estimates. It is possible to explain this in part with reference to studies' patient characteristics, different length of stay figures, different methodologies of analysis and different underlying unit cost estimates. However, the information contained in all the UK papers reviewed do not allow us to say with certainty why studies' cost estimates differed. It was shown, however, that overall, the British cost estimates were more similar in comparison to those of other countries than it may have appeared at first glance. However, as the comparison with Dolan showed, discrepancies in the costs associated with hip fracture exist even among British studies with seemingly similar methodologies. This confirms to a certain extent what was found earlier in the chapter in the context of comparing different countries' cost estimates. Differences between countries were in many cases no bigger than differences between cost estimates derived from different studies in the same country.

7.6. Conclusions

This chapter began with a comparison of the costs associated with hip fracture across the world. In comparison, both the costs associated with hip fracture in Tayside in the four and the twelve months following the fracture appear to be located near the lower end of the middle of cost distributions. Both estimates are located near the lower end of cost estimates when the actual amounts involved are considered. Puzzled by the vast differences in costs associated with the condition across the world, the question was explored whether cost estimates were significantly influenced by characteristics of the patient sample they were based on or by differences in study methodology. Comparisons were hampered by the small numbers of studies which allowed the comparison of model inputs, methods and outputs in a consistent and comprehensive fashion.

Bearing this in mind, it was shown that among all the characteristics of the patient sample which were considered, only acute length of stay appeared to have a significant influence on cost estimates. Examination of the methods used to estimate costs showed the following. Among the methodological factors examined, the use of any type of control group and a study's timeframe were shown to lead to systematic differences in a study's estimate of hip fracture costs. Due to the difficulties encountered in standardising studies and studies' heterogeneous reporting of study inputs, processes and results though, it is difficult to say with any certainty though if not other factors but these three might have been the cause of the variation observed in cost estimates. The more detailed comparison of British studies confirmed this possibility. Factors related to characteristics of the patient sample or study methodology were able to explain at least some of the variation observed among studies from the same country.

As a by-product of trying to answer the question why cost estimates varied so much an equally important issue emerged, that of the quality of research design and reporting of methodology. It emerged that studies were extremely variable in what they were measuring as well as in how they were measuring it. This makes them difficult to compare over time and across countries.

Given that studies' timeframes were shown to have a systematic impact on hip fracture cost estimates, the next chapter attempts to use an innovative approach to explore further the question which timeframe is the most appropriate for studying the costs of hip fracture. The fact, that the costs associated with hip fracture in many studies increase as the timeframe increases itself does not pass judgment on the accuracy of that estimate. The next chapter attempts to explore this by resorting to data related to patients' functional outcomes following the hip fracture.

8. Patients' Physical Functioning and a Re-Assessment of Hip Fracture Costs

8.1. Introduction

Health was defined by the WHO in 1948 as a state of complete social, psychological and physical well-being (World Health Organisation, 1948). Although most of us would never be in a state of health by this definition, it does illustrate that the concept of health needs to embrace a number of different elements. Most measures of health status seek to assess deviations from health and thus really measure ill health. The WHO's utopian vision of health has led to a search for broader-based definitions of health than a narrow disease-focused one (Seedhouse,1986). The only agreement there seems to be is that health is more than the mere absence of disease and disability. It also encompasses a notion of 'completeness' and 'full functioning' of mind and body as well as social adjustment (Bowling,1997, p. 5). Lamb (1988) describe positive health as the ability to cope with stress, the ability to maintain a strong social-support system, the ability to integrate into a community, general satisfaction with life, psychological well-being as well as physical health. Functional ability as one measure of physical health appears fundamental to most people's ability to perform social roles. This chapter seeks therefore first of all to gain additional understanding of the physical functioning of Tayside's hip fracture patients. This adds to our understanding of hip fracture in two ways. First, only a minority of publications containing original hip fracture cost data contain any information at all about any aspect of the functional status of patients. Of those 6 that do, most concentrated on using pre- and/ or post-fracture functional outcomes data to draw conclusions about which patients would cost more (Borgquist, et al. 1991; Sernbo and Johnell 1993; Wictorowicz, et al. 2001; Meine, et al. 1993; Campion, et al. 1987; Chamberlin, et al. 1997). Conflicting findings emerged. Chamberlin and colleagues (1997) for example found that neither pre-fracture place of residence, nor functional or mental status had any influence on cost variation. In contrast, Borgquist and colleagues (1991) found that age, pre-fracture ability to cook and clean, the patients' sex and pre-fracture place of residence were the most discriminating factors in relation to cost.[100] Including all published economic evaluations dealing with hip fracture increased the available information.[101] However, only 4 of all full economic evaluations of hip fracture prevention or treatment regimens provided any original information at all, in any shape or form, at the detailed level of their subjects' functional assessment, as opposed to overall QALYs for example (Ankjaer-Jensen, et al. 1996; Jensen, et al. 1980; Kramer, et al. 1997; Parker, et al. 1992). Two further studies in this group provided information on functional assessment, using secondary data (Chrischilles, et al. 1991; Jonsson, et al. 1996). Searching Medline for different permutations of 'osteoporosis', 'hip fracture', functional assessment' and 'quality of life' until the end of 2001 as well as hand-searching relevant journals for additional sources of information with respect the functional outcomes of hip fracture patients further added to this knowledge. The following emerged: Much of the literature on quality of life and functional assessment of these types of patients is just as difficult to compare as the cost literature. This is due, again, to

[100] These contradictory findings may be partly explained by the different timeframes of the two studies.
[101] This refers to the studies identified and reviewed for chapter 4. See chapter 4's methodology section for details of the search strategy.

differences in the underlying patient groups with respect to for example, age, sex, treatment and pre-fracture place of residence. In addition, generic and disease-specific quality of life and functional outcomes are measured in these studies with many different instruments and scales (see also Chrischilles, et al. 1991). Most of the quality of life assessments were based on expert judgment (see also Tosteson, et al. 2001). Compared to patients' own assessment though, this has been shown to overestimate the loss of quality of life due to hip fracture (Ankjaer-Jensen, Johnell 1996). As in the functional assessments of original cost studies, most of the literature focuses on the use of functional assessment pre- and /or post-fracture in order to isolate factors which can identify patients' at risk of adverse long-term outcomes during a study's follow-up period. The dimensions most frequently examined include patients' indoor and outdoor walking ability, pain and independence in activities of daily living, such as getting dressed and shopping for groceries.

It has been mentioned that there is a second reason why the physical functioning of Tayside's hip fracture patients is of interest in the context of cost assessment. Most studies use a change in accommodation as the main way of assessing extra, non-acute resource consumption which is attributed to a sustained hip fracture. Although the issue has been flagged up in the literature, few studies attempt to estimate explicitly what percentage of changes in accommodation are due to patients' advanced age or co-morbidities and which are explicitly due to the sustained hip fracture. In order to present an accurate picture of the resource implications of hip fracture as a basis for making policy, it is, however, necessary to distinguish between these two. The analysis underpinning this chapter attempts to use data on patients' physical functioning to make that distinction. The chapter thus presents the results from an analysis of the patient sample's functional ability with respect to their ability to walk, dress and experience of pain over the study period. The next section describes the methodology according to which this data was collected. Subsequent sections explore how patients' functional ability developed over time and its possible relationship with resource consumption.

8.2. Methodology of Data Collection

Information was collected as part of the Dundee Hip Fracture Audit on a several aspects of patients' physical functioning. As the patient was hospitalised immediately following the fracture, a dedicated Audit nurse collected data concerning the pre-fracture status of the patient with respect to the patient's general locomotor ability before the fracture as well as their use of walking aids for indoors use. Patients' walking ability was classified as follows:

- Could walk alone out of doors
- Could walk out of doors only accompanied
- Could walk alone indoors but not out of doors
- Could walk indoors only accompanied
- Could not walk but was sitting in a chair
- Always bedridden

Patients were divided into the following categories relating to their indoors use of walking aids:

- Can walk without aids
- One stick (crutch or tripod, hemiwalker)
- Two sticks
- One stick + one tripod
- Two tripods
- Rollator/ walking frame
- Wheelchair
- Does not walk

Four months and one year after their hip fracture, patients were contacted by an Audit nurse again, mainly by telephone, to answer another questionnaire. This questionnaire included questions about patients' walking ability at that point in time, patients' experience of pain and whether they could dress and undress themselves. The questions about their walking ability sought to gain a relatively more objective picture of their functional ability as well as a subjective one of patients' perception of their walking ability four months and one year after the fracture. The questions posed were the following:

How good is your walking ability?

- Can walk alone out of doors
- Can walk out of doors only accompanied
- Can walk alone indoors but not out of doors
- Can walk indoors only accompanied
- Can not walk but is sitting in a chair
- Always bedridden

Which walking aids do you use indoors now?

- Can walk without aids
- One stick (crutch or tripod, hemiwalker)
- Two sticks
- One stick and one tripod
- Two tripods
- Rollator/ walking frame
- Wheelchair
- Does not walk

Do you walk equally well now as before the fracture?

- Yes
- No, the fractured hip gives me problems
- No, for other reasons

Do you have pain when you put weight on the operated extremity?

- Yes, quite a lot
- Yes, a little
- No, not at all

Have you taken analgesics several days during the last week because of pain from your hip?

- Yes
- No

Can you dress- undress yourself?

- Yes
- No

8.3. Pre-Fracture Mobility

Before proceeding to the comparison of patients physical functioning over the study period, patients' pre-fracture walking ability and use of walking aids is described.

8.3.1. Walking Ability

Prior to their hip fracture, less than half of all patients were able to walk alone outdoors. 78% of all patients, however, were able to walk alone either indoors or outdoors. *(Table 8.1)*

Table 8.1. Pre-Fracture Walking Ability

	% of whole dataset
Could walk alone out of doors	41
Could walk out of doors only accompanied	8
Could walk alone indoors but not out of doors	37
Could walk indoors only accompanied	11
Could not walk but was sitting in chair	3
Always bedridden	0

Next, this information is complemented by exploring to what extent patients needed the help of mechanical walking aids to achieve this level of walking ability prior to fracture.

8.3.2. Use of Walking Aids

Just under half of all patients were able to walk indoors without the use of walking aids prior to fracture. *(Table 8.2.)* The majority of patients needed one or more walking aids to move around indoors at this time. Around three-quarters of patients were thus able to get around indoors with minimal or no help. The remaining quarter was, however, dependent on several aids already before the fracture.

Table 8.2. Pre-Fracture Indoors Use of Walking Aids

	% of whole dataset
Can walk without aids	45
1 stick (crutch or tripod, hemiwalker)	25
2 sticks	4
1 stick and 1 tripod	18
2 tripods	8
Rollator/ walking frame	0
Wheelchair	0
Does not walk	0

Prior to their hip fracture, half of all patients were thus independent with respect to their ability to walk. The other half already exhibited a precarious grasp on that most basic of functions for leading an independent life.

8.4. Comparison of Pre- and Post-Fracture Mobility

On the basis of the described pre-fracture status, it can now be explored how patients' walking ability, experience of pain and ability to dress developed in the year following the fracture.

8.4.1. Walking Ability

Four months post-fracture, 38% of patients had regained their pre-fracture walking ability. 10% actually walked better than before their fracture.[102] 29% of survivors walked less well than before even after four months had elapsed. *(Table 8.3.)* Data was missing on only 1% of patients and 22% of patients had died by this stage.

Table 8.3. Comparison of Walking Ability Pre- and 4-Months Post-Fracture

	% of whole dataset[103]
Better	10
Worse	29
Same	38

Twelve months after the fracture, the following picture emerges. *(Table 8.4.)*

[102] Although this could not be explained on the basis of the gathered data, one possible explanation might be related to the accuracy of patients' self-assessment of their walking ability. Another might be that the surgery (e.g. hip replacement) and physical rehabilitation received in the wake of the fracture might conceivably have led to this improvement. This phenomenon has also been observed by Keene, et al. 1993., who found that 1% of subjects using sticks or a walking frame prior to the fracture has improved on their pre-fracture levels twelve months post-fracture.

[103] The figures in this column add up to 100% when those 22% of patients are added who died and the 1% of patients whose data was missing, as indicated in the text immediately prior to the table.

Table 8.4. Comparison of Walking Ability after 4 and 12 Months

	% of whole dataset[104]	% of survivors
Better	21	32
Worse	17	26
Same	28	43

Although almost half of all patients had managed to sustain their level of walking ability between four months and a year following the hip fracture, more than half of the surviving patients, 58%, experienced a change in walking ability. One third of survivors' ability to walk improved, that of a sizeable 26% though declined. *Table 8.5.* summarises patients' walking ability one year after the fracture compared to prior to the fracture.

[104] The figures in this column do not add up to 100% because for enhanced carity, they do not include those who died (see chapter 6, section 2) or those whose data was missing at that point in time (see chapter 5, section 5.2.2.4.).

Table 8.5. Walking Ability 12-Months Post-Fracture

Walking Ability[105]	Could Walk Outdoors Alone or Accompanied	Could Walk Alone Indoors, But Not Outdoors	Could Walk Indoors Only Accompanied	Not Able to Walk (Sit in Chair or Bedridden)	Mortality	Total No. of patients
Could Walk Alone or Accompanied Out of Doors Pre-Fracture	65% (32%)	8% (5%)	8% (1%)	2% (1%)	17%	**218**
Could Walk Alone Indoors, But Not Outdoors Pre-Fracture	12% (5%)	21% (8%)	12% (4%)	10% (4%)	45%	**168**
Could Walk Indoors Only Accompanied	2% (0%)	8% (1%)	15% (2%)	19% (2%)	56%	**48**
Not Able to Walk (Sit in Chair or Bedridden)	7% (0%)	13% (0%)		27% (1%)	53%	**15**
Percentage of total 449 patients[106,107]	**37 %**	**14%**	**7%**	**8%**	**33%**	**66%**

The twelve-months mortality rate of around 50% among patients who even pre-fracture were only mobile indoors is striking. The table also illustrates how many more of the more independent future hip fracture patients[108] recovered or even improved their walking ability one year after the fracture. In contrast, among the most dependent people[109], the likelihood of dying or losing the ability to walk in any shape or form completely was much higher than the likelihood of recovering

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[105] The number refers to the percentage of patients whose walking ability fell into this category pre-fracture. The number in brackets refers to the same number of patients but expressed as a percentage of the total number of 449 patients comprising the whole dataset.

[106] Percentage figures were rounded and may thus not add up to 100%.

[107] The 66% figure refers to the percentage of total patients referred to in the column above under "total number of patients" for each category of walking ability. The number of patients covered by the information in the table (if one ignores the rounding error) is thus 99%: 66% plus the 33% mortality referred to in the last row of the same table.

[108] Those able to walk outdoors, alone or accompanied, pre-fracture.

[109] Those not able to walk at all, or only able to walk even indoors accompanied prior to the fracture.

or improving. The patients falling into these more dependent categories were, however, not shown to be significantly different in age (Mann-Whitney U-test, U=10550, asympt. Sig. (2-tailed) 0.092). Age does therefore not appear to be the reason for the difference in recuperation and mortality rates between these two broad categories of patients.

8.4.2. Indoors Use of Walking Aids

A third of all patients used the same amount of walking aids four months after their fracture compared to before. 5% managed to decrease their use of indoors walking aids during this period. However, more typically patients' use of walking aids increased. *(Table 8.6.)*

Table 8.6. Comparison of Walking Aids Pre- and 4-Months Post-Fracture

	% of whole dataset[110]
More	39
Less	5
Same	33

As with patients' walking ability in the previous section, mortality was most striking for those patients with the frailest grasp on mobility prior to the fracture *(Table 8.7.)*. Again, the most independent patients who used no walking aids indoors mostly regained their function. Those using any number of walking aids indoors already prior to the fracture were at far more risk of their use increasing twelve months after the fracture.

[110] Again, this table excludes mortality and missing data and thus does not appear to add up to 100%. See footnote to Table 8.3.

Table 8.7. Indoor Use of Walking Aids 12-Months Post-Fracture

Indoors Use of Walking Aids[111]	No Aids	1 Stick	Several Aids [112]	Rollator/ Walking Frame	Wheelchair / Does Not Walk	Mortality	Total No. of Patients
No Aids Pre-Fracture	41% (19%)	18% (8%)	3% (1%)	9% (4%)	6% (2%)	23%	204
1 Stick Pre-Fracture	8% (2%)	18% (4%)	7% (2%)	16% (4%)	12% (3%)	39%	112
Several Aids Pre-Fracture[113]	5% (1%)	5% (1%)	2% (0%)	22% (7%)	18% (5%)	48%	133
Total as % of 449 patients[114]	22%	13%	3%	15%	10%	33%	63%

Table 8.8. summarises the evolution of patients' indoors use of walking aids between four and twelve-month post-fracture.

Table 8.8. Comparison of Walking Aids after 4- and 12-Months

	% of whole dataset[115]	% of survivors
More	28	43
Less	19	30
Same	18	27

Although 19% of patients, almost one third of survivors, managed to decrease their use of indoors walking aids between four and twelve months after their fracture, almost half of all survivors, 28% of the total, were dependent on more walking aids one year after the fracture compared to the time of the first follow-up.

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[111] The percentage indicates the percentage of patients in this pre-fracture category. The percentage in brackets indicates the same expressed as a percentage of the total 449 patients of the dataset.

[112] This includes people using either 2 sticks, 1 stick and 1 tripod or 2 tripods.

[113] This includes people using either 2 sticks, 1 stick and 1 tripod or 2 tripods.

[114] This row adds up to less than 100% due to missing data for this data item. And again, as in Table 8.5., the 63% total number of patients is the sum of the numbers in the column above it, rather than the sum of this row.

[115] As in the tables prior to this one, this column does not add up to 100% due to missing data and mortality.

The following section investigates whether these developments in patients walking ability as measured by these relatively more objective means (compared to patients' perception) was mirrored in patients' own perception of their walking ability.

8.4.3. Perception of Walking Ability

60% of patients reported their walking ability to have declined four-months post-fracture compared to before the fracture. *(Table 8.9.)* Markedly more patients thus considered their walking ability to have declined, than was in evidence from the analysis of walking ability presented above: Table 8.3. showed that 29% of patients' experienced a decline in walking ability as defined by patients' ability to walk in- and outdoors with or without being accompanied. *Table 8.5.* reported a need for more indoors walking aids experienced by 39% of patients. Both objective assessments of walking ability thus reported a decline for less patients than patients' own assessment. But: Only slightly more then half of the patients considered this decline to be directly linked to their fracture

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Table 8.9. Patients' Perception of Comparative Walking Ability Pre- and 4-Months Post-Fracture

	% of whole dataset[116]
Walk equally well as before fracture	17
Walk less well because of fracture	37
Walk less well because of other reasons	23

Of the 37% of patients who were of the opinion that they walked less well four months after the fracture than before, the majority, 16% of all patients, said that

[116] As explained in previous tables, this column does not add up to 100% due to mortality and missing data.

this situation had neither improved nor declined twelve months post-fracture. The majority of the remainder, 14% of all patients, considered their walking ability to have declined between four and twelve months, but not for reasons they readily associated with the fracture.

7% of all patients who at four months had reported a decline in walking ability for reasons unconnected to the fracture, at twelve months reported an additional decline in walking ability which they connected with the fracture. Overall, 8% of the total patient sample (12% of those who survived for a year post-fracture) reported a decline in walking ability between four and twelve months when they had thought they walked equally well after four months as before the fracture.

These figures show that both patients' objective walking ability as well as their subjective perceptions of it changed not only between the time of fracture and four-months follow-up. It continued to change between four months and twelve months after the fracture in a sizeable proportion of survivors.

The next sections explore three additional aspects of patients' quality of life: patients' ability to dress and undress on their own, their use of pain medication and their experience of pain related to the fractured hip. The latter is of particular interest since the existence of pain could possibly be easily remedied. The pain might indicate that there is scope for improving the treatment of the fractured hip somehow for these patients. Apart from that, the existence of pain might be partially to blame for the poor mobility of some patients. Addressing the pain might therefore lead to a relatively easy remedy for some of the mobility problems.

8.4.4. Pain

Four months after their fracture, 9% of all patients still experienced a lot of pain when they put weight on the operated extremity. Another 29% of patients experienced 'a little pain' in the same situation, while the majority of surviving patients, 39% of the total, experienced no pain at all.

A narrow majority of patients, 55% of the total, had not taken analgesics several times per week for pain in their fractured hip in the week prior to the four-month follow-up. However, this left more than half of all patients who experienced anything upwards from 'a little pain' regularly dependent on painkillers four months post-fracture.

Twelve months post-fracture, the majority of patients were without pain *(Table 8.10.)*. However, almost half of all patients living in their own homes at that point in time experienced everything from a little to a lot of pain in their hip.

Table 8.10. Experience of Pain 12-Months Post-Fracture

Experience of Pain 12-Months Post-Fracture	Yes, a lot.	Yes, a little.	No, not at all.
% of total 449 patients[117]	6%	20%	39%
% of those living in their own homes 12-Months Post-Fracture	12%	35%	54%

The majority of patients experiencing pain at that point of time did appear to take analgesics for the pain on a regular basis (13% of the total of 449 patients). Less than half of the patients experiencing pain who were living in their own homes did so though (*Table 8.11.*).

[117] As explained in previous tables, this row does not add up to 100% due to mortality and missing data.

Table 8.11. Use of Analgesics 12-Months Post-Fracture

Use of Analgesics at 12-Month Post-Fracture	Yes	No
% of total 449 patients[118]	13%	52%
% of those living in their own homes at 12-Months Post-Fracture	22%	78%

Comparatively speaking, twelve months post-fracture, most patients' use of painkillers was identical to that after four months. *(Table 8.12.)* Only slightly less than one fifth of surviving patients each, however, experienced a decline or an increase in the consumption of painkillers during this time period.

Table 8.12. Comparative Use of Painkillers 4-Months and 12-Months Post-Fracture

	% of total[119]	% of survivors
Same	42	65
Less	12	19
More	11	17

For patients whose pain decreased between four and twelve months post-fracture, the data from this second follow-up period mirrors their experience of pain. A further 24% of all patients (37% of survivors) though experienced an increase in pain, most of which is thus not reflected in their use of painkillers. *(Table 8.13.)*

118 This row does not add up to 100% due to mortality and missing data, as explained before.

119 As explained in previous tables, this column does not add up to 100% due to mortality and missing data.

Table 8.13. Comparative Pain 4- and 12-Months Post-Fracture

	% of total[120]	% of survivors
Same	31	47
Less	12	18
More	24	37

It thus appears that pain is not the main underlying reason for many of the mobility problems encountered in this set of patients. However, there might be differences among patient groups. These are explored in the next section of this chapter, following the examination of patients' ability to dress independently.

8.4.5. Ability to Dress

Four months after the fracture, the majority of surviving patients, 54% of the total dataset, were able to dress and undress themselves. 23% of patients were not able to do so. Between four and twelve months after fracturing their hip, the majority of survivors did not experience any change in their ability to dress and undress. One-fifth of survivors improved during the same time span. Only a smaller proportion, 13% of survivors, experienced a decline. *(Table 8.14.)*

Table 8.14. Comparative Ability to Dress Independently 4- and 12-Months Post-Fracture

	% of total[121]	% of survivors
Same	45	69
Better	13	20
Worse	8	13

[120] As explained in previous tables, this column does not add up to 100% due to mortality and missing data.
[121] This column does not add up to 100% due to mortality and missing data.

Although many patients' walking ability thus declined in the wake of the fracture, patients' ability to dress and undress independently appears somewhat less affected. However, this is ultimately difficult to judge for certain since no comparative more objective pre-fracture data was collected.

Table 8.15. Ability to Dress Independently 12-Months Post-Fracture

Ability to Dress Independently 12-Month Post-Fracture	**Yes**	**No**
% of total 449 patients[122]	46%	19%
% of those living in their own homes 12-Months Post-Fracture	93%	6%

One year after the fracture, less than half of the original 449 patients were able to dress themselves independently *(Table 8.15.)*. Given the mortality rate of 33%, however, this represents the majority of survivors. Almost all of the patients living in their own homes at that point in time were able to dress and undress themselves. Examination of this aspect of functional outcome thus confirms that the choice of accommodation as an indicator of functional dependence of the study subjects may indeed provide a useful approximation of this variable, at least as far as the more independent patients are concerned. Accommodation in one's own home does therefore seem to indicate relative functional independence of the patient. Whether institutionalisation in turn indicates functional dependence is explored in section 8.5. following a summary of what has been found by comparing pre- and post-fracture mobility.

[122] This row does not add up to 100% due to mortality and missing data.

8.4.6. Section Summary

The analysis presented above has revealed that half of all patients' walking ability has recovered to pre-fracture levels or even improved after four months. That of 30% of all patients, however, had not done so. 38% of all patients (58% of survivors) experienced further changes in their ability to walk between four and twelve months post-fracture. Both in terms of walking ability and indoors use of walking aids, a substantial minority of patients experienced changes even more than four months after the fracture.

23% of all patients experienced a decline in perceived walking ability past the four-months follow-up that was attributed to the hip fracture. Patients' post-fracture ability to dress and undress by themselves appeared relatively independent of their walking ability. Only a minority of all patients, 9%, experienced a lot of pain in their fractured hip four months after the fracture. But almost a third of all patients still experienced a little pain even after four months. 37% of survivors experienced an increase in pain between four and twelve months. Over half of all patients who experience pain of any sort regularly took painkillers. This did not change between the first and the second follow-up period.

Overall, the data presented here pertaining to patients physical functioning has thus shown that significant changes occur across several dimensions during the entire one-year follow-up period. Compared to the more objective measurements of walking ability and use of walking aids, many more patients thought their walking ability had declined post-fracture compared to their pre-fracture levels. However, only a minority of patients attributed this perceived decline to the hip fracture. Comparing pre- and twelve-months post-fracture assessments of walking ability and use of walking aids revealed the existence of two groups of patients. The majority of pre-fracture independent patients recovered their independence within twelve months, despite getting older. The patients whose pre-fracture ability to walk was precarious to start with appeared to have a relatively much higher chance of either dying or losing even more of their ability to walk. There did not appear to be a significant difference in the age between the members of each of these groups. Having seen that the ability to dress independently did appear to be mirrored in patients' accommodation, the next section seeks to examine the relationship between changes in walking ability and changes in patients' accommodation in more detail.

8.5. Functional Abilities and Accommodation

The existence of individualised data on accommodation as well as physical functioning allows the examination of the issue to what extent the choice of accommodation of a patient reflects his or her functional abilities. The previous section has shown already that patients living in their own homes appear independent as far as their ability to dress is concerned. This section investigates in some more detail the functional abilities of the institutionalised patients of this dataset.

21% of the total 449 patients were resident in a home for the elderly or a nursing home one year after their fracture. The majority of them were able to get dressed and undressed independently at that point in time. However, walking ability was poor. Only 5% of them were able to walk alone outdoors at that point in time.

14% overall were at all able to walk outdoors, whether alone or accompanied. 25% of the institutionalised patients could not walk at all. 85% of institutionalised patients were dependent on walking aids even for walking indoors. Only 8% of institutionalised patients experienced a lot of pain in their fractured hip one year after the fracture. 34% had no pain at all. 60% had a little pain. Blinding pain does thus not seem to be the reason for the poor mobility of the institutionalised patients.

It follows that the majority of institutionalised patients were functionally dependent, as measured by walking ability, indoors use of walking aids and even the ability to get dressed independently. Pain does not appear to be the main reason for this. Hence, there does not appear to be any reason for believing that patients' accommodation might be structurally determined by the health and social care system of Tayside. Instead the choice of accommodation does appear to be an indicator of functional dependence in this set of patients twelve months post-fracture. In the context of exploring the costs of hip fracture though what is of interest is to know to what extent the fracture, rather than for example old age or other co-morbidities can be held responsible for that.

8.6. Relationship Between Walking Ability and Changes in Accommodation

Linking patients' walking ability and pain or perception thereof from their pre-fracture levels to four and twelve months after the fracture with their accommodation during the same period lead to a startling observation. Neither people's changes in walking ability, nor their perception of changes in their walking ability appeared to be decisively linked to an increase in dependence as far as their accommodation was concerned *(Table 8.16.)*

Table 8.16. Relationship between perceived walking ability and changes in accommodation

Functional Outcome Measure	No. of Patients	% of all 449 Patients
Perceived walking ability as worse at 4M compared to pre-fracture	130	29%
Lived in more Dependent Accommodation at 4M compared to pre-fracture	34	8%
Attributed the Decline in Perceived Walking Ability at 4M to the Hip Fracture	13	3%
Attributed the Decline in Perceived Walking Ability at 12M to the Hip Fracture	1	0.2%

The walking ability of 130 patients had declined after four months compared to their pre-fracture levels. 83 of them stayed in the same type of accommodation four months post-facture as before the fracture. 34, however, moved to accommodation designed to cater for increased care needs. Hence, it appears that less than a third of these patients (8% of the original total number of 449 patients) followed up a decline in this aspect of physical functioning with a change to accommodation to cater for this. The picture becomes even more interesting when one considers that less than half, only 66 of 130 patients, whose walking ability had declined attributed this decline to their hip fracture (15% of the total of 449 patients). And only 13 of these 66 patients, or 3% of the total number of patients moved to accommodation to cater for their increased care needs between sustaining their fracture and four months later. After twelve months, this picture is thrown into even starker relief. Only one person who attributed the decline in her walking ability one year post-fracture compared to pre-fracture levels to the sustained fracture had increased care needs resulting in a change of accommodation.

Not surprisingly, since the use of indoors walking aids and perceived walking ability at that time were correlated[123], after four months, 173 cases used more walking aids indoors than before the fracture. 34 of them had also changed to more dependent accommodation by that time. These were the same 34 patients who changed accommodation due to their perceived worse walking ability described in the previous paragraph. Only 12 of these 34 though attributed their decline in walking ability at four months compared to pre-fracture to the hip fracture *(Table 8.17.)*.

Table 8.17. Relationship between indoor use of walking aids and changes in accommodation

Functional Outcome Measure	No. of Patients	% of all 449 Patients
Indoors use of walking aids worse at 4M compared to pre-fracture	173	39%
Lived in more Dependent Accommodation at 4M compared to pre-fracture	34	8%
Attributed the Decline in Perceived Walking Ability at 4M to the Hip Fracture	12	3%

[123] The two are positively correlated (Spearman's rho 0.743). The association is highly significant at the 0.01 level (2-tailed sign. 0.000).

After one year, 166 patients used more walking aids indoors than before the fracture. 44 of them changed to a more dependent type of accommodation at that point in time. But only three of them attributed their decline in walking ability to the hip fracture by that time.

It follows from this that many patients experienced a decline in both, objective and subjective walking ability between the time of fracture and twelve months post-fracture. However, this did not appear to lead to quite as substantial implications for resource use in this model of hip fracture costs than in a model based on the currently prevailing method of cost assessment.

8.7. The Findings in Context

Before exploring the actual financial implications of these findings, this section seeks to provide a background for them. This section seeks to establish to what extent these findings can be trusted. First, it is of interest to what extent the functional outcomes of these 449 Scottish hip fracture patients are similar or different to other studies' findings. Following this the value and reliability of the research methodology on which the findings are based are considered.

8.7.1. The Outcomes of Hip Fracture

As indicated already in the introduction to this chapter, the focus of functional outcomes assessments of hip fracture patients has been to identify patients at risk of long-term adverse outcomes. Most frequently, studies investigate patients' indoors and outdoors walking ability, pain and independence in activities of daily living, such as getting dressed and shopping for groceries. Cook and colleagues (1993) found pain, especially when lifting or carrying things, to be the most important consequence of hip fracture. Different aspects of physical functioning were found to take different amounts of time to improve or return to pre-fracture levels. Some functions came back within four or five months of the fracture. The recuperation time for depressive symptoms was four months, 4.3 months for upper extremity function and 4.4 months for cognition. Lower extremity function was found to have recuperated only 11.2 months post-fracture (Magaziner, et al., 2000). In some aspects of physical functioning, post-fracture status remained below pre-fracture levels for up to two years (Magaziner, et al., 2000; Tosteson, et al., 2001). One study followed hip fracture patients up to ten years post-fracture and found health-related quality of life to be impaired even into the very long-term (Adachi, et al., 2001). It has proven incredibly difficult to obtain or derive data from the published studies of hip fracture outcomes which can be compared across studies. The major studies reporting results in this area are Jette, et al., 1987; Keene, et al. 1993; Sernbo, 1988; Wiktorowicz, et al., 2001; Parker and Myles, 1992 and Meine, et al. 1993. These studies do investigate issues such as basic or instrumental activities of daily living and the use of walking aids. However, they are difficult to categorise because if one study reports who regained a certain type of physical function by a certain point in time, another reporting on the same measure provides information only for those whose function had declined by a certain point in time in such a way that another researcher cannot use one to estimate the other. If the measures are comparable in principle, such as the indoors use of walking aids, they are based on dissimilar patients with respect to pre-fracture status, or only reported for different patient subgroups, etc. In addition, there are a multitude of ways of measuring physical functioning which also limits researchers ability to compare between studies. Chrischilles and colleagues (1991) comment on this for example with respect to the measuring of people's ability to perform activities of daily living. The comparison of patient outcomes is thus hampered by similar issues to those identified for the cost literature in chapters 4 and 7.

The Relationship Between Pre-Fracture Functional Ability and Post-Fracture Outcomes

Campion and colleagues' research (1987) illustrates hip fracture patients' 'precarious grasp' on normal physical function already prior to the fracture. Less than half of their patients had the ability to be mobile within the community, to go shopping or use a bathtub. Only just over a quarter of patients were able to walk outdoors and less than a fifth of patients were able to climb stairs even prior to the fracture. Campion compared future hip fracture patients' physical abilities with elders of a similar age in the Framingham Study (Jette, et al., 1981). Only 82% of future hip fracture patients were able to walk unassisted or transfer independently, compared to the Framingham study's more normal 98%. The same amount of elderly people were also able to dress unassisted, whereas only 88% of hip fracture patients were able to do so even prior to fracturing their hip. Based on a cluster analysis, Michel, et al. (2000), identified pre-fracture ability to walk and perform activities of daily living as significant predictors of the outcome of hip fracture one year post-fracture. Interestingly, among the multitude of factors studied were also factors which fall into the category of mental functioning. Among those, the perceived comparative (pre- vs. post-fracture) and the self-rated perceived absolute health level were found to be significant predictors of outcome, as were signs of depression and mental coping strategy. Social functioning has been found to be an important predictor or acute hospital length of stay (Jette, et al., 1987). The same study found that a poor emotional status pre-fracture was predicting increased physical disability six months after the fracture. In contrast, after twelve months, poor physical function prior to the fracture was more predictive of increased physical disability. The factors influencing medium and longer term recovery after the hip fracture may thus be different.

The Relation between Function and Cost

Studies linking costs directly to factors of physical function have so far not been numerous, but the ability to cook, clean and walk pre-fracture have been shown to influence costs systematically (Borgquist, et al., 1991).

The Relationship between Changes in Functional Ability and Changes in Accommodation

No study was found which reported on any attempts at making inferences about the relationship between the development of patients' functional ability over time and changes in their resource consumption via the proxy measure of changes in their accommodation. This, however, is the primary or only measure of resource consumption in the follow-up period in all but the smallest minority of hip fracture cost assessments. If a change in accommodation cannot be linked in some way to a change in physical functioning though, the question arises as to whether changes in patients' post fracture resource consumption can be attributed directly to the sustained hip fracture. Hence one might argue that, although the magnitude of many studies' cost estimates of hip fracture across the world appeared to be linked to studies' timeframes in the previous chapter, this in itself does not automatically imply that a longer timeframe by necessity leads to a more correct assessment of the costs of hip fracture, unless physical and possibly mental functioning can be linked to a change in resource consumption. This might be tested for example by comparing hip fracture patients' changes in physical functioning and changes in accommodation with those of a matched control group of similarly frail individuals as hip fracture patients are already before the fracture. Alternatively, one might attempt to collect data on hip fracture patients' entry into permanent institutional care about their reasons for doing so. Patients' answers with respect to physical function and the attribution of that to the sustained hip fracture might then be compared to health care professionals' assessments of the same.

8.7.2. The Reliability of the Tayside Outcomes Data

The validity of any conclusions one might draw from this data depends, of course, on the quality of the data collected. This in turn depends on the method by which it was gathered. As described at the beginning of this chapter, the data on patients' physical functioning was based on patients' own assessment. This assessment was sought first in a face-to-face interview with a trained research nurse following the questions of a specific and structured questionnaire. Follow-up data was collected mainly by telephone with a trained research nurse, following the same kind of questionnaire. As described earlier, the questions sought to elicit details of patients' physical function by asking questions which asked for both, a relatively more factual assessment, as well as patients' more subjective assessment. For example, one might imagine the question after the indoors use of walking aids to be relatively straightforward and easily compared with the number used prior to the fracture. Even more so, since very specific options were provided to answer this question. More subjective was the question asking patients to assess whether their walking ability was better or worse at the point of asking compared to prior to the fracture. Again, the answer options were numerous as well as specific. In addition, by comparing the answers to both, the question of general walking ability and the use of walking aids, one might gain some assurance that if the two answers match roughly, they might be a reasonable reflection of the patient's true walking ability and use of aids. Most subjective in this dataset is the answer to the question of whether the patient attributes any perceived decline in walking ability to the hip fracture. This very question is probably the cause of most of the criticism which might be levelled at the data.

Given that very few patients who changed accommodation and experienced a decline in physical functioning attributed this to the fracture, the likelihood of overestimating the follow-up costs associated with the hip fracture appears small. The likelihood of patients' underestimating the impact of hip fracture in this respect will be addressed in section 8.8. by calculating another cost estimate of hip fracture which includes all costs due to declining function and a change of accommodation, whether patients' attributed them to the hip fracture or not.

Self-assessment in general, as a means of generating reliable data has been the subject of a number of other criticisms. For example, it has been suggested that self-assessment is likely to be least accurate the more marginal the events in question are to the respondent's life (Oppenheim, 1992, p. 147). Purely by virtue of the hospitalisation required, a hip fracture is in all likelihood far from marginal to the average patient's life. In addition, the localised impact of the fracture is likely to be relatively easy to pinpoint. In contrast, blindness might not as readily be associated with diabetes as walking ability might be with a fractured hip.

The issue of self-assessment had also arisen in the context of some of the standard tools of assessing quality of life, particularly for older people. The validity of particularly the self-administered SF-36 questionnaire, for example, has been questioned for older people on the basis of systematic bias in response rates as well as the quality of responses due to mental or physical impairment (Parker, et al., 1998). The use of an interviewer-administered battery of very specific questions and possible responses was probably in part responsible for the relatively small percentage of missing data and hopefully helped to minimise this source of uncertainty in this dataset.

Concern has also been raised about the effect of different ways of eliciting information on reported outcomes. A study of the effectiveness of a package of physiotherapy for patello-femoral osteoarthritis found results to be different between questionnaires and in-depth interviews in more than 50% of all cases. The authors were not able to discern any systematic difference in the 20 study patients though (Campbell, et al., 2003). Hence, it is clear that there are a number of uncertainties inherent in the study methodology which might have an influence on how reliably responses reflect the underlying reality.

Future research might wish to consider the following suggestions to address these criticisms of self-assessment. First of all, it would be useful to gather data based on patients' own assessment and then compare it with the responses to the same questions when posed to the relevant health care professional who knows the individual patient in question. Secondly, prior to being asked the self-assessment questions asking patients' to attribute symptoms to a particular condition, the patient might be given standardised information with respect to which symptoms might occur as a result of the condition. Otherwise, the patient might be asked a battery of prepared questions with respect to very specific symptoms associated with the condition. This form of questioning though also has a number of problems, it requires more time and assumes that all the significant effects of a condition have already been identified. It might also be useful to have some indication of mental functioning of patients which might allow to place some sort of limit around the uncertainty surrounding patients' answers with respect to physical functioning, assuring the researcher that there is a high likelihood of the patient having understood the question and the possible answers to start with.

Another way of testing the accuracy of patient's attribution of symptoms to the hip fracture would be to collect detailed information with respect to co-morbidities and ask a panel of experts to attribute the observed symptoms to each of these co-morbidities. These expert judgments might then be compared with patients' own judgments to investigate to what extent and when they differ.

Given the existing data collected on the Tayside patients, there is another way of investigating how important the accuracy of patients' attribution of symptoms to the hip fracture is to the overall cost estimate. By leaving out the most opinionated question asking patients' to attribute changes in walking ability to the hip fracture, it might still be possible to add to our knowledge of the effects of hip fracture while trying to minimise the most obvious source of uncertainty. This is explored in the next section.

To reiterate, although stronger data is thus needed to support this claim, based on patients' own self-assessment, the impact of hip fracture on resources as estimated by the standard research design appears to be much lower than previously found. How much lower this resource consumption might be in monetary units is the topic of the next section.

8.8. The Costs of Hip Fracture Re-Considered

Based on patients' functional outcomes data, as well as their own subjective judgement regarding the cause of their decline in walking ability, the revised estimate of the directly attributable costs of hip fracture thus amounts to just over £6,000 per case in the twelve months following the fracture. *(Table 8.18.)* The directly attributable costs of the average case of hip fracture in Tayside are thus much lower than the previous best estimate of just over £9,000. Taking outcomes as well as patient's own attribution data into account thus results in a 33% decrease in costs.

Table 8.18. The Directly Attributable Costs of Hip Fracture (including patients' own attribution)[124]

Net Costs (1999 £s)	Net Costs Primary Admission	Net Costs Subsequent Admissions	4M Net Residence Costs	8M Net Residence Costs	12M Net Cost Estimate
Mean Cost Per Case	**4,746**	**1,057**	**218**	**25**	**6,045**
Total 12-Month Costs, 449 Patients	2,130,847	474,376	97,721	11,187	2,714,131
Total 12-Month Costs, Tayside	3,079,999	685,679	141,249	16,170	3,923,097

The data on health and social care costs incurred in the wake of a hip fracture, as well as the data on hip fracture patients' physical functioning indicates very graphically a general decline among aspects of old people's quality of life. This may well be associated with health and social care costs, even if patients' self-assessment suggests that possibly not all these costs may be directly attributable to the hip fracture. To shed further light on this issue, it would be necessary to use more robust data on hip fracture patients' physical functioning and perception of physical functioning to compare with the same data collected from a matched cohort of non-fractured patients.

To minimize the in all likelihood most obvious source of uncertainty in this self-reported dataset, Table 8.19. shows an alternative way of calculating hip fracture-specific costs using functional data. It summarises the effects on the costs of hip fracture, if only those patient's costs are counted whose decline in walking ability during the study period was accompanied by a change to more dependent accommodation. This cost estimate thus includes all costs incurred by patients who met these criteria without attempting to count only those costs attributed to the hip fracture.

[124] The figures in this table were calculated as indicated in Table 8.16.

Table 8.19. Directly Attributable Costs of Hip Fracture (excluding patients' own attribution)

Net Costs (1999 £s)	Net Costs Primary Admission[125]	Net Costs Subsequent Admissions[126]	4M Net Residence Costs[127]	8M Net Residence Costs[128]	12M Net Cost Estimate[129]
Mean Cost Per Case[130]	**4,746**	**1,057**	**218**	**482**	**6,502**
Total 12-Month Costs, 449 Patients	2,130,847	474,376	97,721	216,630	2,919,573
Total 12-Month Costs, Tayside[131]	3,079,999	685,679	141,249	313,124	4,220,051

The results for the primary and subsequent net inpatient costs, four-month net residence costs as well as therefore total four month net costs are the same as in the previous table. Leaving aside the question of whether the decline in perceived walking ability and accompanying move to more dependent accommodation was due to the hip fracture does lead to substantially different results for the eight-month residence costs though. When counting only the costs of those patients who attributed their 'double' decline to the hip fracture, the average costs across all 449 patients during this period were £25. Leaving aside the attribution, the average costs rise to £482 per case. Overall, however, this increase is not as pronounced, as total costs, leaving aside the question of attribution, are only 8% higher than before. It does therefore appear that, the question of the accuracy with which patients are able to correctly attribute functional outcomes to the

[125] Calculated as described in chapters 5 and 6.
[126] Calculated as described in chapter 5 and 6.
[127] Calculated by adding only those patients' costs whose walking ability was worse at four months than pre-fracture and who had changed to a more dependent type of accommodation by four months post-fracture compared to pre-fracture.
[128] Calculated by adding only those patients' costs for eight months of follow-up whose walking ability as well as their type of accommodation had become more dependent twelve months post-compared to pre-fracture.
[129] The sum of all the previous columns.
[130] This was calculated as Total Cost divided by all 449 patients.
[131] Average Cost per case multiplied by the on average 649 annual cases of hip fracture in Tayside.

fracture is of importance in estimating the costs of hip fracture. Eliminating the worst source of uncertainty does not, however, appear to change the issue that taking physical functioning data into account appears to lead to substantially reduced costs of hip fracture in this model.

Additionally adjusting for mortality with the Kaplan-Meier procedure, as in chapter 6, reduces the new best estimate of 12-Month costs (including patients' attribution) only by 2% *(Table 8.20.)*, compared to 6% with the conventional costing methodology (*Table 6.20).* Adjusting for censoring reduces the estimate excluding patients' attribution by 3%. One may conclude from this that adjusting for censoring does lead to a small but systematic downward adjustment of hip fracture costs even when functional data is taken into account. The use of functional data in cost assessment though led to the lessening of censoring bias compared to the standard costing methodology in this dataset. Given that the use of functional data for costing purposes leads to a concentration of costs close to the time of hip fracture, this is not surprising. Overall, it thus appears that the real costs of hip fracture are between 25% and 33% lower than previously thought, whether or not patients managed to attribute their functional decline correctly to the hip fracture.

Table 8.20. Summary of 3 Models of Hip Fracture Costs

Net Costs of Hip Fracture (1999 £s)	**More dependent Function & Accommodation (incl. patients' own attribution): New Best Estimate**	**More dependent Function & Accommodation (excl. patients' own attribution)**	**Best Estimate Using Conventional Costing Methodology (excl. patients' functional outcomes)**
Mean 12M Cost, per case	**6,045**	6,502	9,036
(same, using Kaplan-Meier)	**(5,952)**	(6,308)	(8,523)
Total 12M Costs of Hip Fracture in Tayside	**3,923,097**	4,220,051	5,864,286
(same, using Kaplan-Meier)	**(3,861,655)**	(4,093,279)	(5,531,427)

Hip Fracture Costs of Different Types of Patients

Using the data on physical functioning of patients to distinguish between the costs of different types of patients allows furthermore to shed more light on the question of whether hip fracture costs differ between different types of patients. Comparing twelve month costs of patients who at twelve months were able to walk outdoors either alone or accompanied with those of patients who were only able to walk indoors or not at all, showed that the mean costs of the two groups were significantly different at the 5% level (Mann-Whitney U-test, U=9917.500, asympt. Sig (2-tailed) 0.419). The mean costs of the frailer patients were much higher. Those able to walk outdoors incurred mean twelve months costs of only £4,543 (stdev. 2506.36), compared to the frailer patients' £7,648 (stdev. 9945.322). Compared to the Kaplan-Meier-adjusted mean 12-Month costs overall (which in addition included the frailer patients already), the costs per case of the frailer patients were thus 27% higher on average. Compared to the analysis presented in chapter 6 which showed that institutionalised patients were cheaper, the use of functional data in this case at least thus appears as if it might reflect our present society's shared values in a more immediately appealing way.

8.9. Summary

The main implications of the results presented in this chapter are that the methodology of economic evaluations as it stands, without reference to patients' physical functioning does not allow for the most accurate estimation of the costs of hip fracture. Instead the standard methodology employed for cost assessments would lead to consistently overestimated costs, even with a marginal costing methodology and the use of a control group. The Tayside data examined here suggest that this is in the order of magnitude of between 25% -33%, depending on the decision to give credence to patients' ability to attribute their functional decline to the fractured hip correctly or not. It is thus suggested that the standard hip fracture costing methodology should be adjusted in the following way. When the costs of long-term care are considered, only those costs which are directly attributable to the hip fracture should be counted. It has been argued in this chapter that only long-term care costs which can be shown to be accompanied by a decline in physical function (such as walking ability) should be considered directly attributable to a fractured hip. In addition, one should also distinguish between a decline in physical functioning which can be attributed to the fracture and one which is due to other factors. This chapter has illustrated one such way of making these adjustments. It suggests that existing estimates of hip fracture costs based on standard costing methodology are too high by between 25% and 33%. This has implications for recommendation as to the relative costs and benefits of available prevention and treatment regimens. One implication of this would be to move upwards the threshold for prevention by suggesting that preventative measures may be less cost-effective and offer less value-for-money than previous research suggests.

9. Discussion

9.1. Introduction

This last chapter serves to summarise the findings of the research presented in all the previous chapters, to integrate these findings, place them in context and explore some of their wider ramifications as well as their limitations. Section 9.2. presents again briefly the results of the different pieces of analysis conducted to shed light on the costs of hip fracture in Tayside thus far. Section 9.3. summarises and reflects on the uncertainties inherent in the Tayside hip fracture cost estimate. Sections 9.4., 9.5. and 9.6. explore in more detail some of the most important issues surfaced by the research presented here. These concern secondary data use, the question of a technical appendix and the issues of currency conversion and relative purchasing power which are important for comparing studies. The chapter closes with a reflection on the main contribution of the research presented in this thesis, the value of using outcomes data to assess costs.

9.2. Summary of Findings

Chapter 2 established that hip fractures present a serious problem to the health care systems of the developed world in particular. The age-structure of these societies also implies that this is a problem which is unlikely to decline in significance in the coming decades (Cooper, 1992). It was further established that although the condition is not yet fully understood, a substantial amount of research has been conducted into the causes of hip fracture. The main cause of hip fractures, particularly in older adults appears to be osteoporosis. The definition of osteoporosis has changed and continues to change, although current technology more or less forces the medical profession to equate osteoporosis with low bone mass. However, differences among fracture rates across countries emphasise that this is by no means the only determinant of fracture risk. Until the technology for assessing the various components of bone strength progresses through, policy makers will be forced to make policy concerning the prevention and treatment of hip fracture and osteoporosis on the basis of often conflicting epidemiological evidence. Even though the exact risk of hip fracture and osteoporosis is thus disputed, what does not appear disputed is that hip fractures do take their toll on society. However, a number of treatments exist which have been shown to be effective at ameliorating or even reversing the progress of the condition (National Osteoporosis Foundation, 1998; Melton, 1999). Much research was shown to have been conducted into risk factors for primary and secondary forms of osteoporosis. One of the reasons behind this is to enable the better targeting of these treatments to people who are considered to be most likely to benefit from them (Torgerson and Reid, 1993, p. 606).

Value-for-Money

The scarcity of resources available for health care has focused increased attention on the concept of obtaining value-for-money in health care spending (Muir Gray, 1997, p. 20). Increased use of economic evaluations for the assessment of health care programmes has been one way of addressing this issue (Fendrick, 1999). In order to decide which treatment offers the best value-for-money, the costs and outcomes of each treatment option need to be established. More concretely in the case of hip fracture, this involves the assessment of the costs associated with hip fracture which would be averted by the treatment, the costs of treatment and the outcomes of the treatment.

Much of the methodological discussion concerning the comparison of these types of data has tended to centre around the question of outcomes measures. This includes questions raised in the mainstream press concerning the morality of assessing an individual's quality of life, assigning a monetary value to it and using it to determine whether technically available treatment is given or withheld. However, when assessing treatment options and thus potential alternative investments in health care, the assessment of outcomes needs to be compared with an assessment of the costs associated with the different options under debate. Cost assessment is thus fundamental to obtaining value-for-money.

The Methodology of Cost Assessment

A survey of the literature on the methodology of assessing costs reveals the following. There does not appear to have been similar debate concerning the assessment of costs as there has been concerning the assessment of outcomes.

It is generally agreed that in order to assess the change in resource use associated with different programmes, certain types of resource use need to be measured, usually in physical units, and assigned a monetary value. The specific methodological choices facing a researcher of the impact of hip fracture were explored in chapter 3. These included the study perspective and the location of the study in time and space. Other methodological issues concern the timeframe chosen for the analysis. Related to this are the types of costs which are collected as is the method chosen for costing itself.

In the light of these methodological choices, existing studies of hip fracture were reviewed in chapter 4.

Characteristics of Existing Hip Fracture Cost Research

Although a sizeable body of literature on the costs associated with hip fracture across the globe exists, this review revealed that the majority of studies seeking to evaluate the costs and outcomes of medical intervention with respect to hip fractures did not collect original cost data. The majority of all full economic evaluations relied on other studies' cost estimates for their assessment of the costs associated with averted hip fractures. Of those that did collect original data, the majority employed per diem estimates of resource utilization, or they relied on other people's estimates of resource utilization without relating these estimates either to the original patient population, or to their own patient population. Those studies which did collect original cost data were then compared across variables relating to the methodological choices derived from the literature reviewed in chapters 2 and 3. These variables covered aspects of a study with respect to the characteristics of its patient population, its unit cost data and the modelling process itself. It was found that studies existed for most developed countries, covering all types of patients from all walks of life. Zethraeus and Gerdham's (1998) criticism of the state of the literature did thus not appear to hold anymore. In contrast, it was found that the majority of studies adopted a timeframe which was consistent with including an estimate of the more long-term costs which might be associated with hip facture. Most studies thus included not merely acute costs in their assessment but also rehabilitation and costs associated with patients' accommodation. However, only one study attempted to include indirect costs in its assessment. Few of the studies included aspects of intangibles, such as physical functioning, in their assessment and none attempted to assign any costs to it. All studies of the costs associated with hip fracture shared the assumption of the costs of zero costs of excess mortality. In comparing studies' methodological choices, it was found that reporting of results, and even more, the reporting of model inputs and processes was very heterogeneous, thus potentially rendering comparison among model results difficult. However, addressing Zethraeus and Gerdham's (1998) criticism, many hip fracture studies made methodological choices consistent with what was established in chapter 3 to be an appropriately comprehensive form of cost assessment.

The Tayside Model

To find out about the cost implications of hip fracture locally, a model of hip fracture in Tayside was constructed from the perspective of the regional health and social services. The methodological choices made in the construction of this model were described in chapter 5. They were based on what was established as 'best practice' in the literature reviewed in chapter 3 as much as possible. This included the use of existing and detailed information concerning the resource utilisation of patients in acute care as well as information on their rehabilitation and long-term care. This was combined with routinely generated local cost data in a one-year framework using a self-control marginal costing methodology.

Costs Associated with Hip Fracture in Tayside

Overall, the changes in resource consumption to Tayside's health and social services associated with one case of hip fracture was estimated to amount to £7,600 in the four months following the fracture. This rises to £9,000 in the twelve months following the fracture. For the whole of Tayside, the model estimated that hip fractures account for a cost of £5,900,000 per year.

Cost Composition

According to the model proposed here, 76% of the costs associated with hip fracture in the year following the fracture are the result of the primary and subsequent hospitalisation episodes. Even in the twelve-months model, the residence cost component only accounts for 36% of the total cost estimate. This would seem to indicate that even using a standard study methodology, at least in the case of Tayside, according to this model, the popular news reports of wide-spread disability and permanent incapacitation, if they occur at all, do not appear to translate into corresponding higher residence costs for the budgets of the health and social services.

Tayside Hip Fracture Costs in Comparison

Comparing the costs associated with hip fracture in Tayside with those associated with the condition by the global literature, Tayside's four- and twelve-month costs per case would appear to be at the lower end of the range. Overall, hip fracture costs appeared to vary widely indeed, from between US$ 3,600 to US$ 72,000 per case, even though estimates had been adjusted for relative price levels. The remainder of chapter 7 was dedicated to attempting to investigate whether the observed variation in cost estimates could be shown to reflect real underlying differences in cost. This was hampered by studies' heterogeneous way of reporting not only the inputs and processes of modelling but also outcomes. Bearing these limitations in mind, cost estimates were, however, shown to be significantly linked with the use of any type of control group, the acute length of stay and the timeframe of the study. Chapter 8 then attempted to shed new light on the question which is the appropriate timeframe within which to assess the impact of a fractured hip. It was attempted to do so by analysing data on aspects of patients' physical functioning and the relationship between physical functioning and resource consumption.

Comparative Physical Functioning

Most patients walking ability and use of walking aids had recovered to their pre-fracture levels after four months. That of almost a third of all patients had not done so though. The majority of surviving patients experienced further changes in mobility all the way throughout the one-year follow-up period.

Patients' ability to get dressed and undressed without assistance appeared quite separate from their ability to walk. More than a third of the surviving patients still experienced at least a little pain in their fractured hip after four months.

Patients appeared to think their comparative walking ability was worse than the evidence suggested by the more factual questions about their walking ability and indoors use of walking aids.

There appeared two quite distinct groups of patients with respect to comparative functional ability. Despite getting older, the majority of pre-fracture independent patients recovered their independence within twelve months. The patients whose pre-fracture ability to walk was already precarious appeared to have a far higher probability of either dying or losing even more of their ability to walk. The mean age of the members of the two groups did not appear to differ, however.

Relationship Between Functional Ability and Accommodation

Individualised data for each patient on functional abilities as well as accommodation enabled the examination of the question to what extent the choice of accommodation can serve as a proxy for functional dependence. The majority of this dataset's institutionalised patients appeared to be functionally dependent as far as walking ability, indoors use of walking aids and the ability to dress independently was concerned. The choice of accommodation did therefore appear to be reasonable indicator of functional dependence. This alone does not, however, answer the issue to what extent the choice of accommodation and therefore resource consumption can be attributed to a fractured hip rather than other pre-existing co-morbid conditions.

Relationship Between Changes in Walking Ability and Accommodation

To gain a different perspective of which changes in resource use after a hip fracture can be directly attributed to the fracture, the information on patients' comparative pre- and post-fracture walking ability and perception thereof was linked with patients' changes in accommodation during the study period. The idea behind this was that the costs of a move to more dependent accommodation should only be attributed to the hip fracture if patients' functional ability could also be shown to have changed for the worse.

Surprisingly, neither patients' relative walking ability nor their perception of their relative walking ability appeared to be decisively linked with a move to accommodation designed to cater to increased care needs. Only 13 patients out of 449 who had experienced a decline in their ability to walk within four months and attributed this to the hip fracture moved to more care-intensive accommodation. Within the one-year framework, the same was true for only one of these 13 patients. This appears to indicate that although many patients experienced a decline in walking ability in the year following the fracture, this did not appear to lead to substantial implications for resource use.

Taking into account increased accommodation costs only when they were accompanied by a decline in the individual patient's physical function reduced the costs associated with hip fracture in the year following the fracture by between 25% and 33%. The directly attributable hip fracture costs in the year following the fracture would thus on average amount only to just over £6,000, instead of the just over £9,000 attributed to it in the same set of patients using conventional forms of cost assessment.

9.3. Limitations of the Research Presented

The validity of these results is affected by a number of weaknesses inherent the way the data was collected and analysed.

Regarding the comparison of cost studies in chapter 7, the use of univariate analysis identified three factors which were systematically affecting studies' cost estimates. The direction of the association between the use of any type of control group and a study's cost estimate was counter to what one might expect from reading the methodological literature on cost assessment. This illustrates that another third factor may be responsible for the effect on costs. The univariate analysis performed, however, was unable to shed further light on this. Nor could it explain how much of the observed cost variation between studies could be explained by each of these three factors. The structure of the data, the quality of it and the small number of observations did not inspire much confidence though in the robustness of the results of any more involved multivariate analysis.

Reliance on Routinely Collected Cost Data

The reliance on routinely collected data for assigning a monetary value to hip fracture patients' resource consumption limited the extent to which the individualised data on resource consumption could be used to its full effect. This weakness was addressed by making it a central feature of the sensitivity analysis, also involving cost data from other Scottish hospitals. As full details have been provided on the used unit cost estimates and modelling processes, the analysis can be replicated with more accurate cost data should that become available.

Point Estimate of Resource Use

A further weakness is that although continuous information was available on patients' post-fracture dependency levels in the four months following the fracture, only a point estimate was available twelve months after the fracture. Given the reduction in follow-up costs between four and twelve months after the fracture if functional data is used to attribute accommodation costs to the hip fracture, this weakness in data appears to become almost immaterial.

The Limitations of Self-Assessment

Another weakness inherent in the data used in constructing the Tayside estimate of hip fracture costs is the reliance on self-assessment. A trained research nurse was, however, responsible for filling in the datasheet. The answering options to the specific questions asked of the patients were in the majority very detailed. One might hope that this would serve to minimise some of the uncertainty associated with patients' self-assessment. In addition, some of the different aspects of physical function, the ability to walk and the use of walking aids and patients' perception of their relative walking ability could be used to cross-check answers. They appeared in the majority quite consistent. The most obvious source of uncertainty was asking patients' to make a judgment as to whether they associated their changes in walking ability with the hip fracture. Given that very few patients who changed accommodation and experienced a decline in physical functioning attributed this to the fracture, the likelihood of overestimating the follow-up costs associated with the hip fracture appears small. The likelihood of patients' underestimating the impact of hip fracture in this respect has been addressed by calculating another cost estimate of hip fracture which included all costs associated with declining function and a change in accommodation, whether patients' attributed them to the hip fracture or not. Some of the other criticisms of self-assessment have been outlined in chapter 8, together with suggested ways of minimising the resulting uncertainties in future research.

A number of potential weaknesses of the cost estimate were further the result of modelling decisions.

Identical Costs Across Tayside

The assumption that costs are identical across Tayside is one of the main weaknesses of extrapolating the mean hip fracture cost estimate to the whole of Tayside. It was attempted to gauge in which way different costs in different parts of Tayside might affect the cost estimate. The state of cost accounting in the health and social services at this point in time made this, however, fairly futile. Full details were provided though, so that the analysis can be replicated with different unit costs. If policy was made at the local level based on an analysis such as this one, it would be advisable to use the most accurate economic costs that could be found since especially acute costs are such a major component of this hip fracture cost estimate.

The Use of Self-Controls

The effect of using an external control group's, rather than patients' pre-fracture resource consumption as an indication of resource consumption in the year following the fracture is unclear. The effect on the Tayside cost estimate would depend on how well matched these external controls were. The best guess is that the use of external controls would have led to a less accurate cost estimate, unless they matched the frailty of the hip fracture patients exactly. To match this frailty, future studies might wish to consider using cases and control's functional data. The issue of external controls is linked to the next point.

Rising Baseline Costs

Much has been made of the issue of costs of patients rising during the follow-up period of a study such as this one, even if they had not sustained a hip fracture.

This issue is of relevance primarily to estimates based on a traditional methodology of assessing costs. It has been demonstrated that the use of functional data leads to most directly attributable costs being concentrated in the time period immediately following the fracture. The issue of rising baseline costs is thus minimised by the use of functional data to attribute costs at least in this set of patients.

Accommodation as a Proxy for Dependency Levels

The use of functional data also confirms that at least in this set of patients, accommodation in an institutional setting did appear to be a reasonable proxy for increased dependency levels. The use of functional data at the individual patient level allows furthermore to bypass this weakness of most hip fracture cost estimates by linking physical function, accommodation and therefore resource consumption.

Having considered some of the limitations of the data used and the modelling decisions made, the following sections discuss in some more detail the main implications of the research presented in this thesis.

9.4. Secondary Data Use

The first implication arises from the survey of the existing knowledge base on the costs and outcomes of hip fracture prevention and treatment programmes. Much of this knowledge appears to be based on secondary data of hip fracture costs. The cost estimates attributed to hip fracture by those studies using original cost data, however, has been shown to vary widely. Of numerous variables which were identified as crucial from the methodological literature, only three (timeframe, controls and length of acute stay) were shown to be linked with cost estimates in a statistically significant fashion. Policy conclusions based on secondary cost data thus deserve closer scrutiny than has hitherto been advocated in the literature. The use of secondary data without reference to characteristics of the underlying patient population, treatment patterns and unit costs in economic evaluations designed to inform decision-making cannot automatically be assumed to achieve this aim. Researchers are not helped in this by the fact that the patient characteristics, unit cost data, methodological choices in modelling and outcomes are reported in very heterogeneous ways in different studies.

9.5. Technical Appendix

To allow researchers to compare studies' results and determine whether a study's results might be applicable in a different setting he or she must be given sufficient information to judge this. Based on chapters 2 and 3, this information needs to cover significant aspects of model inputs and processes as well as outputs. Due to journals' space constraints, it has been advocated to supply a technical report with each published research paper. The contents of such a technical report have been discussed in the literature in general terms (Drummond, 1997; Gold, 1996). The costing aspects have also received some attention. Gold (1996, p. 297) suggest the following:

> " If costs were obtained from a hospital accounting system, for example, the author might describe the cost elements included and excluded and the assumptions used in much greater detail than is feasible in the journal report. Methods for allocating overhead costs, for adjusting professional charges for actual collection fractions, and other features of the cost accounting system could be described."

Drummond and colleagues (1997, p. 266-275)'s suggestions go further. They suggest that apart from the basic demography and epidemiology of the disease, details need to be supplied on the patient population with respect to variables relevant to the disease in question. It is also suggested to include details on the availability of health care resources, variations in clinical practice, incentives to health care professionals and institutions as well information concerning the relative prices and costs.

Both of these sets of suggestions are expressed in rather broad terms. The research presented in this thesis (for example concerning the appropriateness of patients' own pre-fracture resource consumption as a control group in hip fracture patients) appears to suggest it might be beneficial to define in more detail the contents of such a technical appendix with respect to the costing of hip fracture.

The evidence presented in chapters 2, 3 and 4 suggest that with respect to inputs, the technical appendix of hip fracture studies ought to contain information on the characteristics of the patient sample upon whom the model is based. This should include:

- The actual year of data collection
- The country and region where the data was collected
- The age distribution of the sample (mean and median age as well as age inclusion criteria)
- The sex distribution of the sample
- The length of stay in acute care
- The length of stay in rehabilitation
- The patient origin

- The percentage of the population of the study country that is resident in their own home, with their family, a home for the elderly or long term care at age 80
- Details of the control group used.

In addition, information should be given on the unit costs used for at least acute care and rehabilitation, preferably also for the follow-up costs. This should include details of the type of accounting system which collected these costs, i.e. is it patient-specific data or allocated to departments from the top down, and whether the data includes items such as fixed costs and overheads.

With respect to the way the model was constructed on the basis of these reported inputs, information should be supplied as to

- The timeframe of the study
- The type of cost data collected (acute, rehabilitation, long-term- and community-care costs, etc.) and
- The costing methodology (average, detailed average or marginal costing).

In addition, the way in which cost items, whether unit costs or the model cost estimate, are presented is of importance to facilitate comparison between studies. Having seen that costs differ depending on patients' functional ability, the collection and provision of a standard set of functional data for any patient sample should also help to make studies even easier to compare, although this might require additional research resources.

To circumvent journal's space constraints yet maintain accessibility, such a technical report might be made available on journals' websites. The research into hip fracture presented here thus affirms the importance of supplying technical information which has already been suggested in the existing literature (for example, see Gold et al (1996) and Drummond et al (1997)). It also suggests that it might be of value to present also more disease-specific technical information than hitherto suggested.

9.6. Currency Conversion and Relative Purchasing Power

The wide-spread use of secondary data has also highlighted another issue concerning the comparability of studies. Even assuming the same exchange and inflation rates are used, different methods exist to convert results in various historical currencies to a common currency. Cost estimates were shown to vary by as much as 66% depending on which method was used. This appears to be an issue which deserves further attention to ensure as much as possible that studies reflect underlying real differences in hip fracture resource consumption, rather than exchange rate fluctuations. It is noteworthy in this context that none of the studies examined addressed the issue of differences in purchasing power between countries, although guidance on the use of particular conversion factors has been issued by the Department of Health (Department of Health, 1994). This issue is of particular concern when policy advice must be given involving the resource implications of diseases for which the UK-based knowledge base is more narrow than that of hip fracture.

The following last section presents the main contribution of the research, which is its contribution to the methodology of cost assessment in general.

9.7. Methodological Contributions

The research presented in this thesis furthers current knowledge on several fronts. The thesis furnishes the first comprehensive and systematic review of the global disease-specific literature seeking to estimate the burden of hip fracture. It is the first time that a comprehensive assessment of the burden of hip fracture in Tayside has been made available to policy makers. It concludes that although there are issues with the absolute numbers, mainly due to limitations of the available cost data, the impact of hip fracture is substantial. However, the joint analysis of resource use and physical function on an individualised level revealed that this kind of standard cost assessment may be overstating the true costs of hip fracture substantially. It has thus been argued that standard methods of assessing costs cannot distinguish between costs which are incurred as a result of a fractured hip and costs which are incurred for unconnected reasons after a hip fracture.

This standard methodology for assessing health care costs was established in the late 1950s and 60s by a number of different authors. Amongst those, Dorothy Rice's 1966 study of the costs of illness by ICD category stands out for seeking to establish a standardised framework for conducting these types of study (Rice,1966). Much of the debate has taken the distinction between direct and indirect costs and intangibles as a given, even if somewhat different terms were used by different authors. The main debate of cost assessment has concentrated on the assessment of indirect costs, as indicated in chapter 3. Methodological concern though has been expressed already in the context of other diseases over the distinction between incurred costs and costs incurred as a direct result of a health care event or intervention. The way this has been addressed so far has been by debating the merits of various types of control groups and the assessment of marginal costs. The research presented in this thesis suggests another way of addressing this issue which is of importance to the assessment of hip fracture costs. It has been shown in the existing literature that hip fractures appear to carry in their wake not only substantial mortality but also long term morbidity. The way the latter is usually assessed is by determining how many patients of a particular sample have greater care needs post-fracture compared to before. The major cost component in this for most Western health and social care systems is institutionalised care in the form of a home for the elderly or a nursing home. When the costs of hip fracture are assessed, the costs associated with long term morbidity are thus usually approximated by estimating the costs associated with a change to accommodation to reflect increased care needs following the hip fracture. The examination of each individual patient's accommodation changes combined with changes in their physical functioning appears to suggest that this standard method of assigning these costs to the hip fracture directly is inaccurate. The discrepancy observed between changes in accommodation and declining physical function suggests that not all accommodation changes occurring post-fracture may be attributable to the fracture. It has been argued that for an accommodation change to be attributable to the hip fracture, it must be accompanied by a decline in a related physical function, such as the ability to walk. It can further be argued that a change in accommodation and a concurrent change in walking ability may still be unconnected to the fractured hip. As a result, it could further be argued that costs associated with a change in accommodation should be counted as directly attributable to hip fracture only, if they are not only accompanied by a change in a related physical function but also if this change in physical function can be directly attributed to the hip fracture. Depending on the specific disease in question, the person best qualified to make such a judgement could either be the patient him or herself, a health care professional or a combination of the two.

Since many conditions and diseases include in their costs a component relying on changes in accommodation, there would appear to be scope for testing the validity of this refined method of cost assessment not only with other hip fracture data but also patients with other diseases. The basic question to ask while assessing a particular cost component would thus appear to be:

> "Can this cost component be linked directly with the condition I am trying to assess due to the changes I observe in individual patients' functioning in related areas?"

To the best knowledge of the author, the research presented here is the first ever attempt of using data commonly associated with the area of outcomes assessment to refine the art of cost assessment. The effects on costs of making use of this dataset's individual outcomes data suggests though that outcomes data may be able to play an important role in refining current knowledge of the costs of different diseases far beyond those of hip fracture. It may well result in a reassessment of the relative costs and benefits of more than one health care intervention.

Appendix 1

Authors	PPP-adjusted cost estimate	average total cost estimate M3	Country (simplified)	Year of Publ.	Timeframe (simpl.)	Cost. Method. (simpl.)
Arboleya	11103.75	8883	Spain	1997	3	average
Autier	16351.515	16188	Belgium	2000	12	marginal
Borgquist	12512.288	14765	Sweden	1991	4	average
Brainsky	20004.951	20205	USA	1997	12	marginal
Braithwaite	72475.248	73200	USA	2000	12	unclear
Campion	13543.564	13679	USA	1987	3	average
Chamberlin	4467	4646	France	1997	3	average
Cox	5421.4286	4175	New Zealand	1993	12	average
De Laet	14412.5	13836	Netherlands	1999	24	marginal
Diez Perez	7160	5728	Spain	1989	3	average
Dolan	20139.623	21348	UK	1998	12	marginal
Farnworth	12435	10445	Australia	1994	12	average
French	5296.6981	5615	UK	1995	3	average
Hollingworth	9978.7736	10578	UK	1995	3	average
Jacobs	10441	10545	USA	1999	3	average
Koeck	7354	7501	Austria	2001	3	average
Lane	45879.221	35327	New Zealand	1996	24	average (better quality)
Levy	16624.519	17290	France	1989	3	average
Lippuner	15518.898	19709	Switzerland	1997	3	average (better quality)
Lyritis	14477.632	11003	Greece	1992	3	average
Meine	48553.15	61663	Switzerland	1993	24	average
Pientka	13168.095	13827	Germany	1999	6	marginal
Randell	14582.143	12249	Australia	1995	12	average
Reginster	9873.5	9874	Belgium	1999	12	marginal
Ruchlin	18548	18733	USA	2001	18	marginal
Schurch	32029.528	40678	Switzerland	1996	12	average
Sernbo	34111.864	40252	Sweden	1993	12	marginal
Stromberg	28379.661	33488	Sweden	1997	12	average
Thorngren	10504.237	12395	Sweden	1991	24	average
Treves	4671.1538	4858	France	1985	24	average
Vaz	3697.0588	2514	Portugal	1993	12	average
Wiktorowicz	23598	19114	Canada	2001	12	marginal (subgroups)
Zethraeus & Gerdham	23084.746	27240	Sweden	1998	12	marginal
Zethraeus & Stromberg	38078.814	44933	Sweden	1997	12	marginal

This represents an extract of all the data extracted from the original cost studies for illustration purposes.

Appendix 2

authors	title	journal	reason for exclusion
Agency for Healthcare Research and Quality (AHRQ)	Osteoporosis in postmenopausal women: diagnosis and monitoring	AHQR, Evidence Report/ technology Assessment 28, 2001, Rockville, MD (USA)	review or cost data/ costing based on other studies
Ankjaer-Jensen A, Jonell O	Prevention of osteoporosis: a cost-effectiveness of different pharmaceutical treatments	Osteoporosis International (1996); 6(4): 265-75	original data, but information sufficient for analysis only given in referenced publication by first author in Danish
Armstrong K, Chen TM, Albert D, et al	Cost-effectiveness of raloxifene and hormone replacement therapy in post-menopausal women: impact of breast cancer risk	Obstetrics and Gynecology 2001; 98(6): 996-1003	review or cost data/ costing based on other studies
Barlow Report	Report of the Advisory Group on Osteoporosis	Dep. Of Health, Nov. 1994	review or cost data/ costing based on other studies
Bendich A, Leader S, Muhuri P	Supplemental calcium for the prevention of hip fracture: potential health-economic benefits	Clinical Therapeutics 1999; 21(6): 1058-1072	review or cost data/ costing based on other studies
Brecht JG, Schaedlich PK	Burden of illness imposed by osteoporosis in Germany	Health Economics in Prevention and Care (2000); 1: 26-32	review or cost data/ costing based on other studies
Cameron I, Crotty M, Currie C, et al.	Geriatric rehabilitation following fractures in older people: a systematic review	Health Technology Assessment 2000; 4(2): 1-111	review or cost data/ costing based on other studies
Cheung AP, Wren BG	A Cost-effectiveness analysis of hormone replacement therapy in menopause	Med J Aust (1992); 156: 312-6	original, study based on Australian health department routine survey data, but not enough information given to enable any analysis
Chrischilles EA, Dasbach EJ, Rubenstein LM, et al.	The effect of alendronate on fracture-related healthcare utilization and costs: The fracture intervention trial	Osteoporosis International (2001); 12: 654-660	original data, but reported as average hip fracture costs across control group and cases together and hence incomparable
Chrischilles EA, Butler CD, Davis CS, Wallace RB	A model of lifetime osteoporosis impact	Arch Intern Med (1991); 151: 2026-2032	no monetary measure of resource consumption
Chrischilles E, Shireman T, Wallace R	Costs and Health Effects of Osteoporotic Fractures	Bone (1994); 15(4): 377-386	review or cost data/ costing based on other studies
Clark AP, Schuttinga JA	Targeted Estrogen Progestogen Replacement Therapy for Osteoporosis - Calculation of Health-Care Cost Savings	Osteoporosis International (1992); 2(4): 195-200	review or cost data/ costing based on other studies
Coyle D, Cranney A, Lee KM, et al.	Cost effectiveness of nasal calcitonin in postmenopausal women: use of Cochrane Collaboration methods for meta-analysis within economic evaluation	Ann Meet Int Soc Technol Assess Health Care (1999); 15: 58	lack of sufficient information to include in analysis
Coyle D, Cranney A, Lee KM, et al.	Cost-effectiveness research in osteoporosis	Drug Development Research (2000); 49(3): 135-140	review or cost data/ costing based on other studies

Daly E, Roche M, Barlow D, et al.	HRT: An analysis of benefits, risks and costs	British Medical Bulletin (1992); 48 (2): 368-400	review or cost data/ costing based on other studies
Geelhoed E, Harris A, Prince R	Cost-effectiveness analysis of hormone replacement therapy and lifestyle interventions for hip fracture	Aust J Public Health (1994) Jun; 18(2): 153-60	review or cost data/ costing based on other studies
Givon U	Consensus conference on the treatment and rehabilitation of hip fractures in the elderly	The Israel Medical Association Journal 1999 (1)	review or cost data/ costing based on other studies
Gluer CC, Felsenberg D	Cost-effectiveness of various strategies for the diagnosis of steoporosis	Radiologe (1996); 36 (4): 315-326	review or cost data/ costing based on other studies
Hamilton BH, Hamilton VH, Mayo NE	What are the costs of queuing for hip fracture surgery in Canada?	Journal of Health Economics (1986); 15: 161-185	no monetary measure of resource consumption
Hollingworth W, Todd C, Parker M, et al.	Cost analysis of early discharge after hip fracture	BMJ (1993) Oct 9; 307(6909): 903-6	duplicate publication
Jensen JS, Toendevold E, Soerensen PH	Costs of Treatment of Hip Fractures	Acta Orthop Scand (1980); 51: 289-296	no monetary measure of resource consumption
Jonsson B, Christiansen C, Johnell O, Hedbrandt J	Cost-effectiveness of fracture prevention in established osteoporosis	Scandinavian Journal of Rheumatology (1996); 103: 30-38	review or cost data/ costing based on other studies
Jonsson B, Christiansen C, Johnell O, Hedbrandt J	Cost-effectiveness of fracture prevention in established osteoporosis	Osteoporosis International (1995); 5(2): 136-142	review or cost data/ costing based on other studies
Jonsson B, Kanis J, Dawson A, et al.	Effect and offset of effect of treatments for hip fracture on health outcomes	Osteoporosis International 1999; 10(3): 193-199	review or cost data/ costing based on other studies
Kanis JA, Dawson A, Oden A, et al.	Cost-effectiveness of preventing hip fracture in the general female population	Osteoporosis International 2001; 12(5): 356-361	review or cost data/ costing based on other studies
Kramer A, Steiner JF, Schlenker RE, et al.	Outcomes and Costs after hip fracture and stroke - A Comparison of Rehabilitation Settings	JAMA (1997) Feb 5; 277 (5): 396-404	rehabilitation only
Krappweis J, Rentsch A, Schwarz UI, et al.	Outpatient costs of osteoporosis in a national health insurance population	Clinical Therapeutics (1999); 21(11): 2001-2014 and 2015	outpatient costs only
Kristiansen IS, Falch JA, Andersen L, et al	Use of alendronate in osteoporosis: is it cost-effective? (Nr.)	Tidskrift for Den Norske Laegeforening 1997; 117(18): 2619-2622	primary cost data on avoided HFs, publication only in Norwegian, NHS CRD record does not yield enough enough info in English to incl. in analysis
Kumar BA, Parker MJ	Are hip protectors cost effective?	Injury- International Journal of the Care of the Injured 2000; 31(9): 693-695	review or cost data/ costing based on other studies
Lindsay R	The Burden of Osteoporosis - Cost	American Journal of Medicine (1995); 98: S9-S11	review or cost data/ costing based on other studies

Lippuner K, Fuchs G, Ruetsche AG, et al.	How well do radiographic absorptiometry and quantitative ultrasound predict osteoporosis at spine or hip? A cost-effectiveness analysis	J Clin Densitom (2000); 3(3): 241-249	not enough info to enable analysis
Maggiani G	The therapy of osteoporosis with clodronate I.m.: From kinetics to cost of therapy - the reasons of success	Journal of Bone and Mineral Research (1999); 14: SU375	not enough info to enable analysis
Melton LJ 3rd	Cost-effective treatment strategies for osteoporosis	Osteoporosis Int (1999); 9 Suppl 2: S111-6	review or cost data/ costing based on other studies
Meunier PJ	Evidence-based medicine and osteoporosis: a comparison of fracture risk reduction data from osteoporosis randomised clinical trials	International Journal of Clinical Practice 1999; 53(2): 122-129	review or cost data/ costing based on other studies
Morbia P, Jung M, Michel T, Sizemore G	Osteoporosis - Cost of Treatment with various Calcium Preparations	Clinical Research (1986); 34(2): A377	not enough info to enable analysis
National Osteoporosis Foundation	Osteoporosis: review of the evidence for prevention, diagnosis, and treatment and cost-effectiveness analysis, status report.	Osteoporosis International (1998);8 Suppl 4:S1-88	review or cost data/ costing based on other studies
Newman ED, Starkey RH, Ayoub WT, et al.	The Penn State Geisinger Health System Osteoporosis Disease Management Program: Cost Analysis, Guidelines, and Outcomes after Three Years	Arthritis and Rheumatism (1999); 42(9): 1898	not enough info to enable analysis
Norlund A	Prevention of osteoporosis: a cost-effectiveness analysis regarding fractures	Scandinavian Journal of Rheumatology 1996; 25(Suppl. 103): 42-45	review or cost data/ costing based on other studies
Norris RJ	Medical Costs of Osteoporosis	Bone (1992); 13: S11-S16	review or cost data/ costing based on other studies
Office of Technology Assessment	Cost-effectiveness analysis	Washington (DC): US Office of Technology Assessment (1995)	review or cost data/ costing based on other studies
Palmer SJ, Parker MJ, Hollingworth W	The cost and implications of reoperation after surgery for fracture of the hip	Journal of Bone and Joint Surgery (Br) (2000) 82B (6):864-866	reoperations only
Parker MJ, Myles JW, Anand JK, Drewett R	Cost-benefit analysis of hip fracture treatment	J Bone Joint Surgery (British) (1992) Mar; 74(2): 262-4	review or cost data/ costing based on other studies
Peretz A	Evaluation of the cost of non-hormonal treatment of osteoporosis (Fr.)	Rev Med Brux (1998) Sep; 19(4): A204-7	preventative treatment costs only
Phillips CJ, Moore RA	Developing a strategy for the prevention of hip fractures in the elderly due to osteoporosis: the application of economics to the findings from a clinical trial	International Journal of Clinical Practice (1998); 52(5): 335-340	review or cost data/ costing based on other studies
Phillips S, Fox N, Jacobs J, Wright E	The direct medical costs of osteoporosis for American women aged 45 and older, 1986	Bone (1988); 9: 271-279	hip fracture costs not reported separately

Roche M, Vessey M	Hormone Replacement Therapy in the menopause: risks, benefits and costs	p.189-198?, chapter 18 of a book	review or cost data/ costing based on other studies
Rodriguez Escolar C, Fidalgo Garcia ML, Rubio Cebrian S	Alendronate cost-effectiveness analysis versus placebo in the prevention of hip fractures	Atencion Primaria 1999; 24(7): 390-396	review or cost data/ costing based on other studies
Rosner AJ, Grima DT, Torrance GW, et al.	Cost-effectiveness of multi-therapy treatment strategies in the prevention of vertebral fractures in postmenopausal women with osteoporosis	Pharmacoeconomics (1998) Nov; 14(5): 559-73	vertebral fractures only
Ross PD, Wasnich RD, Maclean CJ, et al.	A model for estimating the potential costs and savings of osteoporosis prevention strategies	Bone (1988); 9(6): 337-347	no measure of resource consumption in monetary terms
Schroder HM	The cost of hospitalizing hip fracture patients has increased despite shorter hospitalization time	Injury (1991) Mar; 22(2): 135-8	review or cost data/ costing based on other studies
Sendi P, Palmer AJ	Modelling the Socioeconomic Impact of Osteoporosis-Related Hip Fractures in Switzerland	Osteoporosis International (2000) 11: 92-94	review or cost data/ costing based on other studies
Soderstrom L, Tousignant P, Kaufman T	The health and cost effects of substituting home care for inpatient acute care: a review of the evidence	Canadian Medical Association Journal 1999; 160(8): 1151-1155	review or cost data/ costing based on other studies
Solomon DH, Kuntz KM	Should postmenopausal women with rheumatoid arthritis who are starting corticosteroid treatment be screened for osteoporosis? A cost-effectiveness analysis	Arthritis and Rheumatism 2000; 43(9): 1967-1975	review or cost data/ costing based on other studies
Torgerson DJ, Donaldson C, Russell IT, Reid DM	Hormone Replacement Therapy - Compliance and Cost After Screening for Osteoporosis	European Journal of Obstetrics Gynecology and Reproductive Biology (1995); 59 (1): 57-60	no measure of averted hip fracture costs
Torgerson DJ, Kanis JA	Cost-effectiveness of preventing hip fractures in the elderly population using vitamin D and calcium	QJM (1995) Feb; 88(2): 135-9	review or cost data/ costing based on other studies
Torgerson DJ, Reid DM	Osteoporosis Prevention Through Screening - will it be cost-effective	Baillieres Clinical Rheumatology (1993); 7(3): 603-622	no measure of averted hip fracture costs
Tosteson AN, Weinstein MC	Cost-effectiveness of hormone replacement therapy after the menopause.	Baillieres Clin Obstet Gynecol (1991); 5: 943-57	review or cost data/ costing based on other studies
Tosteson ANA, Rosenthal DI, Melton LJ, Weinstein MC	Cost-effectiveness of screening perimenopausal white women for osteoporosis - bone densitometry and hormone replacement therapy	Annals of Internal Medicine (1990); 113(8) : 594-603	review or cost data/ costing based on other studies

Van der Loos M, Paccaud F, Gutzwiller F, Chrzanowski R	Impact of hormonal prevention on fractures of the proximal femur in postmenopausal women: a simulation study	Soz Praventivmed (1988); 33: 162-6	review or cost data/ costing based on other studies
van der Voort DJ, Brandon S, Dinant GJ, van Wersch JW	Screening for osteoporosis using easily obtainable biometrical data: diagnostic accuracy of measured, self-reported and recalled BMI, and related costs of bone mineral density measurements	Osteoporosis International (2000); 11(3): 233-9	no measure of averted hip fracture costs
Vestergaard P, Mosekilde L	Costs of different intervention strategies to prevent hip fractures (Dan.)	Ugeskr Laeger (1999) Aug 2; 161(31): 4400-5	paper only available in Danish
Vestergaard P, Rejnmark L, Mosekilde L	Hip fracture prevention: cost-effective strategies	Pharmacoeconomics 2001; 19(5 Pt 1): 449-468	review or cost data/ costing based on other studies
Visentin P, Ciravegna R, Corcelli F, et al.	Cost-effectiveness of hip fracture prevention	Epidemiologia e Prevenzione 1998; 22(1): 44-8	review or cost data/ costing based on other studies
Visentin P, Ciravegna R, Fabris F	Estimating the cost per avoided hip fracture by osteoporosis treatment in Italy	Maturitas 1997; 26(3): 185-192	review or cost data/ costing based on other studies
Weinstein MC, Schiff I	Cost-effectiveness of hormone replacement therapy in the menopause.	Obstet Gynecol Surv (1983); 38: 445-55	review or cost data/ costing based on other studies
Weinstein MC, Tosteson AN	Cost-effectiveness of hormone replacement	Ann N Y Acad Sci (1990); 592:162-72	review or cost data/ costing based on other studies
Youm T, Koval KJ, Zuckerman JD	The economic impact of geriatric hip fractures	Americal Journal of Orthopaedics (1999); 28(7): 423-428	review or cost data/ costing based on other studies
Zacker C, Shea D	An economic evaluation of energy-absorbing flooring to prevent hip fractures	Int J Technol Assess Health Care (1998) Summer; 14(3): 446-57	review or cost data/ costing based on other studies
Zethraeus N, Johannesson M, Jonsson B	A computer model to analyse the cost-effectiveness of hormone replacement therapy	International Journal of technology Assessmen in Health Care 1999; 15(2): 352-365	review or cost data/ costing based on other studies

References

Aaron JE, Makins NB, Sagreiya K, 1987. The microanatomy of trabecular bone loss in normal ageing men and women. *Clin Orthop*; 215: 260-71

Agency for Healthcare Research and Quality (AHRQ), 2001. *Osteoporosis in postmenopausal women: diagnosis and monitoring.* Rockville, MD (USA): AHQR, Evidence Report/ Technology Assessment 28

Agnusdei D, Camporeale A, Gerardi D, Rossi S, Bocchi L, Gennari C, 1993. Trends in the incidence of hip fracture in Siena, Italy, from 1980 to 1991. *Bone*; 4: S31-4

Alderman BW, Weiss NS, Daling JR, et al, 1986. Reproductive history and postmenopausal risk of hip and forearm fracture. *Am J Epidemiol*; 124: 262-267

Ankjaer-Jensen A, Jonell O, 1996. Prevention of osteoporosis: cost-effectiveness of different pharmaceutical treatments. *Osteoporosis International*; 6 (4): 265-75

Anon., 1993. Consensus Development Conference: Diagnosis, Prophylaxis and Treatment of Osteoporosis. *American Journal of Medicine*; 94: 646-650

Arboleya LR, Castro MA, Bartolome E, et al, 1997. Epidemiology of the osteoporotic fracture of the hip in the province of Palencia. *Rev Clin Esp. Sep*; 197(9): 611-7

Armstrong K, Chen TM, Albert D, et al., 2001. Cost-effectiveness of raloxifene and hormone replacement therapy in post-menopausal women: impact of breast cancer risk. *Obstetrics and Gynecology*; 98(6): 996-1003

Ashmore M, Mulkay M and Pinch T, 1989. *Health and Efficiency – a sociology of health economics.* Buckingham: Open University Press

Autier P, Haentjens P, Bentin J, et al, 2000. Costs Induced by Hip Fractures: A Prospective Controlled Study in Belgium. *Osteoporosis International*; 11: 373-380

Bacon WE, Maggi S, Looker A, Harris T, Nair CR, Giaconi J, Honkanen R, Ho SC, Peffers KA, Torring O, Gass R and Gonzalez N, 1996. International comparison of hip fracture rates in 1988-89. *Osteoporosis International*; 6: 69-75

Barlow Report, 1994. *Report of the Advisory Group on Osteoporosis.* London: Department of Health

Baudoin C, Fardellone P, Thelot B, Juvin R, Potard V, Bean K and Sebert J-L, 1996. Hip fractures in France: The magnitude and perspective of the problem. *Osteoporosis International*; Suppl. 3 : S1-S10

Bendich A, Leader S, Muhuri P, 1999. Supplemental calcium for the prevention of hip fracture: potential health-economic benefits. *Clin Ther*; 21(6): 1058-72

Beaglehole R, Bonita R, Kjellstroem, 1993. *Basic Epidemiology*. Geneva: World Health Organisation

Bonetti S, 2001. Department of Economics, University of St Andrews. Personal Communication.

Borgquist L, Lindeloew, Thorngren KG, 1991. Costs of Hip Fracture - Rehabilitation of 180 patients in primary health care. *Acta Orthop Scand*; 62(1): 39-48

Bowling A., 1997. *Measuring Health. A review of quality of life measurement scales*. 2nd ed. Buckingham: Open University Press

Bowling A., 1995. *Measuring Disease. A review of disease-specific quality of life measuring scales*. Buckingham: Open University Press

Brainsky A, Glick H, Lydick E, et al, 1997. The Economic Cost of Hip Fractures in Community-Dwelling Older Adults: A Prospective Study. *Journal of the American Geriatrics Society*; 45: 281-287

Braithwaite RS, Col NF, Hirota LK, Wong JB, 2000. Estimating hip fracture morbidity, mortality, and costs. *Journal of General Internal Medicine*; 15: 55

Brazier J, Pitt FA, 1991. Economic Evaluation of a Population Screening Programme for Postmenopausal Osteoporosis. Oxford: HESG Study Group Meeting; January

Brecht JG, Schaedlich PK, 2000. Burden of illness imposed by osteoporosis in Germany. *Health Economics in Prevention and Care*; 1: 26-32

Buntin MB, Huskamp H, 2002. What is known about the economics of end-of-life care for Medicare beneficiaries? *The Gerontologist*; 42: 40-48

Busse R, Krauth C, Schwarz FW, 2002. Use of acute hospital beds does not increase as the population ages: results from a seven year cohort study in Germany. *Journal of Epidemiology and Community Health*; 56: 289-293

Burr DB, Martin RB, 1992. Mechanisms of bone adaptation to the mechanical environment. *Triangle*; vol. 31 no 2/3: 59

Cameron I, Crotty M, Currie C, et al., 2000. Geriatric rehabilitation following fractures in older people: a systematic review. *Health Technology Assessment*; 4(2): 1-111

Campion EW, Jette AM, Cleary PD, Harris BA, 1987. Hip fracture: a prospective study of hospital course, complications, and costs. *J Gen Intern Med*; 2(2): 78-82

Casey Horton (ed.), 1987. *Atlas of Anatomy*. Marshall Cavendish: London

Cauley JA, Thompson DE, Ensrud KC, Scott JC, Black D, 2000. Risk of mortality following clinical fractures. *Osteoporosis International*; 11: 556-561

Chalmers J, Ho KC, 1970. Geographical variations in senile osteoporosis. *J Bone Joint Surg Br*; 52:667-75

Cheung AP, Wren BG, 1992. A Cost-effectiveness analysis of hormone replacement therapy in menopause. *Med J Aust*; 156: 312-6

Chrischilles EA, Dasbach EJ, Rubenstein LM, et al., 2001. The effect of alendronate on fracture-related healthcare utilization and costs: The fracture intervention trial. *Osteoporosis International*; 12: 654-660

Chrischilles EA, Butler CD, Davis CS, Wallace RB, 1991. A model of lifetime osteoporosis impact. *Arch Intern Med*; 151: 2026-2032

Chrischilles E, Shireman T, Wallace R, 1994. Costs and Health Effects of Osteoporotic Fractures. *Bone*; 15(4): 377-386

Churchill's Illustrated Medical Dictionary. 1989. New York: Churchill Livingstone

Clark AP, Schuttinga JA, 1992. Targeted Estrogen Progestogen Replacement Therapy for Osteoporosis - Calculation of Health-Care Cost Savings. *Osteoporosis International*; 2(4): 195-200

Cobham D, 2001. Department of Economics, University of St Andrews. Personal Communication.

Compston JE, Judd D, Crawley EO, et al, 1987. Osteoporosis in patients with inflammatory bowel disease. *Gut*; 28: 410-5

Cooper C, Campion G and Melton LJ, III, 1992. Hip Fractures in the Elderly: A World-Wide Projection. *Osteoporosis International*; 2: 285-289

Cooper C, 1993. Epidemiology and public health impact of osteoporosis. *Baillieres Clinical Rheumatol*; 7: 459-477

Cooper C, 1996. Femoral neck Bone Density and Fracture Risk. *Osteoporosis International*; Suppl. 3:S24-S26

Courtney AC, Wachtel EF, Myers ER, Hayes WC, 1995. Age-related reductions in the strength of the femur tested in a fall-loading configuration. *J Bone Joint Surg*; 77-A:387-395

Cox MA, Bowie R, Horne G, 1993. Hip fractures: an increasing health care cost. *J Orthop Trauma*; 7(1): 52-7

Coyle D, Cranney A, Lee KM, et al. , 1999. Cost effectiveness of nasal calcitonin in postmenopausal women: use of Cochrane Collaboration methods for meta-analysis within economic evaluation. *Ann Meet Int Soc Technol Assess Health Care*; 15: 58

Coyle D, Cranney A, Lee KM, et al. , 2000. Cost-effectiveness research in osteoporosis. *Drug Development Research*; 49(3): 135-140

Cumming RG, 1990. Calcium intake and bone mass: a quantitative review of the evidence. *Calcif Tissue Int*; 47: 194-201

Cummings SR, Black DM, Nevitt MC, et al, 1993. Bone density at various sites for prediction of hip fractures. *Lancet*; 341: 72-75

Cummings SR, Cauley JA, Palermo L, et al, for the study of Osteoporotic Fractures Research Group, 1994. Racial differences in hip axis lengths might explain racial differences in rates of hip fractures. *Osteoporosis International*; 4: 226-9

Cummings SR, Kelsey JL, Nevitt MC, et al, 1985. Epidemiology of osteoporosis and osteoporotic fractures. *Epidemiol Rev*; 7: 178-208

Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Cauley J, Black D, and Vogt TM, 1995. Risk factors for hip fracture in white women. *New England Journal of Medicine*; 332: 767-773

Cundy T, Cornish J, Evans MG, et al, 1995. Sources of interracial variation in bone mineral density. *J Bone Miner Res*; 10: 368-73

Daly E, Roche M, Barlow D, et al, 1992. HRT: An analysis of benefits, risks and costs. *British Medical Bulletin*; 48 (2): 368-400

Davis JW, Nevitt MC, Wasnich RD, Ross PD, 1999. A cross-cultural comparison of neuromuscular performance, functional status, and falls between Japanese and white women. J Gerontol A Biol Sci Med Sci; 54(6): M288-92

De Laet CEDH, van Hout BA, Burger H, et al, 1999. Incremental Cost of Medical Care after Hip Fracture and First Vertebral Fracture: The Rotterdam Study. *Osteoporosis International*; 10: 66-72

De Seze L, Rickewaert A, 1954. *Maladies des os et des articulations*, 2 vols. Paris: Flammarion Medicine-Sciences; cited in Schapira and Schapira, 1992

Delmas PD, 2000. Do we need to change the WHO definition of osteoporosis? Oste*oporosis International*; 11: 189-191

Del Puente A, heyse SP, Mandes MG, et al, 1998. Epidemiology of osteoporosis in women in southern Italy. *Ageing (Milano)*; 10(1): 53-8

Dennison E, Yoshimura N, Hashimoto T, Cooper C, 1998. Bone loss in Great Britain and Japan: a comparative longitudinal study. *Bone*; 23 (4): 279-82

Department of Health, 1994. *Economics and Operational Research Division. Register of Cost-Effectiveness Studies*. London: DoH

Department of Health, 2001. *National Service Framework for Older People*. London: DoH. Available at: www.doh.gov.uk/nsf/frameup/contents_.html; accessed September 2002

Diez Perez A, Puig Manresa J, Martinez Izquierdo MT, et al, 1989. Estimate of the costs of osteoporotic fractures of the femur in Spain. *Med Clin (Barc)*; 92(19): 721-3

Dolan P, Torgerson DJ, 1998. The Cost of Treating Osteoporotic Fractures in the United Kingdom Female Population. *Osteoporosis International*; 8: 611-617

Dorlands Medical Dictionary, 27th ed, 1988. Philadelphia and London: WB Saunders

Drummond MF and Jefferson TO, 1996. Guidelines for authors and peer reviewers of economic submissions to the BMJ. *BMJ*; 313:275-283

Drummond MF, O'Brien B, Stoddart GL and Torrance GW, 1997. *Methods for the Economic Evaluation of Health Care Programmes*. 2nd ed. Oxford: Oxford University Press

Earl-Slater A. 1999. Dictionary of Health Economics. Abington: Radcliffe Medical Press

Elffors L, 1998. Are osteoporotic fractures due to osteoporosis? – Impact of a frailty pandemic in an aging world. *Ageing Clin Exp Res* 10:191-204

Ellwood, S.,1992. *Cost Methods for NHS Healthcare Contracts*. London: Chartered Institute of Management Accountants

Ellwood, S. ,1996. Cost-based Pricing in the NHS Internal Market. London: Chartered Institute of Management Accountants

Ensrud KE, Duong T, Cauley JA, et al, 2000. Low fractional calcium absorption increases the risk for hip fracture in women with low calcium intake. Study of Osteoporotic Fractures Research Group. *Ann Intern Med*; 132(5): 345-53

EPOS, 2002. Incidence of vertebral fracture in Europe: results from the European Prospective Osteoporosis Study (EPOS). *J Bone Miner Res*; 17(4): 716-24

Eriksen EF and Kassem M, 1992. The cellular basis of bone remodelling. *Triangle*; vol. 31 no 2/3: 45

Farnworth MG, Kenny P, Shiell A, 1994. The costs and effects of early discharge in the management of fractured hip. *Age and Ageing*; 23: 190-194

Faulkner KG, Cummings SR, Black D, Palermo L, Gluer CC, Genant HK, 1993. Simple measurement of femoral geometry predicts hip fracture: the study of osteoporotic fractures. *J Bone Miner Res*; 8: 1211-7

Fendrick AM, 1999. The Role of Economic Information in Clinical Decision Making. *PharmacoEconomic News Special Issue*. Institute of Health Economics, Alberta, Canada

Fenn P, McGuire A, Phillips V, Backhouse M, Jones D, 1995. The analysis of censored treatment cost data in economic evaluation. *Medical Care*; 33(8): 851-863

Fenn P, McGuire A, Backhouse M, Jones D, 1996. Modelling programme costs in economic evaluation. *Journal of Health Economics*; 15: 115-125

Finkler SA, 1982. The Distinction between Cost and Charges. *Annals of Internal Medicine*; 96:102-109

Francis RM, Peacock M, Marshall DH, Horsman A, Aaron JE, 1988. Spinal Osteoporosis in Men. *Bone Miner*; 5: 347-57

French FH, Torgerson DJ, Porter RW, 1995. Cost Analysis of Fracture of the Neck of Femur. *Age and Ageing*; 24: 185-189

Frost HM, 1985. The pathomechanics of osteoporoses. *Clin Orthop*; 200: 198

Garn SM, Pao EM, Rihl ME, 1964. Compact bone in Chinese and Japanese. *Science*; 143: 1439-40

Gaumer GL, Stavins J, 1992. Medicare use in the last ninety days of life. *Health Services Research*; 26: 725-742

Geelhoed E, Harris A, Prince R, 1994. Cost-effectiveness analysis of hormone replacement therapy and lifestyle interventions for hip fracture. *Aust J Public Health*; 18(2): 153-60

Gerdtham UG, Joensson B, 1991. Conversion Factor Instability in International Comparisons of Health Care Expenditure. *Journal of Health Economics*; 10: 227-234

Geusens P, 1996. Geometric characteristics of the proximal femur and hip fracture risk. *Osteoporosis International*; Suppl. 3:S27-30

Gillespie WJ, 21 April 2001. Hip fracture – Extracts from 'Clinical Evidence'. *BMJ*; 322:968-975

Givon U, 1999. Consensus conference on the treatment and rehabilitation of hip fractures in the elderly. *The Israel Medical Association Journal*; (1): Suppl.

Gluer CC, Felsenberg D, 1996. Cost-effectiveness of various strategies for the diagnosis of osteoporosis. *Radiologe*; 36 (4): 315-326

Gold MR, Siegel JE, RusselLB, Weinstein MC, 1996. *Cost-effectiveness in health and medicine*. New York: Oxford University Press

Gosden TB, Torgerson DJ, 2002. Converting International Cost Effectiveness Data to UK Prices. *BMJ*; 325: 275-276

Grisso JA, Kelsey JL, Strom BL, et al, 1991. Risk factors for falls as a cause of hip fractures in women. *N Engl J Med*; 324: 1326-1331

Hagiwara S, Miki T, Nishizawa Y, et al, 1989. Quantification of bone mineral content using dual-photon absorptiometry in a normal Japanese population. *J Bone Miner Res*; 4: 217-22

Hamilton BH, Hamilton VH, Mayo NE, 1986. What are the costs of queuing for hip fracture surgery in Canada? *Journal of Health Economics*; 15: 161-185

Heaney RP, 1991. Osteoporosis at the end of the century (editorial). *Western J Med*; 154: 106

Hodgson TA, 1989. Cost of illness studies: no aid to decision making? Comments on the second opinion by Shiell et al. (Health Policy, 8(1987) 317-323).
Health Policy. 11(1):57-60., 1989

Hodgson TA, 1994. Cost of Illness in Cost-Effectiveness Analysis – A Review of the Methodology. *Pharmacoeconomics* 6(6): 536-552

Hodgson TA and Meiners MR, 1982. Cost of Illness Methodology: A Guide to Current Practices and Procedures. Millbank Memorial Fund Quarterly / Health and Society, 60 (3)

Hoffman S, Grisso JA, Kelsey JL, et al, 1993. Parity, lactation, and hip fracture. *Osteoporosis International*; 3: 171-176

Hogan C, Lynn J, Gabel J, et al., 2000. Medicare *beneficiaries' costs and use of care in the last year of life (Medicare Payment Advisory Commission, Report No. 00-01)*. Washington, DC: Medicare Payment Advisory Commission; cited in Buntin MB, Huskamp H, 2002.

Hollingworth W, Todd C, Parker M, et al., 1993. Cost analysis of early discharge after hip fracture. *BMJ*; 307(6909): 903-6

Hollingworth W, Todd C, Parker M, 1995. The cost of treating hip fractures in the 21st century. *Journal of Public Health Medicine*; 17 (3): 269-276

Hui SL, Slemenda CW, Johnston CC, 1989. Baseline measurement of bone mass predicts fracture in White women. *Ann Intern Med*; 111: 355-361

ISD, 1999/00, 1997/98, 1993/94. *Scottish Health Service Costs*. Edinburgh: Information and Statistics Division

Ismail AA, Pye SR, Cockerill WC, et al, 2002. Incidence of limb fracture across Europe: results from the European Prospective Osteoporosis Study. *Osteoporos Int*; 13 (7): 565-71

Jacobsen SJ, Goldberg J, Miles TP, et al, 1990. Regional variation in the incidence of hip fractures: US white women aged 65 years and older. *JAMA*; 264: 500-502

Jee WSS and Frost HM, 1992. Skeletal adaptations during growth. *Triangle*; vol. 31 no 2/3: 77

Jefferson T, Mugford M, Gray A, Demicheli V, 1996. An exercise on the feasibility of carrying out secondary economic analyses. *Health Econ*; 5: 155-165

Jensen JS, Tondevold E, 1980. A prognostic evaluation of the hospital resources required for the treatment of hip fractures. *Acta Orthop Scand*; 51: 515-522

Joensson B, 1996. Economic Evaluations and clinical practice. In: Peckham M and Smith R. 1996. Scientific Basis of Health Services. London: BMJ Publishing Group

Johansson I, Larsson G, Hamrin E., 1998. Sense of coherence, quality of life, and function among elderly hip fracture patients. *Aging* (Milano). Oct;10(5):377-84.

Johnell O, Guilberg B, Allander E, Kanis JA, and the MEDOS Study Group, 1992. The apparent incidence of hip fracture in Europe: a study of national register sources.
Osteoporosis International; 2: 298-302

Johnell O, Guilberg B, Kanis JA, Allander E, Elffors L, Dequecker J, et al, 1995. Risk factors for hip fracture in European women. *J Bone Miner Res*; 10: 1802-15

Johnell O, Gullberg B, Allander E, et al, 1992. The apparent incidence of hip fracture in Europe: a study of national register sources. *Osteoporosis International*; 2: 298-302

Johnston CC, Miller JZ, Slemenda CW, et al, 1992. Calcium supplementation and increases in bone mineral density in children. *N Engl J Med*; 327: 82-87

Jones G, Nguyen T, Sambrook PN, et al, 1994. Symptomatic fracture incidence in elderly men and women: the Dubbo Osteoporosis Epidemiology Study (DOES). *Osteoporosis Int*; 4(5): 277-82

Jonsson B, Christiansen C, Johnell O, Hedbrandt J, 1996. Cost-effectiveness of fracture prevention in established osteoporosis. *Scandinavian Journal of Rheumatology*; 103: 30-38

Kanis JA and the WHO Study Group, 1994. Assessment of Fracture Risk and its Application to Screening for Postmenopausal Osteoporosis : Synopsis of a WHO Report. *Osteoporosis International*; 4; 368-81

Kanis JA, Melton LJ, Christansen C, 1994.The diagnosis of osteoporosis. Journal of Bone Mineral Research, in press, quoted by Kanis, 1994.

Kelsey JL. Epidemiology of osteoporosis and associated fractures, 1987. *J Bone Miner Res*; 5: 409

Kin K, Kushida K, Yamazaki K, Okamoto S, Inoue T, 1991. Bone mineral density of the spine in normal Japanese subjects using dual-energy X-ray absorptiometry: effect of obesity and menopausal status. *Calcif Tissue Int*; 49: 101-6

Kin K, Lee JHE, Kushida K, et al, 1993. Bone density and body composition on the Pacific Rim: a comparison between Japan- born and US-born Japanese - American women. *J Bone Miner Res*; 8: 861-9

Koopmanschap MA. 1998. Cost-of-illness studies. Useful for health policy? *Pharmacoeconomics.* Aug;14(2):143-8.

Koopmanschap MA, Rutten FF, van Ineveld BM, van Roijen L., 1995. The friction cost method for measuring indirect costs of disease. *J Health Econ.* Jun;14(2):171-89.

Kreiger N, Kelsey JL, Holford TR, et al, 1982. An epideiologic study of hip fractures in postmenopausal women. *Am J Epidemiol*; 116: 141-148

Kristiansen IS, Falch JA, Andersen L, Aursnes I, 1997. Use of alendronate in osteoporosis - is it cost-effective? *Tidsskr Nor Laengeforen*; 117(18): 2619-22

Kumar BA, Parker MJ, 2000. Are hip protectors cost effective? *Injury-International Journal of the Care of the Injured*; 31(9): 693-695

Lamb KL, Brodie DA and Roberts K, 1988. Physical fitness and health-related fitness as indicators of a positive health state. *Health Promotion*, 3: 171-82

Lane, A, 1996. Direct Costs of Osteoporosis for New Zealand Women. *Pharmacoeconomics*; 9(3): 231-245

Larousse Medical Illustre, 1971. Paris : Larousse

Lau E, Donnan D, Barker D, Cooper C, 1988. Physical activity and calcium intake in fracture of the proximal femur in Hong Kong. *BMJ*; 296: 1441

Lau E. Hip fracture in Asia: trends, risk factors and prevention. In: Christiansen C, Riis B, eds, 1993. *Proceedings of the Fourth International Symposium on Osteoporosis*. Aalborg: Handelstrykkeriet Aalborg APS: 56-81

Lau EMC, 1996. The Epidemiology of Hip Fracture in Asia: An Update. *Osteoporosis International*; Suppl.3: S19-S23

Law M, Wald NJ, Meade TW, 1991. Strategies for the prevention of osteoporosis and hip fracture. *BMJ*; 303: 453

Levinsky NG, Yu W, Ash A, et al., 2001. Influence of Age on Medicare Expenditures and Medical Care in the Last Year of Life. *JAMA*; 286: 1349-1355

Levy E, 1989. Cost Analysis of osteoporosis related to untreated menopause. *Clinical Rheumatology*; 8 (Suppl.2): 76-82

Lewinnek GG, Kelsey J, White AA, et al, 1980. The significance and a comparative analysis of the epidemiology of hip fractures. *Clin Orthop*; 152: 35-43

Lindsay R, Hart DM, Forrest C, Baird C, 1980. Prevention of Spinal Osteoporosis in Oophorectomised Women. *Lancet*; 2: 1151-3

Lindsay R, 1995. The Burden of Osteoporosis – Cost. *American Journal of Medicine*; 98: S9-S11

Lippuner K, Fuchs G, Ruetsche AG, et al., 2000. How well do radiographic absorptiometry and quantitative ultrasound predict osteoporosis at spine or hip? A cost-effectiveness analysis. *J Clin Densitom*; 3(3): 241-249

Lippuner K, von Overbeck J, Perrelet R, et al, 1997. Incidence and direct medical costs of hospitalizations due to osteoporotic fractures in Switzerland. *Osteoporosis International*; 7: 414-25

Long SH, Gibbs JO, Crozier JP, et al., 1984. Medical expenditures of terminal cancer patients during the last year of life. *Inquiry*; 21: 315-327

Lubitz J, Prihoda R, 1984. The use and costs of Medicare services in the last 2 years of life. *Health Care Financing Review*; 5(3): 117-131

Lubitz JD, Riley GF, 1993. Trends in Medicare payments in the last year of life. *New England Journal of Medicine*; 328 (15): 1092-1096

Lubitz J, Beebe J, Baker C, 1995. Longevity and Medicare Expenditures. *New England Journal of Medicine*; 332(15): 999-1003

Luce BR, Manning WG, Siegel JE and Lipscomb J, 1996. Estimating Costs in Cost-Effectiveness Analysis. In: Gold MR, Siegel JE, RussellLB, Weinstein MC, 1996. *Cost-effectiveness in health and medicine*. New York: Oxford University Press

Luckey MM, Wallenstein S, Lapinski R, Meier DE, 1996. A prospective study of bone loss in African-American and white women – a clinical research center study. J Clin Endocrinol Metab; 81 (8): 2948-56

Lyritis G, 1992. Epidemiology and Socioeconomic Cost of Osteoporotic Fractures in Greece. *Calcif Tissue Int*; 51: 93-94

Lyritis GP and the MEDOS Study Group, 1996. Epidemiology of Hip Fracture: The MEDOS Study. *Osteoporosis International*; Suppl. 3: S11-S15

MacIntyre A., 1991. *A Short History of Ethics*. London: Routledge

Magaziner J, Simonsick EM, Kashner TM, Hebel JR, Kenzora JE, 1990. Predictors of functional recovery one year following hospital discharge for hip fracture: a prospective study. *J Gerontol.* May;45(3):M101-7.

Magaziner J, Simonsick EM, Kashner TM, Hebel JR, Kenzora JE, 1989. Survival experience of aged hip fracture patients. *Am J Public Health.* Mar;79(3):274-8.

Maggi S, Kelsey JL, Kitvak J, Heyse SP, 1991. Incidence of hip fractures in the elderly: a cross-national analysis. *Osteoporosis International*; 3: 232-242

Maggiani G, 1999. The therapy of osteoporosis with clodronate I.m.: From kinetics to cost of therapy - the reasons of success. *Journal of Bone and Mineral Research*; 14: SU375

Mazess RB, 1982. On Aging Bone Loss. *Clin Orthop*; 165: 239-52

McCall N, 1984. Utilization and costs of Medicare services by beneficiaries in their last year of life. *Medical Care*; 22: 329-342

Meyer HE, Tverdal A, Falch JA, Pedersen JI, 2000. Factors associated with mortality after hip fracture. *Osteoporosis International*; 11: 228-232

Meine J, Regazzoni P, Konig W, 1993. Fractures du femur proximal: reeducation et repercussions socio-economiques. *Z Unfallchir Versicherungsmed*; 86: 66-80

Mellett H, Marriott N, Harries S. 1993. *Financial Management in the NHS – A Manager's Handbook.* London: Chapman and Hall

Melton LJ III, 1999. Cost-effective Treatment Strategies for Osteoporosis. *Osteoporosis International*; Suppl. 2: S111-S116

Melton LJ III. Epidemiology of fractures. In Riggs BL, Melton LJIII, eds, 1988. *Osteoporosis, etiology, diagnosis and management*. New York: Raven Press: 133-154

Melton LJ, Atkinson EJ, O'Fallon WM, et al, 1993. Long-term fracture risk prediction by bone mineral assessment at various skeletal sites. *J Bone Min Res*; 8: 1227-1233

Melton LJ, Chao EYS, Lane J. Biomechanical aspects of fractures. In: Riggs BL, Melton LJ, eds, 1988. *Osteoporosis: Etiology, Diagnosis, and Management*. New York: Raven Press; 111

Melton LJ, Wahner HW, Richelson LS, O'Fallon WM, Riggs BL., 1986. Osteoporosis and the risk of hip fracture. *Am J Epidemiol* ; 124: 254-261

Meltzer D, 1997. Accounting for future costs in medical cost-effectiveness analysis.
J Health Econ. Feb;16(1):33-64.

Meunier PJ, 1999. Evidence-based medicine and osteoporosis: a comparison of fracture risk reduction data from osteoporosis randomised clinical trials. *International Journal of Clinical Practice*; 53(2): 122-129

Mooney G, 1992. *Economics, medicine and health care*. 2nd ed. London: Harvester Wheatsheaf

Morbia P, Jung M, Michel T, Sizemore G, 1986. Osteoporosis - Cost of Treatment with various Calcium Preparations. *Clinical Research*; 34(2): A377

Mosekilde L, Bentzen SM, Ortoft G, Jorgensen J, 1989. The predictive value of quantitative computed tomography for vertebral body compressive strength and ash density. *Bone*; 10:465

Mountain JA, Currie CT, 1997. *Scottish Hip Fracture Audit – Outcomes of Surgery and Rehabilitation after Hip Fracture. 3rd Report to CRAG.* January.

Mountain JA, Audit Sisters at Participating Hospitals. 2001. *Scottish Hip Fracture Audit. Comparative Report.* May.

Mosekilde L, Mosekilde D, 1990. Sex Differences in Age-related changes in vertebral body size, density and biomechanical competence in normal individuals. *Bone*; 11: 67-73

Muir Gray JA, 1997. *Evidence-based Healthcare – How to make health policy and management decisions.* London: Churchill Livingstone

Nakamura T, Turner CH, Yoshikawa T, et al, 1994. Do variations in hip geometry explain differences in hip fracture risk between Japanese and white Americans? *J Bone Miner Res*; 9: 1071-1076

Nakamura T, Yoshikawa T, Mizuno Y, et al, 1993. Do geometric properties of the femoral neck explain Japanese-American differences in hip fracture incidence? (abstract) *J Bone Miner Res*; 8 (Suppl.1): 867

National Osteoporosis Foundation. 1998. Osteoporosis: review of the evidence for prevention, diagnosis, and treatment and cost-effectiveness analysis, status report. *Osteoporosis International*; 8 Suppl 4:S1-88

Newman ED, Starkey RH, Ayoub WT, et al., 1999. The Penn State Geisinger Health System Osteoporosis Disease Management Program: Cost Analysis, Guidelines, and Outcomes after Three Years. *Arthritis and Rheumatism*; 42(9): 1898

Nordin BEC, 1987. The definition and diagnosis of osteoporosis. *Calcif Tissue Int*; 40: 57-8

Norimatsu H, Mori S, Uesato T, Yoshikawa T, Katsuyama N, 1989. Bone mineral density of the spine and proximal femur in normal and ostoporotic subjects in Japan. *Bone Miner*; 5: 213-22

Norlund A, 1996. Prevention of osteoporosis - A cost-effectiveness analysis regarding fractures. *Scandinavian Journal of Rheumatology*; 103: 42-45

Normand C. 1999. Strategic Issues in Health Care Management – Future Challenges. In: Davies HTO, Tavakoli M, Malek M, Neilson AR, eds, 1999. *Controlling Costs: Strategic Issues in Health Care Management*. Aldershot: Ashgate Publishing Ltd.

O'Neill TW, et al, 1996. The prevalence of vertebral deformity in European men and women. The European vertebral osteoporosis study. *JBMR*, vol. II, no 7

Office of Technology Assessment, 1995. *Cost-effectiveness analysis*. Washington (DC): US Office of Technology Assessment

Oppenheim AN, 1992. *Questionnaire Design, Interviewing and Attitude Measurement*. London: Pinter Publishers

OECD Health Data, 2002: www.oecd.org in July 2002-10-11

OSCE, 2002. *Main Economic Indicators: Purchasing Power Parities*. Paris: OSCE. Available at: www.oecd.org. Accessed August 2002

Ostir GV, Simonsick E, Kasper JD, Guralnik JM., 2002. Satisfaction with support given and its association with subsequent health status. *J Aging Health*, Aug;14(3):355-69.

Paganini-Hill A, Chao A, Ross RK, et al, 1991. Exercise and other factors in the prevention of hip fracture: the leisure world study. *Epidemiology*; 2: 16-25

Parfitt AM, Mathews CHE, Villaneuva AR, Kleerekoper M, Frame B, Rao DS, 1983. Relationships between surface, volume, and thickness of iliac trabecular bone in aging and osteoporosis. *J Clin Invest*; 72: 1396-409

Parfitt AM, 1979. Quantum concept of bone remodeling and turnover: implications for the pathogenesis of osteoporosis. *Calcified Tissue International*; 28: 1-5

Parfitt AM, 1987. Trabecular bone architecture in the pathogenesis and prevention of fracture. *Am J Med*; 82: 68-72

Parker MJ, Myles JW, Anand JK, Drewett R. Cost-benefit analysis of hip fracture treatment. J Bone Joint Surgery (British) 1992; 74(2): 262-4

Parker MJ, Pryor GA, 1993. *Hip Fracture Management*. Oxford: Blackwell Scientific

Parkin D, McGuire A, Yule B, 1987. Aggregate health care expenditures and national income: is health care a luxury good? *Journal of Health Economics*; 6: 109-127

Phillips CJ, Moore RA, 1998. Developing a strategy for the prevention of hip fractures in the elderly due to osteoporosis: the application of economics to the findings from a clinical trial. *International Journal of Clinical Practice*; 52(5): 335-340

Phillips S, Fox N, Jacobs J, Wright E, 1988. The direct medical costs of osteoporosis for American women aged 45 and older, 1986. *Bone*; 9: 271-279

Pientka L, Friedrich C, 1999. Die Kosten hueftgelenknaher Frakturen in Deutschland: Eine prospektive Untersuchung. *Z Gerontol Geriatr*; 32(5): 326-32

Pigot F, Roux C, Chaussade S, et al, 1992. Low bone mineral density in patients with inflammatory bowel disease. *Dig Dis Sci*; 37: 1396-403

Pschyrembel Klinisches Woerterbuch, 257th edition, 1994, de Gruyter, Berlin, translation: E.Brock

Randell A, Sambrook PN, Nguyen TV, et al, 1995. Direct clinical and welfare costs of osteoporotic fractures in elderly men and women. *Osteoporosis International*; 5(6): 427-32

Ray WA, Griffin MR, West R, et al, 1990. Incidence of hip fracture in Saskatchewan, Canada, 1976-1985. *Am J Epidemiol*; 131: 502-509

Reeve J on behalf of the EPOS Study Group, 1996. The European Prospective Osteoporosis Study. *Osteoporosis International*; Suppl.3: S16-S19

Reginster JY, Gillet P, Ben Sedrine W, et al, 1999. Direct Costs of Hip Fractures in Patients over 60 years of age in Belgium. *Pharmacoeconomics*; 15(5): 507-14

Rice DP, 1994. Cost-of-illness studies: fact or fiction?
Lancet. Dec 3;344(8936):1519-20.

Riggs B.L. and Melton L.J.III, 1986. Involutional Osteoporosis. *New England Journal of Medicine*; vol. 314, no.26, pp.1676-1686

Riggs BL, Wahner HW, Dunn WL, Mazess RB, Offord KP, Melton LJ III, 1981. Differential Changes in Bone Mineral Density of the Appendicular and Axial Skeleton with Aging: Relationship to Spinal Osteoporosis. *J Clin Invest*; 67:328-35

Ringe J.D, 1996. Hip Fractures in Men. *Osteoporosis International*; Suppl. 3: S48-S51

Ringe JD, Dorst A, 1994. Osteoporose bei Maennern: Pathogenese und klinische Einteilung bei 254 Faellen. *Dtsch Med Wochenschr*; 119: 943-7

Ringe JD, Dorst , 1993. Osteoporosis in males: Pathogenesis and clinical classification. In: Christiansen C, Riis B, editors. *Osteoporosis. Proceedings of the Fourth International Symposion 0n Osteoporosis*. Hong Kong: 184-5

Ringe JD, Rehpenning W, Steinhagen-Thiessen E, 1985. Increasing skeletal involutional in the elderly? *Mech Ageing Dev*; 29: 83-8

Roche M, Vessey M Hormone Replacement Therapy in the menopause: risks, benefits and costs p.189-198, chapter 18 of a book published during or before 1995; unable to trace source, Xerox in possession of author

Rodriguez Escolar C, Fidalgo Garcia ML, Rubio Cebrian S, 1999. Alendronate cost-effectiveness analysis versus placebo in the prevention of hip fractures. *Atencion Primaria*; 24(7): 390-396

Roos NP, Montgomery P, Roos LL, 1987. Health care utilization in the years prior to death. *Milbank Quarterly*; 65 (2): 231-254

Rosner AJ, Grima DT, Torrance GW, et al., 1998. Cost-effectiveness of multi-therapy treatment strategies in the prevention of vertebral fractures in postmenopausal women with osteoporosis. *Pharmacoeconomics*; 14(5): 559-73

Ross PD, Wasnich RD, Maclean CJ, et al., 1988. A model for estimating the potential costs and savings of osteoporosis prevention strategies. *Bone*; 9(6): 337-347

Roux C, Abitbol V, Chaussade S, Kolta S, Guillemant S, Dougados M, Amor A and Couturier D, 1995. Bone loss in patients with inflammatory bowel disease: a prospective study. *Osteoporosis International*; 5: 156-160

Roy DK, Pye SR, Lunt M, et al, 2002. Falls explain between-center differences in the incidence of limb fracture across Europe. *Bone*; 31(6): 712-7

Royal College of Physicians. Fractured neck of femur, prevention and management. Summary and recommendations of a report of the Royal College of Physicians. J R Coll Physicians Lond. 1989; 23: 8-12

Ruff CB, Hayes WC, 1988. Sex Differences in age-related remodeling of the femur and tibia. *J Orthop Res*; 17: 264-9

Russell-Aulet M, Wang J, Thornton JC, Colt EWD, Pierson RN, 1993. Bone mineral density and mass in a cross-sectional study of White and Asian women. *J Bone Miner Res*; 8: 575-82

Sarkisian CA, Liu H, Gutierrez PR, et al, 2000. Modifiable risk factors predict functional decline among older women: a prospectively validated clinical prediction tool. The Study of Osteoporotic Fractures Research Group. *J Am Geriatr Soc*; 48(2):170-8

Schapira, D. and Schapira C, 1992. Osteoporosis: The Evolution of a Scientific Term. *Osteoporosis International*; 2: 164-167

Schroder HM, 1991. The cost of hospitalizing hip fracture patients has increased despite shorter hospitalization time. *Injury*; 22(2): 135-8

Schurch MA, Rizzoli R, Mermillod B, et al, 1996. A prospective study on socioeconomic aspects of fracture of the proximal femur. *J Bone Miner Res*; 11(12): 1935-42

Scitovsky AA, 1988. Medical care in the last twelve months of life: the relationship between age, functional status and medical care expenditures. *Milbank Quarterly*; 66(4): 640-660

Scitovsky AA, 1994. "The high cost of dying" revisited. *Milbank Quarterly*; 72(4): 561-91

Seedhouse D, 1986. *Health: The Foundations of Achievement*. Chichester: John Wiley

Seeman E, Melton LJ II, O'Fallon WM, Riggs BL, 1983. Risk Factors for Spinal Osteoporosis in men. *Am J Med*; 75: 977-83

Seeman E, 1995. The Dilemma of Osteoporosis in Men. *American Journal of Medicine*; 98 (Suppl. 2A): 76S

Sendi P, Palmer AJ, 2000. Modelling the Socioeconomic Impact of Osteoporosis-Related Hip Fractures in Switzerland . *Osteoporosis International*; 11: 92-94

Sernbo I, Johnell O, 1993. Consequences of a hip fracture: a prospective study over 1 year. *Osteoporosis International*; 3(3): 148-53

Shiell, A, Gerard K and Donaldson C , 1987. Cost of illness studies: an aid to decision making? *Health Policy* 8: 317-323

Siris ES, Miller PD, Barrett-Connor E, et al, 2001. Identification and fracture outcomes of undiagnosed low bone mineral density in postmenopausal women: results from the National Osteoporosis Risk Assessment. *JAMA*; 286(22): 2815-22

Slemenda CW, Turner CH, Peacock M, Christian JC, Sorbel J, Hui SL and Johnston CC, 1996. The genetics of proximal femur geometry, distribution of bone mass and bone mineral density. *Osteoporosis International*; 6: 178-182

Smith DM, Khairi MRA, Johnston CC Jr, 1975. The Loss of Bone Mineral with Aging and its Relationship to Risk of Fracture. *J Clin Invest*; 56: 311-8

Spadaro JA, Werner FW, Brenner RA, Fortino MD, Fay LA, Edwards WT, 1994. Cortical and trabacular bone contribute strength to the osteopenic distal radius. *J Orthop Res*; 12: 211

Spector WD, Mor V, 1984. Utilization and charges for terminal cancer patients in Rhode Island. *Inquiry*; 21: 328-337

Stromberg L, Ohlen G, Svensson O, 1997. Prospective payment systems and hip fracture treatment costs. *Acta Orthop Scand*; 68 (1): 6-12

Soderstrom L, Tousignant P, Kaufman T, 1999. The health and cost effects of substituting home care for inpatient acute care: a review of the evidence. *Canadian Medical Association Journal*; 160(8): 1151-1155

Solomon DH, Kuntz KM, 2000. Should postmenopausal women with rheumatoid arthritis who are starting corticosteroid treatment be screened for osteoporosis? A cost-effectiveness analysis. *Arthritis and Rheumatism*; 43(9): 1967-1975

Sugden R, Williams A., 1978. *The principles of practical cost-benefit analysis*. Oxford: Oxford University Press

Tayside Health Board, Statistics Division, Personal Communication, 2001

Temkin-Greener HA, Meiners MR, Petty EA, Szydlowski JS, 1992. Th use and cost of health services prior to death: A comparison of Medicare-only and the Medicare-Medicaid elderly populations. *Milbank Quarterly*; 70(4): 679-701

Theobald TM, Cauley JA, Gluer CC, 1998. Black-white differences in hip geometry. Study of Osteoporotic Fractures Research Group. Osteoporos Int; 8(1): 61-7

Thorngren KG, 1991. Cost comparison in hip fracture treatment. *Acta Orthop Scand*; Suppl; 241: 38-9

Torgerson DJ and Reid DM, 1993. Osteoporosis prevention through screening: will it be cost-effective? *Baillieres Clinical Rheumatology*; vol.7, no.3: 603-622

Tosteson ANA, Rosenthal DI, Melton LJ, Weinstein MC, 1990. Cost-effectiveness of screening perimenopausal white women for osteoporosis - bone densitometry and hormone replacement therapy. *Annals of Internal Medicine*; 113(8) : 594-603

Treves R, Burki F, Hugon J, et al, 1985. Evaluation du cout hospitalier de l'osteoporose sur une periode de deux ans. *Revue du Rheumatisme*; 52(3): 191-193

Van der Loos M, Paccaud F, Gutzwiller F, Chrzanowski R, 1988. Impact of hormonal prevention on fractures of the proximal femur in postmenopausal women: a simulation study. *Soz Praventivmed*; 33: 162-6

Van der Voort DJ, Brandon S, Dinant GJ, van Wersch JW, 2000. Screening for osteoporosis using easily obtainable biometrical data: diagnostic accuracy of measured, self-reported and recalled BMI, and related costs of bone mineral density measurements. *Osteoporosis International*; 11(3): 233-9

Vaz AL, 1993. Epidemiology and costs of osteoporotic hip fractures in Portugal. *Bone*; 14 Suppl 1: S9

Vestergaard P, Mosekilde L, 1999. Costs of different intervention strategies to prevent hip fractures (Dan.). *Ugeskr Laeger*; 161(31): 4400-5

Vestergaard P, Rejnmark L, Mosekilde L, 2001. Hip fracture prevention: cost-effective strategies. *Pharmacoeconomics*; 19(5 Pt 1): 449-468

Visentin P, Ciravegna R, Corcelli F, et al., 1998. Cost-effectiveness of hip fracture prevention. *Epidemiologia e Prevenzione*; 22(1): 44-8

Visentin P, Ciravegna R, Fabris F, 1997. Estimating the cost per avoided hip fracture by osteoporosis treatment in Italy. *Maturitas*; 26(3): 185-192

Vogelsang H, Ferenci P, Woloszeznk W, et al, 1989. Bone disease in vitamin D deficient patients with Crohn's disease. *Dig Dis Sci*; 34: 1094-9

Waher HW, Looker A, Walters L, Dunn WL, 1994. Racial and gender differences in the shape of the proximal femur. *J Bone Miner Res*; 9(Suppl): S401

Walker D, 2001. Cost and cost-effectiveness guidelines: which ones to use? *Health Policy Management*, 16(1): 113-21

Wasnich RD, Ross PD, Davis JW, 1991. Osteoporosis - current practice and future perspectives. *Trends Endocrinol Metab*; 2: 59-62

Weinstein MC, 1999. Theoretically correct cost-effectiveness analysis. *Med Decis Making.* Oct-Dec;19(4):381-2; discussion 383-4.

Weinstein MC, Schiff I, 1983. Cost-effectiveness of hormone replacement therapy in the menopause. *Obstet Gynecol Surv* ; 38: 445-55

Weinstein MC, Tosteson AN, 1990. Cost-effectiveness of hormone replacement. *Ann N Y Acad Sci*; 592:162-72

World Health Organization, 1994. *Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. WHO Technical Report Series 843*. Geneve: WHO

Yang Z, Norton EC, Stearns SC, 2003. Longevity and Health Care Expenditures – The real reasons older people spend more. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. 58: S2-S10

Youm T, Koval KJ, Zuckerman JD, 1999. The economic impact of geriatric hip fractures. *American Journal of Orthopaedics*; 28(7): 423-428

Youngson RM, 1992. *Collins Dictionary of Medicine*. Harper Collins

Zethraeus N, Gerdtham UG, 1998. Estimating the costs of hip fracture and potential savings. *Int J Technology Assess Health Care*; 14(2): 255-67

Zethraeus N, Stromberg L, Jonsson B, et al, 1997. The cost of a hip fracture. Estimates for 1,709 patients in Sweden. *Acta Orthop Scand*; 68(1): 13-7 and 1-2 and 6-12